AN ATLAS OF THE MOSQUITOES OF WESTERN AUSTRALIA

Western Australia

Health Department of Western Australia

AN ATLAS OF THE MOSQUITOES OF WESTERN AUSTRALIA

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MINISTERIAL FOREWORD

Mosquitoes in Western Australia are responsible for carrying human diseases, notably the rare but sometimes fatal disease Australian encephalitis in the north, and the debilitating arthritic disease Ross River virus infection throughout the State. Historically mosquitoes have also carried dengue and malaria in Western Australia, although the introduction of scheme water and modern housing has eradicated these two diseases.

As well as carrying diseases, mosquitoes can create a severe nuisance problem for outdoor recreation activities.

Fortunately only a few of the ninety or so species of mosquito in Western Australia carry human disease, and many species are either uncommon or do not bite humans. For these reasons a working knowledge of mosquito classification is important to any effective mosquito control program.

Until now people involved in control of mosquitoes and the diseases they carry in Western Australia have been handicapped by the fact that there has never been a suitable reference work available to assist them. Instead they have had to rely on often inappropriate interstate reference material, or piecemeal local information.

The production of 'An Atlas of the Mosquitoes of Western Australia' is therefore a milestone in the development of mosquito control in Western Australia. As a consultant to the Health Department, Peter Liehne has produced not only a comprehensive aid to effective mosquito identification in Western Australia, but also an invaluable source of information concerning the ecology, behaviour and distribution of Western Australian mosquitoes. In addition, the 'Atlas' contains useful information about the diseases carried by mosquitoes in Western Australia, along with a balanced overview of the theory and practice of mosquito control.

I commend the 'Atlas of the Mosquitoes of Western Australia' to those concerned about mosquitoes or the diseases they carry in Western Australia.

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INTRODUCTION

For most of us, mosquitoes need no introduction. They are very much a part of the Australian environment. Mosquitoes can be significant nuisance pests greatly reducing the enjoyment and quality of the outdoor lifestyle which is so much a part of our culture. These insects can also be significant as vectors of diseases (of both man and animals), and may constitute a significant health risk.

The diversity of this group, however, is often not appreciated. Some 90 species have been recorded in Western Australia alone, and it is certain that more species will be discovered as further collections are made. It should be noted that the vast majority of species are very rarely encountered, and that only 30 or so species make up the significant pest and/or vector populations.

In recent times, greater understanding of the importance of mosquito-borne disease, and the rising expectations among the public for pest free urban and leisure environments, have led to the increased study of mosquito related problems and to increased calls for mosquito management programmes.

The success and efficiency (both cost and effort) of management programmes depends on a precise definition of the problem at hand. This means, primarily, that the mosquito species involved must be identified accurately to ensure that any management effort can be directed at the most vulnerable parts of the target species life cycle. Species identification can be a significant problem for the non-professional. Keys and descriptions are often difficult to obtain and, to the inexperienced, can be difficult to follow, particularly when technical jargon is used. However, in any work such as this, there is a need to use technical terms to describe the species and aspects of their ecology. Where such terminology is used in this atlas, it is generally explained on the first occasion. An explanation is also provided in the glossary for rapid referral. With time and use the terms will become second nature.

Irving-Bell and Liehne (revised by Andrew Blair) (1980) presented illustrated keys to the common species in the Perth metropolitan area and the south west of W.A. Thirty five species were listed as being recorded from the south west, but the keys included only the 14 most common species. Dobrotworsky (1965) reviewed the mosquitoes of Victoria, and included descriptions of 73 species, 24 of which occur in W.A. Marks (1982) presented a brief guide to the 25 most common species in Queensland, of which, 20 are found in W.A. (though some are relatively uncommon).

A number of wide ranging reviews of the complete mosquito fauna in the Australasian region have included many or all species found in W.A. (Edwards, 1924; Knight, et. al., 1944; Lee, 1944; Lee and Woodhill, 1944; Lee, et. al. 1980 (and subsequent volumes)). All of these works included many species not found in W.A., and this could be a source of confusion for the inexperienced mosquito worker.

Species identification through a key must be confirmed by a comparison of the morphological appearance of the specimen in question with a specimen identified by a competent taxonomist, or through checking against an adequate published description. The descriptions of many species, however, are only found in the original journal articles and several known species are yet to be formally described. In addition, some of the older descriptions are very brief and are not sufficiently detailed to differentiate between species of more recent discovery.

Some indication of the distribution, biology and abundance of each species, particularly considering the vast area and variety of ecological habitats found within W.A., is often useful in indicating the possible identity of a specimen. Britten (1958) presented detailed distributions for mosquitoes in the southern parts of W.A. and Hodgkin and Britten (1955) and O'Gower (1958) reviewed the distributions of mosquitoes in northern W.A. Other records can be found in taxonomic papers, research papers on mosquitoes and mosquito-borne disease, and in the numerous unpublished reports within the University of W.A., Health Department of W.A. and local authorities.

The results of recent collections and research on the mosquito fauna of W.A. remain largely inaccessible to those involved in management. No single reference contains the relevant information (keys to adults and larvae, descriptions, distributions and notes on biology) necessary for accurate species identification and management.

This atlas has been prepared to combine all these needs into a single volume to be used as a practical guide and reference text to mosquitoes in W.A. The text is aimed particularly at those involved in mosquito management. As such, it presents a brief overview of mosquito ecology sufficient for an understanding of the complexity and diversity amongst this group in order to give the reader sufficient insight into the problems of disease vector and pest management. It makes no attempt to review the vast literature, or to present detailed analyses of the various aspects of mosquito biology, taxonomy and management. Many of the comments may seem simplistic and common sense, but are necessary to provide the broad perspective of mosquito biology, identification and management.

It should be appreciated that there are still many gaps in our knowledge of mosquitoes in W.A. In some ways, there is never really sufficient information for a review such as this to be complete. There are always some extra data which could be gathered and included. Indeed, the survey of past records and collections has shown that many specimens were not kept or lodged in a recognised collection, making the analysis much more difficult. For a great number of species, single specimens make up the sum of our knowledge. It would obviously be preferable to be able to gather further data on the biology of these species. There has, however, been a very significant increase in our knowledge of mosquitoes in W.A. since the last reviews. This atlas, despite the gaps, is timely in that it presents a picture of the current state of our knowledge. It may stimulate others to look at the mosquitoes with a little more detail and hopefully increase our understanding of the W.A. fauna.

The reader should be aware of the limitations of this atlas. The atlas provides keys to all the species currently known from W.A., but provides descriptions only of those species which have been formally described in the literature. In addition, some groups such as the *Culex (Lophoceraomyia)* are in somewhat of a taxonomic disarray, and cannot be treated with any certainty here. The descriptions of species are basic, but are sufficient for confirmation of species identification. They must be used in conjunction with the illustrations. It is also clear that, as our knowledge increases, and as taxonomic descriptions of the many as yet undescribed species find their way into the literature, this manual will have to be revised and updated.

OTHER USEFUL REFERENCES:

There are a number of other texts which may be used to obtain a more general review of mosquitoes, their biology and prospects for management.

Dobrotworsky's 1965 monograph on the mosquitoes of Victoria is a good general reference to Australian mosquitoes.

A more recent and detailed appraisal is to be found in the introduction to Lee et. al. (1980). This presents a readable and accurate historical overview of the study of Australian mosquitoes. This volume also contains a very detailed bibliography of the publications dealing with the Australian mosquitoes (Culicidae) and is an excellent introduction to the literature. This and the subsequent volumes in this series are a must for the serious mosquito worker. Whilst the treatment of species is limited in that only keys to adult females are given, and no descriptions provided, the text reviews in detail the biology, relationship to disease and comprehensive literature records for each species.

Though data have been much refined since the classic work by Marsden Bates was written in 1949, it remains the most readable and accessible treatise on mosquitoes. Muirhead-Thompson (1965) on the biology of disease vectors and Clements (1963) on mosquito physiology are also important reference texts containing much information on the biology, structure and life-cycle of mosquitoes in relation to both pest and vector activity. Service (1976) is a detailed technical volume, but a worthy reference for the person wishing to explore the field ecology of mosquitoes in much greater detail.

Those wishing to delve further into the ecology, systematics and management of mosquitoes are referred to the numerous journals dealing with mosquitoes or vector-borne diseases. The Journal of the American Mosquito Control Association (formerly Mosquito News), Journal of Medical Entomology, and Mosquito Systematics are the best of these. There have been a number of detailed review articles in the Annual Review of Entomology dealing with the ecology, management and vector capacity of mosquitoes. Mosquito Control Research (Annual Reports, University of California) are also very readable and worthwhile publications which report on recent research and developments into mosquito biology, management and vector status in California, a leading centre for research into mosquito biology and control.

A more general, but equally valuable text on insects is 'The Insects of Australia' [CSIRO (1970)]. This wide ranging text has much detailed information on the general biology, physiology, taxonomy, evolution and ecology of insects which is relevant to mosquitoes.

ATLAS STRUCTURE:

The atlas is divided into three sections. The first deals with general aspects of mosquito biology, interactions with man, and reviews the main diseases and pest problems in W.A. The second section is a manual for mosquito management. It contains information on the theory and application of management options. The third section deals with mosquito taxonomy and identification. Keys to species, descriptions, distributions, notes on biology, pest and vector status are included in this section. Illustrated keys to the species in the form of wall charts are also provided.

USING THE ATLAS:

For newcomers to the field of mosquito ecology, Sections 1 and 2 should be read first. These should familiarise the reader with terms and concepts in mosquito biology and management. The glossary should help with terms and definitions. Chapter 7 on survey techniques and Appendix 1 on preservation of specimens should be read thoroughly.

Identification of individual specimens requires the use of a microscope as many diagnostic characters are quite small. Begin by reading the preamble on the use of the keys and then run the specimen through the 'Key to Genera' (Chapter 16). Having determined the genus, ensure that the specimen conforms to the full generic description. If there are problems, carefully run the specimen through the key a second time.

Having determined the genus, species definition can then be made by running the specimen through the key presented in the subsequent chapter dealing with the particular genus. Again, identifications must be confirmed by ensuring that the specimen conforms to the description as presented. You must be prepared for mistakes, particularly in the beginning. A reference collection should be kept for comparisons, and it is wise to confirm your initial identifications with a professional medical entomologist (e.g. Health Department of W.A.). With practice and local knowledge, many species will become recognisable at a glance.

Problems will undoubtedly arise from time to time when new, previously undescribed species, or when species not previously recorded from W.A. appear in collections. If the specimen does not fit the keys or descriptions, pass it on to a medical entomologist for identification. If you feel confident with the terminology and morphology of mosquito anatomy, you may wish to run the specimen through the keys provided in Lee et. al. (1980, 1982, 1984) and subsequent volumes. It is always wise to confirm your identifications with a competent medical entomologist, particularly for species recorded well outside the known distribution.

For those who need to investigate a problem with the aim of management, ensure that you understand the benefits and problems associated with each of the options for management. Read Section 2 thoroughly. Be particularly careful with species identifications and again, if you have any doubts, have your identifications confirmed by a recognised medical entomologist. However, you must appreciate that such entomologists are generally very busy, and it is important not to burden them with unnecessary or frivolous requests for assistance. Overall, professional medical entomologists are usually ready to provide assistance and advice.

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The preparation of this atlas was first suggested by Professor Hugh Paterson when I first commenced my work on the arbovirus research project in the Ord Valley of W.A. in 1982. The format and content of the atlas owes much to N.V. Dobrotworsky's 'Mosquitoes of Victoria' (for taxonomic treatment) and to the various vector control courses sponsored by the NDCP, both at Mildura, and elsewhere in Australia. The resemblances between this atlas and the manuals prepared for these courses is no accident, and I acknowledge all the authors of the relevant sections in the manuals, particularly Dr Richard Russell, Peter Whelan, and Dr Peter Allen.

Much of the data presented in this atlas was gathered whilst I was a researcher at the University of Western Australia, investigating the patterns of arbovirus activity in W.A. I acknowledge the support and encouragement of the late Professor Neville Stanley, Professor Hugh Paterson, Associate Professor John Mackenzie, and all my colleagues in the research laboratory and in the Health Department of W.A. over the years of my association with the project, particularly Tony Wright and Wayne Jolley.

The late Eric Britten, whose pioneering work whilst a health surveyor with the Health Department of W.A., laid the ground work for our knowledge of the mosquitoes of Western Australia, deserves mention for his support and encouragement, and for bequeathing his reference collection to me. Dr Earnest Hodgkin, also a pioneer of mosquito work in W.A., bequeathed his collecting records and reference materials to me.

My contemporary colleagues have provided discussion, support and, in some cases, reference specimens of mosquitoes for the atlas. In this regard I acknowledge Dr Richard Russell, Peter Whelan, Geoff Davis, Dr Ian Marshall, Dr E.N. Marks, and Alan Dyce. The W.A. Museum, Health Department of W.A. and the W.A. Department of Agriculture all gave me access to their collections. Dr Richard Russell and the staff of the former School of Public Health and Tropical Medicine at the University of Sydney provided me with records of specimens in their collections and confirmed identifications of some specimens. Dr Russell and Dr Marks also kindly loaned specimens for taxonomic description.

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AN ATLAS OF THE MOSQUITOES OF WESTERN AUSTRALIA
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SECTION 1

GENERAL INTRODUCTION TO THE BIOLOGY AND ECOLOGY OF MOSQUITOES, AND AN ANALYSIS OF PEST AND VECTOR PROBLEMS IN WESTERN AUSTRALIA

CHAPTER 1 : MOSQUITOES - GENERAL INTRODUCTION AND THE BIOLOGY OF THE PRE-ADULT STAGES.

PART I : GENERAL INTRODUCTION

MOSQUITO NOMENCLATURE AND EVOLUTIONARY RELATIONSHIPS

To understand mosquitoes, some appreciation of the evolutionary relationships of this group is necessary. These evolutionary relationships are generally accepted as forming the basis of taxonomic classification.

In evolutionary terms, species has been defined as 'groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups'. Thus a species forms a unique unit in nature, each characterised by its own unique combination of ecological, behavioural, physiological and morphological traits. The species is the only taxonomic unit which can be practically defined in nature through examination of the various isolation mechanisms which prevent interbreeding and maintain the integrity of the population. The other taxonomic units (e.g. genus, family) are based on perceived evolutionary relationships between species (see below). The closeness of the relationship between species is inferred from the degree to which the species share common biological and morphological characters.

The classification presented here follows that of CSIRO (1970) [see reference list in Introduction] and readers wishing to find out more about the higher taxonomy of the mosquitoes are referred to that text.

The mosquitoes of the world, some three thousand species, are grouped in the Dipteran family Culicidae. The Culicidae include two subfamilies: Chaoborinae and Culicinae. All true mosquitoes belong to the Culicinae. The Chaoborinae (ghost midges) are often placed in a separate family and will not be dealt with further in this manual.

All mosquito species are related to some degree and it is the closeness of these relationships which forms the basis of taxonomy. The subfamily Culicinae combines all those species which conform to the mosquito pattern, and the tribes (Anophelini, Culicini and Toxorhynchitini) group those species which, whilst still conforming to the overall definition of Culicinae, show closer resemblances within the tribe than between tribes.

Within the tribe, closely related species are placed in genera. In the Anophelini, two genera (*Anopheles* and *Bironella)* are known in Australia, though only *Anopheles* occurs in W.A. *Toxorhynchites* is the only genus in the Toxorhynchitini, and the main genera in the Culicini include *Aedes, Coquillettidia, Culex, Mansonia* and *Tripteroides.*

Further groupings, based on even closer relatedness occur within each genus. Such groupings are termed subgenera [e.g. *Aedes (Finlaya); Aedes (Ochlerotatus)].* Finally, the individuals which belong to one type are placed in a species which is given a unique name [e.g. *Aedes (Finlaya) notoscriptus; Aedes (Finlaya) alboannulatus].*

It follows that species belonging to the subgenus *Finlaya* of *Aedes* are more closely related to each other than to members of *Aedes (Ochlerotatus),* and that these are, in turn, more closely related to each other than they are to species of the genus *Culex.* This degree of relatedness is expressed as common characteristics in the morphological appearance and biological attributes of the different genera and tribes. In this context, it becomes clear that the characteristics which define the higher taxonomic groupings such as families are broader than those which define individual species.

In W. A., the most commonly encountered mosquito species belong to three genera: *Aedes, Anopheles* and *Culex.* Some problem species also belong to the genera *Coquillettidia* and *Mansonia.* The species belonging to the remaining genera are generally not significant as pests or vectors.

STANDARD ABBREVIATIONS

In order to simplify the naming of mosquito species within a text, mosquito workers have adopted a scheme where each genus is given a unique two letter abbreviation. The subgenera are treated similarly, and are given a three letter abbreviation so that they can be distinguished from the genera (Table 1.1). This system has been widely adopted in recent times, and readers should familiarise themselves with the standard abbreviations and use them whenever possible.

TABLE 1.1 : STANDARD ABBREVIATIONS FOR GENERA AND SUBGENERA

GENUS	SUBGENUS	ABBREVIATION
Aedeomyia		*Ad*
	Aedimorphus	*Ady*
Aedes		*Ae*
	Aedimorphus	*Adm*
	Chaetocruiomyia	*Cha*
	Finlaya	*Fin*
	Halaedes	*Hal*
	Lorrainea	*Lor*
	Macleaya	*Mac*
	Mucidus	*Muc*
	Neomelaniconion	*Neo*
	Ochlerotatus	*Och*
	Pseudoskusea	*Psk*
	Rhinoskusea	*Rhi*
	Stegomyia	*Stg*
	Verrallina	*Ver*
Anopheles		*An*
	Anopheles	*Ano*
	Cellia	*Cel*
Coquillettidia		*Cq*
	Coquillettidia	*Coq*
Culex		*Cx*
	Culex	*Cux*
	Culiciomyia	*Cui*
	Lophoceraomyia	*Lop*
	Lutzia	*Lut*
	Neoculex	*Neo*
Culiseta		*Cs*
	Culicella	*Cuc*
	Neotheobaldia	*Net*
Hodgesia		*Ho*
Malaya		*Ml*
Mansonia		*Ma*
	Mansonioides	*Mnd*
Mimomyia		*Mi*
	Etorleptiomyia	*Eto*
	Mimomyia	*Mim*
Toxorhynchites		*Tx*
	Toxorhynchites	*Tox*
Tripteroides		*Tp*
	Polylepidomyia	*Pol*
	Rachisoura	*Rac*
	Tripteroides	*Trp*
Uranotaenia		*Ur*
	Pseudoficalbia	*Pfc*
	Uranotaenia	*Ura*

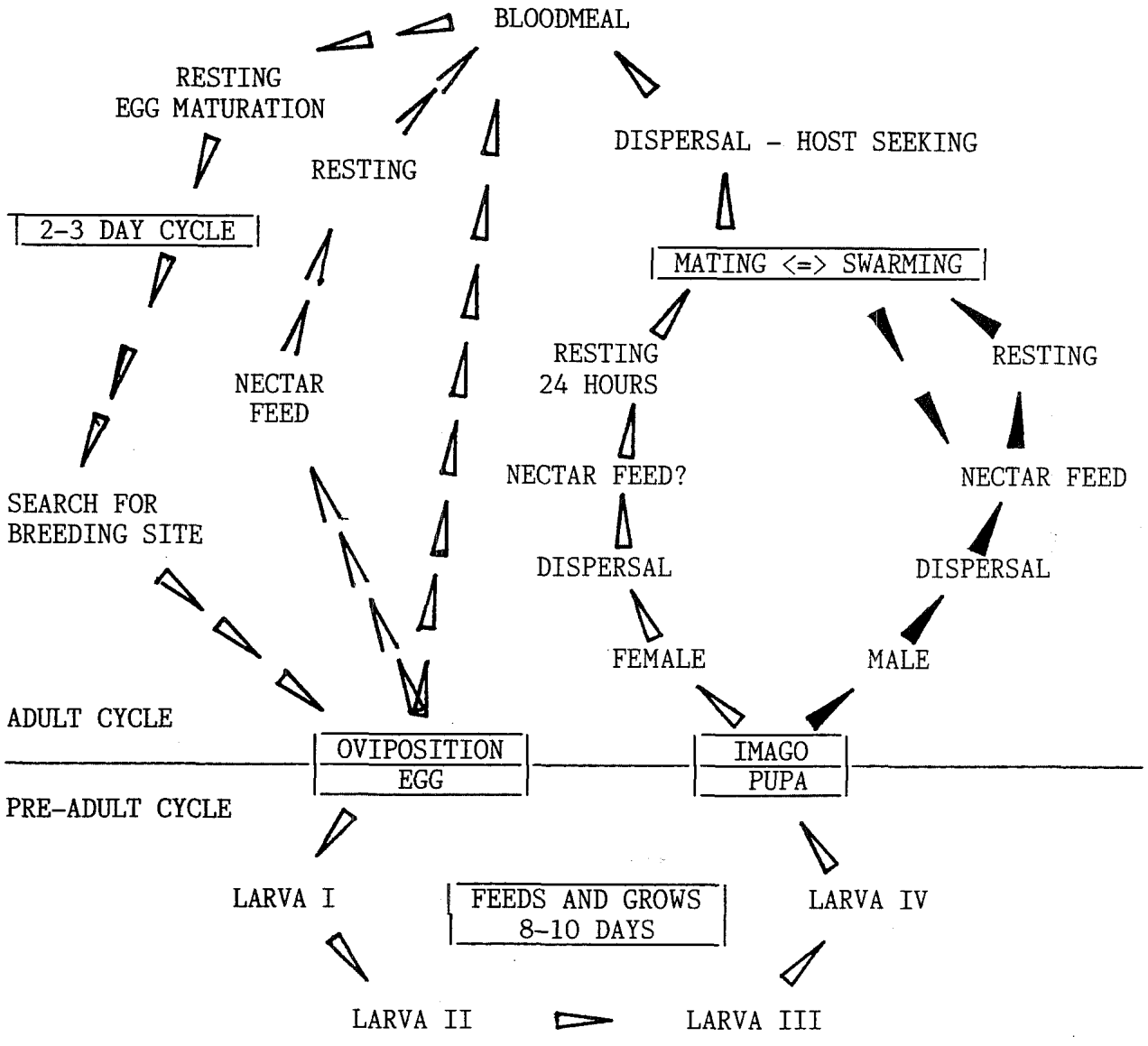
MOSQUITO LIFE CYCLE

The species belonging to any particular tribe or genus of mosquitoes have morphological and biological consistency within the grouping. These similarities stem from common ancestry and all are variations on the same basic mosquito life cycle pattern.

Mosquitoes begin life as eggs. The eggs are laid singly or in groups, either in, on the surface of or at the margins of water bodies. The eggs hatch into free swimming aquatic larvae (1st instar). The larvae are the growth phase of the life cycle and they pass through three moults (2nd,3rd and 4th instars), feeding throughout each stage and progressively increasing in size. They finally moult into the non-feeding, aquatic pupal stage. The pupa is relatively inactive, and it is in the pupal stage that the larval tissues are reorganised into the adult form. When the transformation is complete, the pupa splits along the dorsal surface and the adult emerges. The adult renews the cycle by mating, feeding and producing an egg batch and hence the next generation. Figure 1.1 presents a schematic representation of a generalised mosquito life cycle.

This is a very favourable life cycle pattern as it allows the larva and adult to utilize very different habitats so that the different stages of the mosquito do not compete for the same resources. Similarly, predators and pathogens are only able to affect one part of the life cycle, affording considerable advantages to the mosquito species. The vast array of different water habitats used for breeding decreases interaction and competition between different mosquito species.

FIGURE 1.1: MOSQUITO LIFE CYCLE



PART II : DEVELOPMENT AND BIOLOGY OF THE PRE-ADULT STAGES

THE EGG

Mosquitoes lay their eggs in batches. The number of eggs per batch is a characteristic of the species, and is modified by the size of the individual and the volume of the blood meal.

The fertilised eggs (ova) are surrounded by the vitelline membrane and encased in a strong covering (the chorion) whilst still within the mosquito ovary. The chorion consists of two layers, a thin, transparent outer layer (exochorion) and an inner endochorion. When first laid, the eggs are pale, but they darken as the endochorion hardens. The hardened endochorion and vitelline membrane give the egg resistance against desiccation in some species.

The period of the egg stage varies depending on the time needed for embryonic development of the larva and on the biological characteristics of the particular species, though it is usually only a few days.

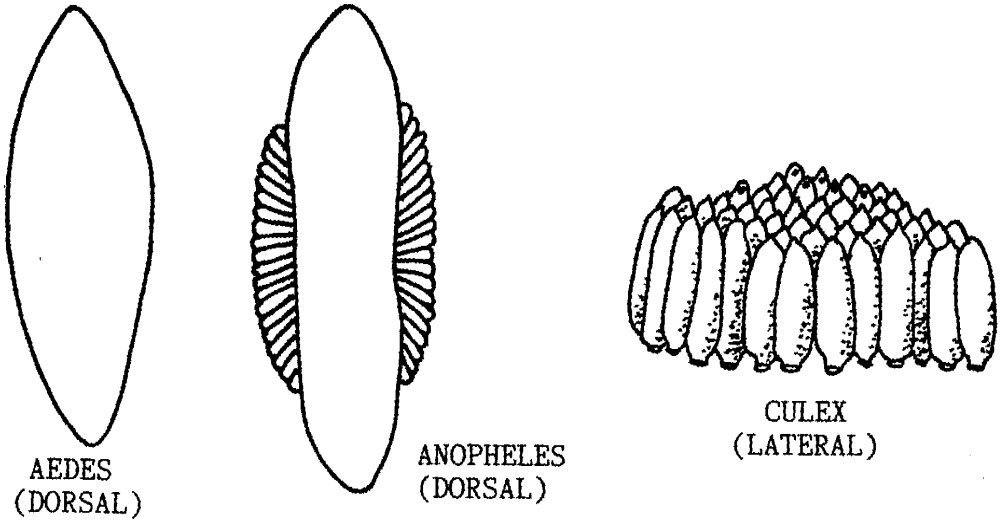
Under magnification the surface of the egg is sculptured, and this surface pattern has been used to identify species in some areas. This is not always practical as the eggs of some species are very difficult to locate and the eggs of many species are unknown. The physical appearance and biology of the eggs are characteristic of different genera (Figure 1.2).

Species of the genus *Anopheles* characteristically lay eggs singly on the surface of water bodies. The eggs are long and narrow (cigar shaped) with a fold of exochorion on each side forming a float. The eggs are prone to desiccation, and consequently, breeding is largely confined to more permanent water bodies.

The eggs of *Culex* species are laid in rafts of up to 200 eggs which float on the water surface. They are also prone to desiccation and breeding is usually confined to more permanent waters.

Mansonia and *Coquillettidia* species lay their eggs in small rafts on or under the surface of the water attached to the stems or leaves of plants. Species of the genus *Aedeomyia* also lay single eggs under the surface of the water, attached to filamentous algae. Breeding of these genera is dependent on the presence of particular plant associations, and is largely confined to the more permanent water bodies.

FIGURE 1.2: CHARACTERISTICS OF THE EGGS OF *AEDES, ANOPHELES* AND *CULEX*



Aedes and *Tripteroides* species lay their eggs singly on the damp edges of suitable breeding sites on the surface of the substrate or on vegetation. This has a twofold function. Firstly, the eggs need to be maintained at high humidity for a period of at least twenty four hours whilst the vitelline membrane and endochorion hardens, and desiccation resistance develops. Secondly, the dampness is an indication that the site is more likely to be inundated before surrounding areas, and is thus indicative of a prospective breeding site.

Aedes eggs are often resistant to desiccation and may survive for long periods before hatching. This resistance to desiccation has allowed the *Aedes* to take advantage of the very large number of temporary water bodies as breeding sites. There is great variability between species as to the degree to which the eggs can resist drying out.

In some species (e.g. all species of the subgenus *Finlaya)* the eggs are ready to hatch as soon as embryonic development is complete, and even short periods without flooding can be lethal for the eggs of some these species.

Others, however, have an obligatory diapause phase before the eggs are ready (primed) to hatch. Some members of the *Aedes (Ochlerotatus)* fall into this group. The priming of the eggs is thought to be related to

the day length, temperature and humidity regimes, though the exact mechanisms are not fully understood and probably vary between species. Subsequent flooding (by rain, flood or tide) will initiate hatching of the eggs, though the complex hatching stimuli are also not fully understood. One of the documented hatching stimuli is reduced oxygen concentration in the water.

A second important characteristic of *Aedes* eggs is that of delayed or staggered hatching. That is, not all the eggs will hatch on the first flooding and some will remain dormant. This trait is advantageous to species breeding in very temporary sites, as the water available on initial flooding may not persist for long enough to allow complete development to the adult stage. Delayed hatching would allow some viable eggs to remain to take advantage of subsequent inundations, and would be an important mechanism in preventing local extinction of the species.

BREEDING HABITATS

The habitats utilised by mosquitoes as breeding sites are very diverse. The exact breeding site for an individual species is chosen by the female when she deposits her eggs (oviposition site). The biological characteristics of the eggs (above) set the overall limits to the suitability of any potential breeding site for each species. There is, however, a vast array of possible breeding sites based on combinations of physical, chemical and biological characteristics. The female responds to a complexity of visual, olfactory, tactile and chemical stimuli in choosing an oviposition site. Each species has breeding sites which can be categorised, at least in a general manner.

TABLE 1.2: A CLASSIFICATION OF MOSQUITO BREEDING SITES

I : FRESHWATER SITES
- A) GROUND WATER
  - a) Natural habitats.
    - 1: Lakes - vegetated margins or floating vegetation.
    - 2: Streams - vegetated margins, isolated backwaters, pools, billabongs.
    - 3: Swamps.
    - 4: Ground pools - temporary and semi-permanent rain filled depressions, hoof prints, animal wallows.
    - 5: Rock pools - marginal or in beds of streams, hollows on rock outcrops - rain filled.
  - b) Man-made habitats
    - 1: Irrigation ditches, overflow, run-off.
    - 2: Dams - vegetated margins or floating vegetation.
    - 3: Excavations - borrow pits, roadside ditches, etc.
    - 4: Wheel ruts.
- B) CONTAINER WATER
  - a) Natural habitats
    - 1: Tree holes.
    - 2: Leaf axils.
    - 3: fruits, husks.
  - b) Man-made habitats
    - 1: Water tanks, animal drinking troughs.
    - 2: Discarded refuse - cans, tyres, car wrecks.
    - 3: Domestic containers - pot plant dishes, disused swimming pools and fish ponds, blocked gutters, etc.

II : POLLUTED WATERS
- 1: Sewage treatment plants and associated overflows or seepage.
- 2: Septic tanks and associated overflows or seepages.
- 3: Drains - urban and industrial.
- 4: Polluted ground water - e.g. seepage from garbage dumps.

III : BRACKISH WATERS
- 1: Tidal marshes or swamps.
- 2: Tidal reaches of river margins.

IV : SALINE WATERS
- 1: Coastal ground pools.
- 2: Rock holes in the splash zone.
- 3: Mangrove forest margins, crab holes.

An artificial classification of breeding sites based on a number of chemical, physical and biological properties is useful as a guide to determining the breeding preferences of particular species (Table 1.2). Such a classification is simplistic as other factors (shade cover, particular plant associations, levels of dissolved or suspended organic matter, detritus levels, predator diversity and density, temperature, pH, substrate quality, etc.) combine to present a great variety in possible breeding sites. It does, however, provide a broad framework and can be a useful guide in the evaluation of particular problems.

THE LARVA

Just as the genera could be characterised by the structure and biology of the eggs, larval structure and biology are also diagnostic. These are summarized in Table 1.3 and in Figure 1.3.

Species of the genus *Anopheles* have larvae with no siphon. They are usually found lying parallel to and feeding on the surface, diving to the bottom only when disturbed. This habit can be used to advantage by muddying the water so that the larvae at the surface are more obvious. The larvae of some species are associated with vegetation and dense shade, whilst others prefer sunlit conditions. Often, the larvae are found in the aggregations of small twigs and leaves which gather at the margins of a water body.

All *Anopheles* larvae have the ability to turn their head through 180 degrees, and usually feed on tiny particles suspended on the water surface. No *Anopheles* species have predatory larvae.

All genera and species of the tribe Culicini possess a siphon through which they breathe. In most cases, they hang from the surface suspended by the siphon, but generally spend less of their time at the surface, and also dive quickly if disturbed.

In *Culex* species, the siphon is generally long with several tufts of hairs on the ventral surface, whilst in *Aedes* the siphon is generally shorter with only one pair of ventral tufts. Some species feed whilst suspended at the water surface, whilst others feed in the mid and lower levels. *Aedes* species often graze on the surface of the substrate.

The genera *Mansonia* and *Coquillettidia* are very closely related *(Coquillettidia* was considered a subgenus of *Mansonia* for a long time), and the larvae of both genera have highly modified siphons. The siphon has become hardened, and forms a saw-like structure which is used to pierce the stems of plants, obtaining oxygen from within the plant tissues. The larvae are inactive and slow moving if dislodged. They are, however, very difficult to find in nature. The cryptic habits of the larvae affords them considerable protection from predators, as predators often rely on movement to find their prey.

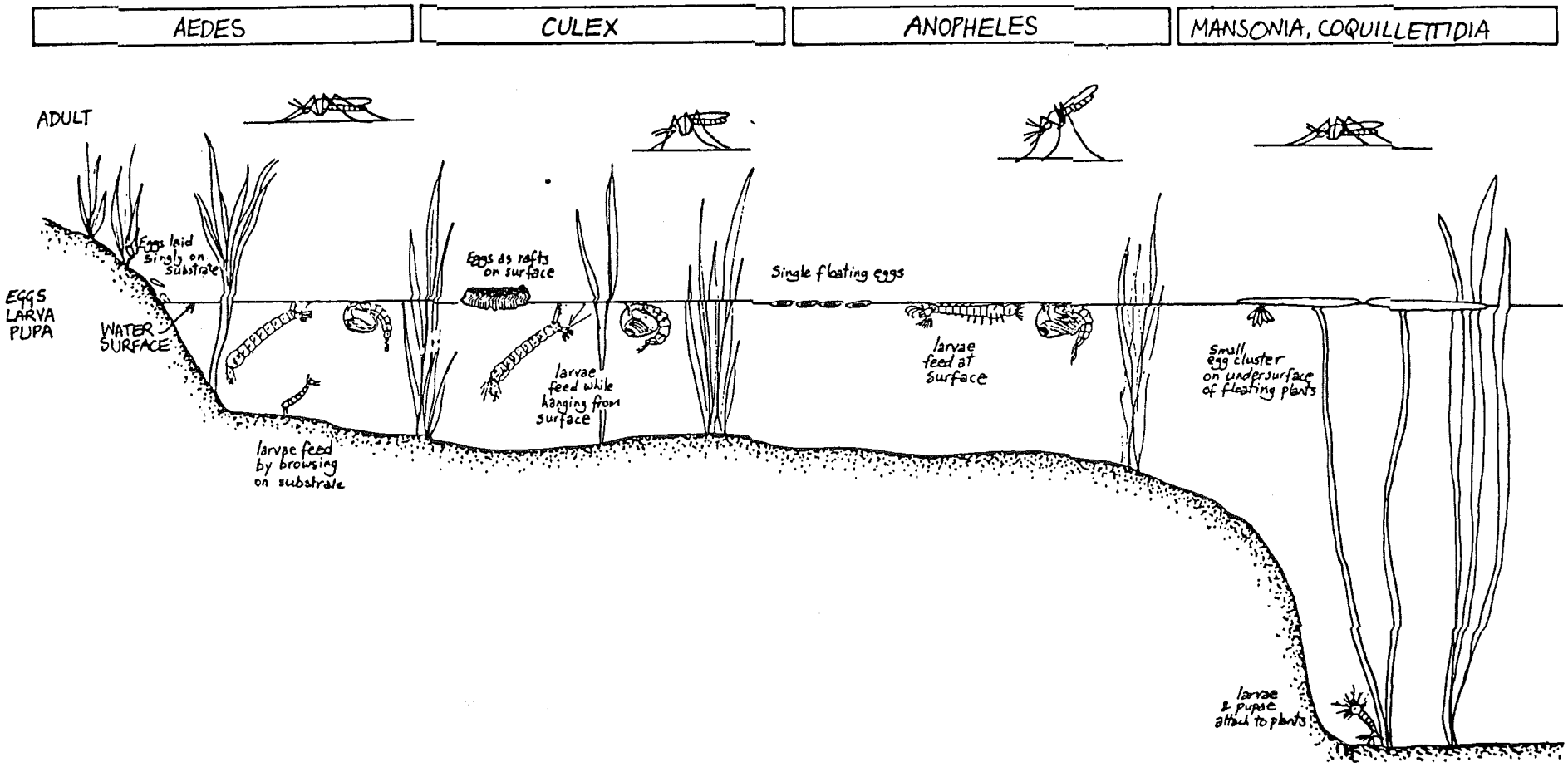
TABLE 1.3 : THE CHARACTERISTICS OF THE PRE-ADULT STAGES OF THE MAJOR MOSQUITO GENERA

GENUS	EGGS	LARVAE
AEDES	Eggs laid singly on damp soil or edges of breeding sites, may be resistant to desiccation.	Larvae hang from the water surface by siphon; single pair subventral siphon tufts near mid-point; feed on suspended matter or grazone on surface of substrate; some predatory species; dive when disturbed.
ANOPHELES	Eggs laid singly on water surface, each with lateral floats; can not resist desiccation.	Larvae have no siphon and lie parallel to water surface; feed on matter on water surface; dive when disturbed.
COQUILLETTIDIA	Eggs normally laid as small rafts on water surface.	Larvae have modified siphons; attach to plant stems and roots; cryptic and hard to find.
CULEX	Eggs normally laid in large rafts on the water surface; susceptible to desiccation.	Larvae hang from surface by siphon; siphon with several pairs of subventral tufts; dive when disturbed; some larvae predatory.

a) Feeding habits

Most mosquito species feed by filtering small particles of suspended food (microscopic plants or animals, organic detritus) from the water. Using rapid movements of the mouthparts, they create a current

FIGURE 1.3 : LARVAL BIOLOGY OF THE MAIN MOSQUITO GENERA



which draws the suspended food through the fine mouthbrushes, where it is trapped. The food is then passed to the mandibles and eaten. Food may be taken from all levels of the water (top, mid levels or the bottom) and even from the surface as in the *Anopheles* species. The mouthbrushes of species which filter-feed consist of very numerous fine hairs.

Some species browse for food trapped or growing on the substrate. The mouth- brushes of species with a browsing habit are shorter, more stout and slightly less numerous than those observed in the filter feeders. The browsing habit is characteristic of some *Aedes* species.

Some species are variable in mouthbrush structure. It is thought that the larvae of these species begin as filter feeders, but alter the structure of the mouthbrushes during a moult, and change to a browsing habit in response to a lack of sufficient suspended food particles.

Some larvae have become predators on the larvae of other mosquito species. These larvae are characterised by highly modified mouthbrushes which are reduced to a few strongly chitinised, curved bristles which are used to grasp the prey. In general, the larvae are large, slow moving and have a prolonged larval development time. Predatory larvae are characteristic of the following Australian genera *Culex (Lutzia), Aedes (Mucidus), Toxorhynchites, Tripteroides (Rachisoura).* Predatory behaviour is also found sporadically among *Aedes (Finlaya)* and *Uranotaenia* species.

b) Growth and development

The growth rate of the larvae is dependent on a number of factors, the most crucial of which are the temperature of the water, the density of larvae and the availability of food.

The biochemical metabolic processes of mosquito larvae are temperature dependent. They have an optimum temperature range, beyond which the metabolic processes are less efficient. Larval temperature is directly correlated to that of the habitat, and, within limits, growth rate generally increases with increased water temperature. The larvae can regulate their body temperature by seeking out and maintaining a position within the habitat which has the most optimal temperature (i.e. at the surface, the mid levels or at the bottom; shaded or sunlit areas).

Extremes in temperature can be lethal. The larvae can avoid high temperature extremes through behaviour as outlined above. In addition, larvae may acclimatise to gradual temperature changes. Often, if food is plentiful, the larvae can complete development despite reduced efficiency in their metabolic processes. The larvae may respond to some extremes by a metabolic shut down until the conditions for growth are more favourable. This is usually a response to low temperatures and has not been recorded in W.A. species.

Larval density affects growth rates in a number of ways. Laboratory experiments have shown that overcrowding can result in reduced viability, reduced size in emerging adults and decreased fecundity in the succeeding generation. The metabolites in the water can affect the wellbeing of other larvae in the habitat, and physical contacts between individual larvae can cause stress. Competition for food resources and positions at the surface are also factors leading to reduced growth rates.

The period of larval development is, in general, about five to seven days. It is much longer for predatory species and in those species which have their larval development during the colder winter period. In some circumstances, it may be reduced for some species which breed in food rich, but very transient habitats.

c) Osmoregulation

A major stress faced by mosquito larvae in the aquatic habitat is the maintenance of the correct concentrations of salts and proteins within their tissues against the osmotic pressures of the aqueous habitat. In general, most water bodies are either more concentrated in salts compared to the insect tissues, or less so, and there is a tendency for the concentrations to equalise. Rarely are the habitat and the larval tissues equal in salt concentration.

The nett effects of these differences are that in waters of higher salinity, there is a tendency for the water within the larvae to pass into the environment, and the salts to pass into the larvae in order to equalise concentrations. The opposite processes occur in waters of lesser salt concentration than the larval tissues. In either case, such changes would be lethal, and the larvae must maintain the correct internal balance through active pumping of salts and/or water.

The larvae have an impermeable outer skin or cuticle, and almost all water and salt exchange occurs across the external membranes of the anal gills. Some water is also taken in through the gut. The ability to maintain internal integrity in saline waters is a characteristic found in species of many genera (Table 1.4). The larvae of species which breed in saline waters can usually be recognised by the structure of the anal gills which are greatly reduced, often appearing only as four small hemispheres at the end of the anal segment. In freshwater species, the anal gills are nearly always long, at least half the length of the saddle.

TABLE 1.4 : A List of Australian Mosquitoes Breeding in Saline or Brackish waters.

Aedes (Halaedes) ashworthi
Aedes (Halaedes) australis
Aedes (Mucidus) alternans
Aedes (Ochlerotatus) camptorhynchus
Aedes (Ochlerotatus) vigilax
Aedes (Rhinoskusea) longirostris
Aedes (Verrallina) funereus
Aedes (?) daliensis

Anopheles (Cellia) farauti
Anopheles (Cellia) hilli

Culex (Culex) sitiens
Culex (Lutzia) halifaxii

Uranotaenia (Uranotaenia) lateralis

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d) Predators and pathogens

Mosquito larvae are predated upon by a large number of aquatic species, and suffer from a number of parasitic and other pathogenic infections. A great deal of study has been undertaken of both predators and particularly the pathogens as these provide the potential control and management tools which are specific for the mosquito.

The most obvious of the vertebrate predators are fish. The mosquito fish *(Gambusia affinis)* has been widely distributed throughout the world for mosquito control. This species is very common in the permanent inland and estuarine waters of the south west of W.A., but has had a severe adverse impact on the native fauna of these water bodies. Recently, attention has turned to species occupying similar ecological niches, but which are less aggressive and have less impact on the local ecology. Australian native fish species have also been examined and one group, the sunfishes or rainbow fish which occur in the northern rivers, is an efficient agent for control within its natural range.

A large number of predatory species also occur among invertebrates. I have already mentioned that the larvae of some mosquito species are very efficient predators. Other predatory groups include Platyhelminths (flatworms) [especially the *Planaria],* Hemiptera (true bugs) [particularly Notonectidae], Coleoptera (beetles) [Dytiscidae], and the aquatic stages of the Odonata (dragonflies).

Pathogens of mosquito larvae range from micro-organisms such as viruses, bacteria, and fungi through to larger organisms such as nematodes. Plant species also play a part in larval mosquito destruction through the exudation of toxins (e.g. *Chara* spp. and *Nitella* spp.), and bacterial toxins are currently being used as commercially available control agents (e.g. *Bacillus thuringiensis* var. *israelensis* [B.t.i.]).

THE PUPA

The pupal stage has been mentioned in passing in the description of the general life cycle of the mosquito. The pupa is a non-growing, non-feeding stage necessary for the larval tissues to be reorganised into the adult configuration. The energy resources of the pupa come from stored nutrients (in the fat body) saved during the larval stage.

Mosquito pupae are characteristically 'comma' shaped, and rest at the surface of the water, suspended by the trumpets or breathing organs. The pupae will dive if disturbed with a characteristic tumbling motion. However, the pupae retain trapped air for buoyancy, and so rise to the surface, and must actively swim in order to remain submerged.

The exceptions to this rule are the pupae of the genera *Coquillettidia* and *Mansonia*, which attach to the submerged stems and roots of aquatic plants using modified trumpets. As with the larval stages of these genera, the pupae are cryptic and very difficult to locate. The pupae release from the plants and float to the surface when the adults are ready to emerge.

In general, the pupal stage lasts about 3-4 days, though this may be extended in some species. In practice, it is easy to determine when a pupa is ready for the adult to emerge as the pupa darkens markedly.

The next chapter deals with the biology of the adult after it emerges from the pupa.

CHAPTER 2 : THE BIOLOGY OF THE ADULT STAGE

In the previous chapter, we saw how the general biological features and structure of the pre-adult stages were characteristic of each of the main genera. The same is true of the adult stage. Adults of the Anophelini are slender, delicate flies which have palps as long as the proboscis in both sexes. In addition, the body of the Anopheline is usually inclined at a steep angle to the surface when resting (Figure 2.1). Species of the Culicini, on the other hand, are slightly more robust. The female palps are generally much shorter than the proboscis (up to two thirds), and the body is usually held parallel to the surface when resting. In males, the palps are markedly club shaped and longer than the proboscis (Figure 2.1).

Mosquitoes are sexually dimorphic. Apart from the structure of the palps, males have characteristic genitalia with large lateral claspers; and bushy antennae. The females generally have only very short processes (cerci) visible at the end of the abdomen or none at all; and the antennae have fine hairs, but are not bushy in appearance. The presence of long clubbed palps and bushy antennae is visible to the naked eye, and sexing of adults is very easy.

ADULT CYCLE

The main function of the larval stage is to obtain nutrients and grow to develop into adults. The main function of the adult stage is to reproduce, and ensure the survival of the species through time.

On emergence from the pupa, the adult remains on the surface of the water for a short period whilst its cuticle hardens before it can fly away. It then seeks out a sheltered resting place. The first meal after emergence is often of nectar or plant juices. The females then mate, and seek a blood meal. Usually, oviposition occurs some 2-3 days later, and the female then seeks out a further blood meal, sometimes with a day's rest between oviposition and feeding. This cycle of blood meal, 2-3 days for egg maturation, oviposition and new blood meal continues for the remainder of the life of the female.

What follows is a general discussion of some aspects of the behaviour of mosquitoes, particularly as this relates to species survival, and to the potential for pest or vector status.

a) Emergence

Once the metamorphosis process within the pupa is complete, the pupa splits along the dorsal surface, and the adult, using air as a pump mechanism, emerges from this split. The adult must then wait for its cuticle to harden before it can fly away.

In general, the males complete their larval development shortly before females, and most will have emerged and dispersed by the time the females start emerging. Some species, which have synchronous hatching (e.g. flood water or tidal *Aedes* species) also have synchronous emergence of adults, and this is sometimes accompanied by mass migration flights.

b) Mating

The specific details of mating behaviour of most mosquito species is not known. For those species for which data are available, it usually occurs in special mating swarms. The males congregate around a visual marker (a log, rock, post, tree or even over bare ground) and begin swarming, usually for a short period around dusk. The changing light intensity at dusk is a major stimulus for swarming activity. Swarming may take place over the same marker each night, or the marker may change daily. The size and duration of swarming is variable. The swarm may contain only one male, or may be several hundred individuals and may last from a few minutes to about an hour.

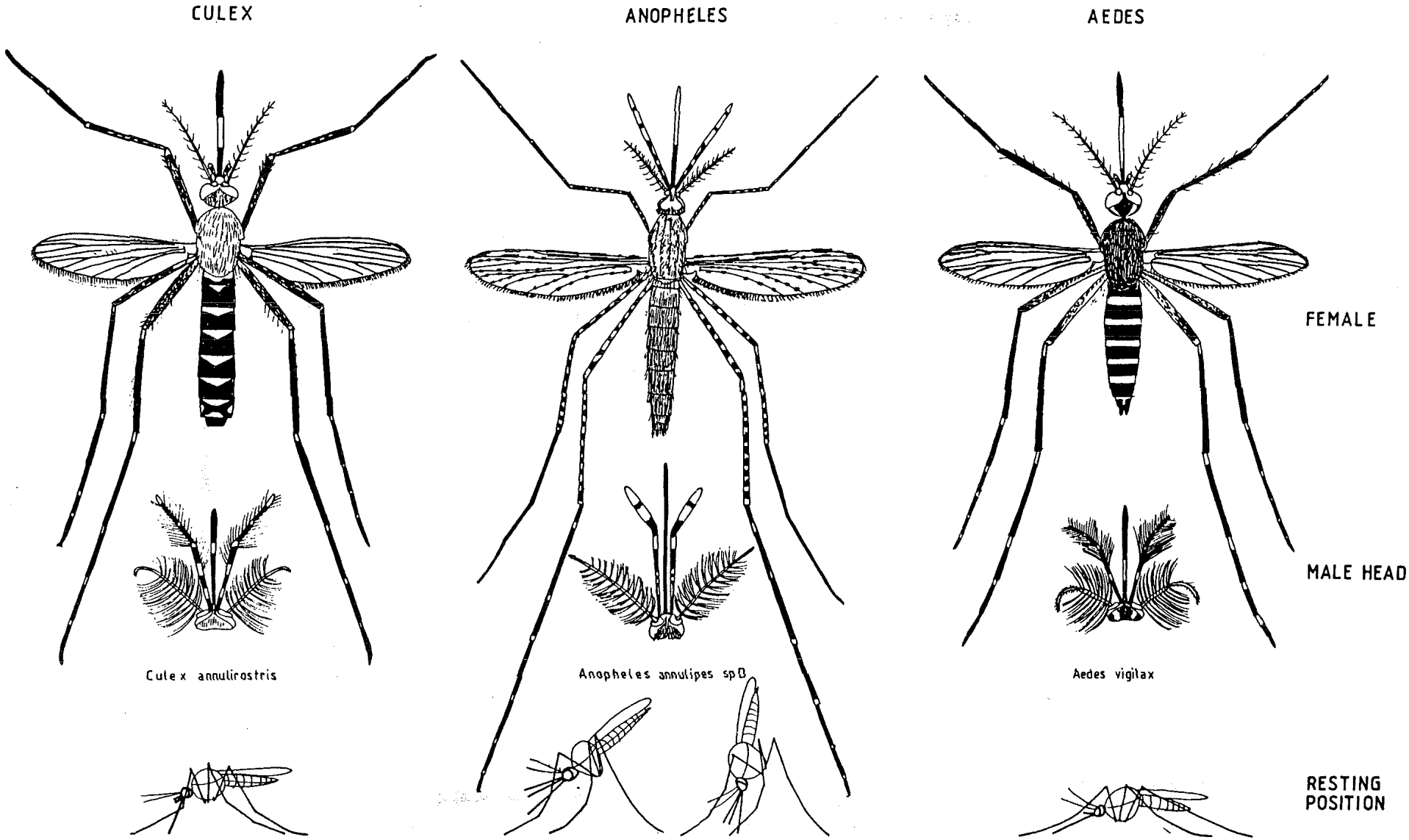
The females are attracted to the swarm, and pairing occurs either within the swarm itself, or when males detach from the swarm to pair with the female. Copulation then takes place. It has long been thought that mosquitoes mate only once. There is evidence of a mating plug being secreted by the successful male, and though the female may copulate again, insemination does not take place. The female stores the sperm in special organs (the spermathecae) situated in the terminal segments of the abdomen, and this store is used to fertilise the eggs as they pass out of the female during oviposition.

There is an age factor in the preparedness of the adults for mating. Generally, the female must be from 24 to 48 hours old before she is receptive and able to mate. Males must also be at least 24 hours old before they can join in the swarming activity. This is because the last segment of the abdomen (segment VIII) must rotate through 180 degrees so that the genitalia are presented correctly for union with the female.

c) Feeding behaviour and egg development

Mosquitoes feed for two reasons. The first is to obtain energy resources to ensure survival. Most feeds taken for this purpose are from plant fluids containing mainly sugars and starches. When the female is producing an egg batch, however, she requires a food source rich in proteins and obtains this by seeking out a blood meal. Males feed exclusively on plant juices.

FIGURE 2.1 : GENERAL CHARACTERISTICS OF THE ADULTS OF THE MAIN MOSQUITO GENERA



There are exceptions, however, and these are worth mentioning. The female of *Malaya genurostris* obtains nutrients exuded by ants. Both males and females of the genus *Toxorhynchites* feed exclusively on plant fluids.

Some species, living in very nutrient rich habitats, have the ability to store sufficient reserves during larval development to allow the maturation of one small egg batch after emergence. The maturation of subsequent egg batches requires a blood meal. This capacity to develop a primary egg batch without taking a blood meal is called autogeny. Autogenous egg maturation has been confirmed in three species from W.A.; *Aedes vigilax, Anopheles hilli* and *Culex molestus.*

Each mosquito species has a characteristic range of vertebrates which it selects when taking blood meals (the host range). For some, the host range is very restricted. For example, some *Uranotaenia* feed mainly on frogs and other amphibia. Other species feed mainly on birds or on particular mammalian groups. Others have broad host ranges and will feed on whatever hosts are available. The host range is an important factor in determining the potential of each species as a vector or pest.

Host seeking behaviour of female mosquitoes has been investigated in some detail, and a variety of factors has been shown to affect the attraction of females to potential blood sources. These include features such as overall size, shape, colour, moisture and temperature. Long range attractants are generally chemical, and the mosquitoes find potential blood hosts by seeking concentration gradients of these attractants, and following them upwind to the source. Carbon dioxide is a particularly important long range attractant (it constitutes the major component of the breath exhaled by animals). In the immediate vicinity of the potential host, other more complex visual, olfactory, chemical and tactile stimuli determine whether the female will initiate feeding. The sense organs which control the initiation of probing are located on the females antennae and palps.

Each species can be characterised by its feeding behaviour. The daily pattern of biting times is usually species characteristic. In general, a species feeds at the same period each day (e.g. at dusk or dawn - a crepuscular biting pattern; through the day - a diurnal biting pattern; mid-evening and through the night - a nocturnal biting pattern), though most species will feed at any time if conditions (light, humidity) are suitable.

Those species feeding mainly on avian hosts will be more active high above the ground in among the branches of trees where they are more likely to encounter birds. Those with a preference for mammalian blood sources will be active closer to the ground. Whilst each species has a preferred height for feeding activity, it will ascend or descend to available hosts in the absence of hosts at the preferred height.

The female, having located a suitable host, positions herself on the surface of the skin and begins probing. The mouth parts have a small saw-like structure at the tip of the mandibles which saws its way into the skin in search of blood. If the proboscis reaches a capillary, blood flow is fast and feeding is completed quite quickly. If a capillary is not encountered, the saw-like structure may be used to cause a small injury, and the blood which pools in this wound will be ingested. The mosquito injects some saliva containing an anti-coagulant into the wound to prevent the blood from clotting and to facilitate blood flow. It is this injection of saliva which is so crucial to the insect's role as a vector (as the disease agent, virus or parasite, is injected with the saliva) and is also the cause of the painful reaction seen in some people.

Some species feed almost always out of doors (exophilic species). Others will readily enter houses and feed there (endophilic species). Endophily and anthropophily (a marked preference for man as a blood host) are important for the efficient transmission of some specifically human diseases.

d) Oviposition

Having obtained a blood meal, the female then seeks out a suitable resting site whilst her eggs mature. Some females may require two feeds to mature their first egg batch, but will produce an egg batch following each subsequent feed. The development of the eggs normally takes from 48 to 72 hours, depending on the prevailing environmental conditions - mainly temperature. The female then leaves the resting site to seek a suitable oviposition site.

The female seeks out suitable oviposition sites which have the correct combinations of physical, chemical and biological parameters. The female will retain the eggs and continue searching until a suitable oviposition site is found, though the viability of the eggs reduces greatly with the length of time which they are retained.

As we have already seen in the previous chapter, the breeding habitats chosen by each species can be restricted, and are the result of the choice of oviposition site by the female. However, the larvae of many species are capable of completing their development over a wider range of habitat conditions than those in which they naturally occur. The females characteristically test the water to determine its suitability as a breeding site. In some species, the presence of eggs or larvae of the same species will enhance the suitability of the site. Oviposition pheromones have been isolated from the eggs of *Culex tarsalis* in the U.S.A.

e) Daily activity patterns

Mosquitoes are relatively small and susceptible to adverse environmental conditions. They avoid the most stressful conditions of the environment by seeking out humid, sheltered resting sites with favourable microclimates. Activity is timed to coincide with the most favourable part of the day, e.g. in the mornings and evenings or at night, when humidity and temperature are most favourable. The actual resting sites selected by mosquitoes are diverse, ranging from animal burrows or the man-made equivalents (culverts, drains), to rock scree, or to particular vegetation associations. For crepuscular species, activity is triggered by the rapid changes in light intensity at dawn and dusk.

Other species are more robust, and are active mainly through the day (diurnal species). Diurnal species are more common in the cooler climates of southern Australia where the day time temperatures are more suitable for mosquito activity than the cold evenings and nights. There are, however, a number of species in the arid zone and the tropics which also have diurnal activity patterns.

f) Dispersal

Mosquitoes disperse from their breeding grounds in search of both possible blood meal hosts and new breeding sites. This flight is quite active, and usually occurs at dawn and dusk.

The mean dispersal range is also characteristic of individual mosquito species. Some species will not disperse far from the breeding site (e.g. *Mansonia uniformis)* whilst others move for very long distances. *Ae vigilax* will fly for distances in excess of 80 km from the nearest breeding site. For most species, the dispersal range is in the vicinity of 5-10 km.

g) Longevity

Mosquitoes are relatively short lived. Some estimates indicate that the daily mortality could be as high as 20%, and some evidence suggests that mortality rates increase with the age of the insect. If daily mortality is 20%, slightly more than 60% of emerging adults will survive to take their first blood meal. The major factors affecting survival are climatic, e.g. temperature, humidity, and wind.

The males generally have much shorter lifespans than the females, though exact measurements of the longevity are not available. Longevity in females has been analysed in some detail as this is crucial to the transmission of disease (see Chapter 3). Techniques have been developed which allow the age grading of the females by determining the number of egg batches which the female has laid. In general terms, a mosquito which survives for three to four weeks after emergence can be considered to be 'old'.

h) Annual patterns of activity

Most mosquito species are active for only a part of the year. In many cases, the seasonal abundance is a reflection of the availability of the breeding grounds. For example, species breeding in tree holes will be active only when the rains fill the tree holes. The same is true for species which breed in sites which are present for only a brief period in the year. Salt marsh breeders can be active for only the few months when the high tides inundate the breeding grounds without the sites being diluted or flushed out by rainfall. Species which are dependent on particular associations of plant growth in the breeding habitat are active only when these conditions are met.

Overriding environmental factors, particularly temperature regimes, will also affect activity patterns. In Australia, some *Culex* species overwinter as adults to overcome the cold winter conditions, becoming active again in the spring when warmer conditions return.

In some desert species, the adults from a successful breeding cycle may become dormant, awaiting the onset of rains to become active again, seeking out blood meals so that they can successfully breed in the ephemeral waters created by rain. Activity in these species is often triggered by the sudden rise in humidity preceding local rainfall.

This discussion has canvassed many aspects of the biology of adult mosquitoes, and it is clear that the unique combination of behavioural and physiological characteristics of a particular species is crucial to its potential to be a pest or vector of disease. In the next chapter, the characteristics of pest and vector mosquitoes are discussed in more detail.

CHAPTER 3: MOSQUITOES AND MAN - GENERAL CHARACTERISTICS OF MOSQUITOES AS PESTS AND VECTORS OF DISEASE

The impact of mosquitoes on man is a result of the female mosquito's need to take sequential blood meals for production of successive egg batches. This allows some mosquito species to be either pests or vectors of disease.

There are many characteristics (biological and behavioural) which determine the capacity of any species to be a pest or vector. Some of these characteristics are common to both groups (pests and vectors). The following discussion is divided into two sections. The first looks at the main characteristics of pest species. An analysis of the dynamics of vector-borne diseases follows.

PART I : MOSQUITOES AS PESTS

GENERAL CHARACTERISTICS OF PEST SPECIES

The potential of a species to be a pest can be summarised as being a measure of the degree of contact between man and the species in question. This contact is the product of a number of different biological traits.

a) Feeding preference

The most obvious and important characteristic for a pest species is that it bites man, using man as a general or preferred blood meal host. Species which rarely bite man are unlikely to be pests. In unusual circumstances, where their preferred blood source is unavailable, or where populations are extremely high, such species may in fact become transient local pests.

b) Population size

The mosquito population generally has to be quite large for the numbers biting to be sufficient to cause discomfort. This can result from influx of large numbers of insects from the surrounding environment, or from local domestic breeding. Domestic species, even though they may have relatively small populations, may be highly significant pests because of the degree of contact between insect and man.

c) Dispersal characteristics

Those species with strong dispersal capabilities may be responsible for significant pest infestations, even though breeding grounds are quite distant. On the other hand, those with very low dispersal capacity usually have to breed in close juxtaposition to human habitation, work or recreation areas to have a similar impact.

d) Biting behaviour and seasonal prevalence

Factors such as the biting periodicity, and seasonal prevalence of the mosquito species can also contribute to its pest status. The most significant impact occurs from crepuscular species, as their biting activity coincides with much of the evening outdoor leisure activity enjoyed by people in warmer weather. Those feeding indoors can be a very significant nuisance, even when populations are quite low. The seasonal prevalence simply means that those species with large populations in the spring and summer months, when people are active out of doors, are more likely to be significant pests than are species which are prevalent in winter.

e) Reactions to bites

Individual people react differently to the bites of different mosquito species. Equally, different individuals will show different reactions to the bite of the same mosquito. These differences in reaction are the result of a combination of factors which are not fully understood. Some factors are the immune response of the blood host against the antigenic properties of the mosquito saliva; the degree of exposure through time; the number of bites received at any one time; the age of the mosquito; the age and sex of the person being bitten; the sensitisation of the host to the bite of the particular species; and the tolerance of the people being bitten.

The importance of any species as a pest is ultimately the result of a combination of factors which determine the actual attack rate on man, modified by the tolerance of the population as a whole to the bites of the mosquito species in question.

PEST SPECIES IN WESTERN AUSTRALIA

When looking at pest mosquito infestations, it becomes clear that the potential problems at any given site will depend on the types of breeding grounds in the immediate vicinity of the human population.

Where there are coastal wetlands which have some tidal influences, the summer species *Aedes vigilax* can be a major problem following high spring tides. In the southern parts of the State, these sites are also used by *Aedes camptorhynchus*, which is also a major pest during the cooler months of the year.

Permanent reed swamps or wetlands with emergent vegetation also produce significant pest populations. In the south, *Coquillettidia linealis* and *Culex annulirostris* can be significant pests during the summer months, whilst in the north, *Anopheles bancroftii, Coquillettidia xanthogaster, Culex annulirostris* and *Mansonia uniformis* are significant pests in some areas.

Domestic breeding pest species include *Aedes notoscriptus, Culex annulirostris* and *Culex quinquefasciatus* (formerly known as *Culexfatigans).* In addition, *Aedes tremulus* can be a minor pest in the north.

The above pest species can be characterised as having regular, predictable seasonal activity. This is due to the predictable occurrence or suitability of the preferred breeding sites either due to seasonal rainfall, warm weather or high tides.

There is another group of species which is an erratic seasonal pest. These are the temporary ground pool breeding *Aedes* species, particularly those belonging to the subgenus *Ochlerotatus*. The populations of these mosquito species can reach enormous proportions following rains and, even if only for very short periods, can be very significant pests. Examples of these are *Aedes (Ochlerotatus) sagax* in the south and *Aedes (Ochlerotatus) normanensis, Aedes (Ochlerolatus) pseudonormanensis* and *Aedes (Pseudoskusea) bancroftians* in the semi-arid tropics. Other species (e.g. *Aedes (Ochlerotatus) vittiger* and *Aedes (Verrallina)funereus)* are recognised pests elsewhere in Australia, but have restricted distributions in W.A., generally away from population centres.

PART II : VECTOR BORNE DISEASE

Mosquitoes can act as vectors of disease because the adult female will seek out repeated blood meals to mature successive egg batches throughout her life. As such, she may pick up an infectious agent in an early blood meal and, after the elapse of any time needed for the development of the pathogen, pass it on in subsequent blood feeds. Obviously the situation is more complex than this simple statement suggests.

Ultimately, the vector capability of any species is the product of its innate capacity to support development of the pathogen, the selectivity of the pathogen with respect to vertebrate host range and the degree of contact between the vector and the respective susceptible host. Those biological attributes discussed above for pest species are crucial in determining the vector/host contact.

The following discussion of the biology of vector-borne diseases will focus on some of the strategies employed for maintenance of transmission cycles. There are two main forms of disease transmission by insects.

MECHANICAL TRANSMISSION

The first is purely 'mechanical', where the mosquito acts as a flying pin, transferring the disease from one blood host to the next by infectious material adhering to the proboscis. In this case, the mosquito has to probe on two hosts in fairly quick succession (as in disrupted feeds) because the pathogen is usually not able to survive for long periods on the proboscis of the insect. An example of this type of transmission is the role that mosquitoes play in the spread of Myxomatosis in rabbits. Unless the insect vector is very closely associated with the vertebrate, and the pathogen is found in exceedingly high concentration, this is a rather inefficient form of transmission, and is at best, a relatively minor factor in the dissemination and maintenance of diseases. There has been some discussion about possible mechanical transmission of AIDS by mosquitoes or other biting insects. The AIDS virus is found at such low concentrations in the blood of infected persons that mechanical transmission is virtually not possible.

BIOLOGICAL TRANSMISSION

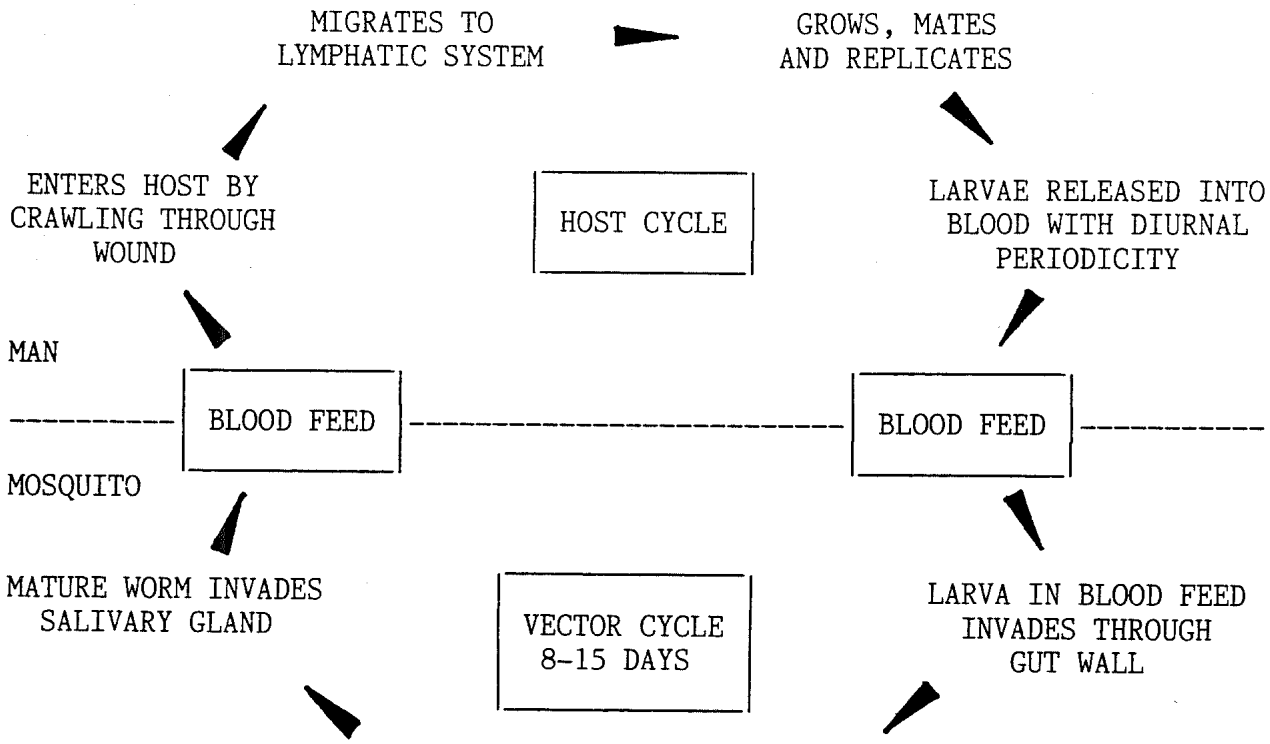
The second form of transmission is termed 'biological transmission' and is characterised by the pathogen undergoing replication or development within the vector. This form of transmission is characterised by a great degree of co-adaptation between the vector, host and pathogen and is therefore much more efficient than mechanical transmission. Most disease agents which are transmitted by biting insects to man or his domestic animals fall into this group.

Biological transmission can be further divided into several classes depending on the fate of the pathogen within the insect. The three main types of disease which are, or have been (historically), important as human diseases in Australia are examples of the three types of biological transmission.

a) Filariasis

'Cyclo-developmental' transmission occurs where the pathogen undergoes some developmental changes but no replication within the vector. The filarial worms are examples of this type of life cycle. The worms are usually host species specific and infection of alternative hosts is usually abortive. The cycle of the human filaria is shown in Figure 3.1.

FIGURE 3.1 : THE TRANSMISSION CYCLE OF THE HUMAN FILARIAL PARASITE



The sexually mature filarial worms mate and breed within the tissues of the vertebrate host, liberating the asexual microfilariae into the blood stream usually with characteristic diurnal periodicity (coinciding with the peak feeding times of the vector). Within the vector, the microfilariae invade through the gut wall and undergo a series of moults within selected tissues (muscle, malpighian tubules). When development is complete, the larval worms migrate to the head and invade the salivary glands. From here they migrate to the sheath of the proboscis. When the mosquito next feeds, the worms crawl out of the proboscis, and enter the host through a skin lesion, often that left by the mosquito when feeding.

Filarial worms, in their development within the mosquito cause a great deal of damage. If the microfilarial load is high, it is likely that the vector will die before development is complete. Therefore, vector populations must be quite high to sustain transmission.

Once infected with the filarial parasite, the vertebrate retains the infection for a prolonged period, unless treatment with an anti-filarial drug is given. Thus the parasite may survive without the presence of the vector for prolonged periods within the vertebrate host.

Human filariasis was historically an important disease in Australia, particularly in Queensland, but has not been active for many years, despite the presence of suitable vectors *(Culex annulirostris, Culex quinquefasciatus).*

Another filarial disease is still prevalent. *Dirofilaria immitis* (heart worm of dogs) is a very common infection in many localities in Australia. There are many mosquito vectors for this disease, among the most prevalent being *Cx. annulirostris, Aedes vigilax* and *Aedes notoscriptus*. Human infection with *Dirofilaria immitis* can result in skin and lung lesions with the lung infections often accompanied by cyst formation. This disease is assuming greater significance and appears to be increasing in prevalence in most centres in Australia.

b) Malaria

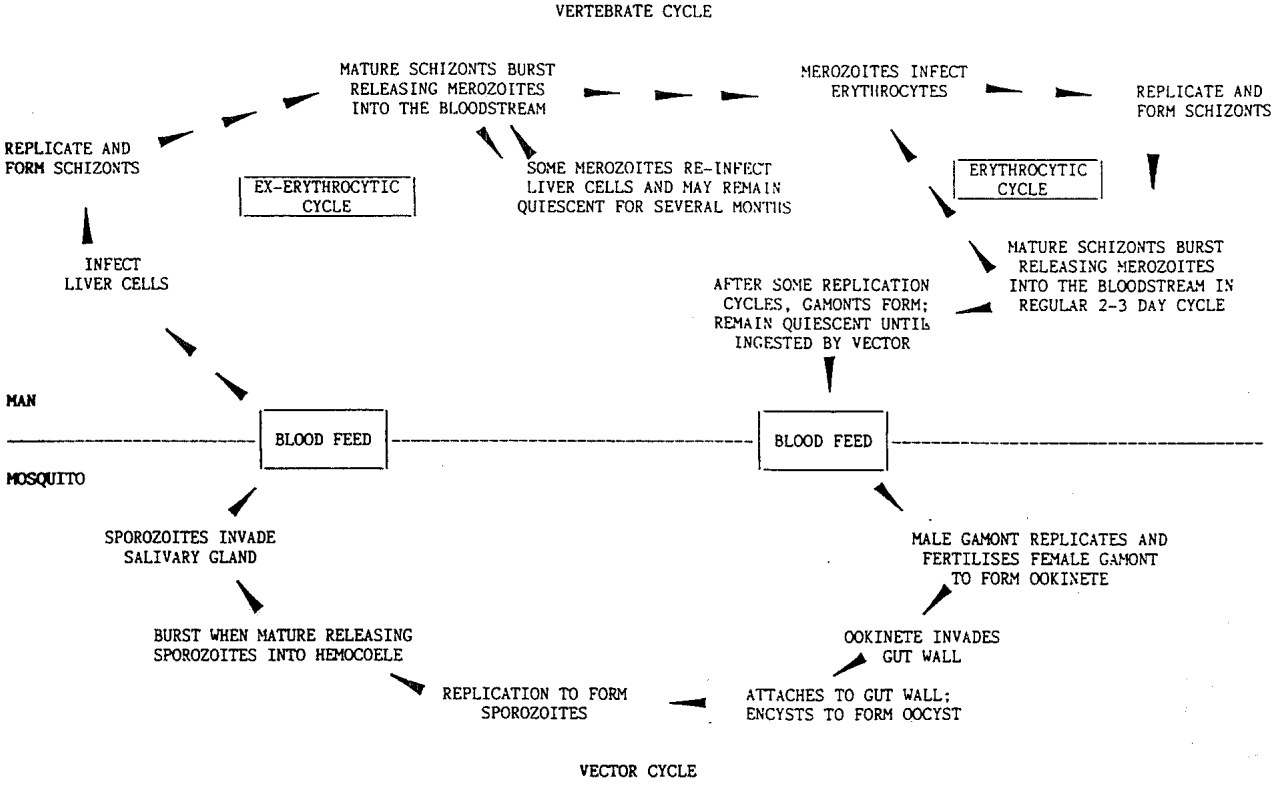
A second type of cycle is the 'cyclo-propogative' transmission cycle and is typified by the malaria parasites *(Plasmodium* species). These parasites undergo a developmental change and then replicate to form the infective stages for transmission by the vector. The malaria life cycle is shown in Figure 3.2.

Malaria parasites are vertebrate host specific. The avian malaria parasites are transmitted by Culicine species. The *Plasmodium* species which infect man are all transmitted by *Anopheles* species. The ability to biologically support the transmission of the human *Plasmodia* is a characteristic of this genus, though the actual vector potential varies with the biology and behaviour of the particular species. There are three species of *Plasmodium* which cause malaria in man: *P. falciparum, P. vivax* and *P. malariae.* A fourth species *(P. ovale)* is restricted to West Africa.

When malaria parasites (sporozoites) are injected into the blood of a man by the bite of an infective vector, they migrate to the liver and form a stage known as schizonts. When mature, the schizonts burst releasing large numbers of merozoites into the blood stream. Some merozoites reinfect liver cells where they can remain quiescent for many months. This part of the cycle is known as the ex-erythrocytic stage.

The erythrocytic stage begins when some of the merozoites attach to the red blood cells (erythrocytes) and again mature into schizonts, which burst synchronously, releasing protein into the bloodstream and causing the typical relapsing malarial fever. Parasite loads may be as high as 100,000 parasites per cubic millimetre of blood. After some generations, the parasites form gametocytes in the red cells. The gametocytes remain quiescent until ingested by the vector in a blood meal.

FIGURE 3.2 : A GENERALISED MALARIA LIFE CYCLE



In the gut of the vector, the female gametocyte forms a spherical macrogamete which is fertilised by the microgametes released from the male gametocyte. The fertilised macrogamete is known as an ookinete. The ookinete invades the gut wall of the vector and replicates forming thousands of sporozoites. These are released when mature and invade the salivary glands, and are passed on to subsequent blood hosts in the saliva. The infectivity of the vector does not diminish for the remainder of its life. The development cycle within the vector takes place over a number of days, the actual period being dependent on both the vector species and the malaria species. The malaria parasite and the vector appear to be well adapted to each other as there is no discernible adverse effect of parasites on the vector.

As for the filarial worms, some malaria species can survive as a latent infection in man for a prolonged period without the presence of the vector.

The main features of efficient malaria vectors are that they feed preferentially on man. In malarious countries, the major vectors are most often endophillic.

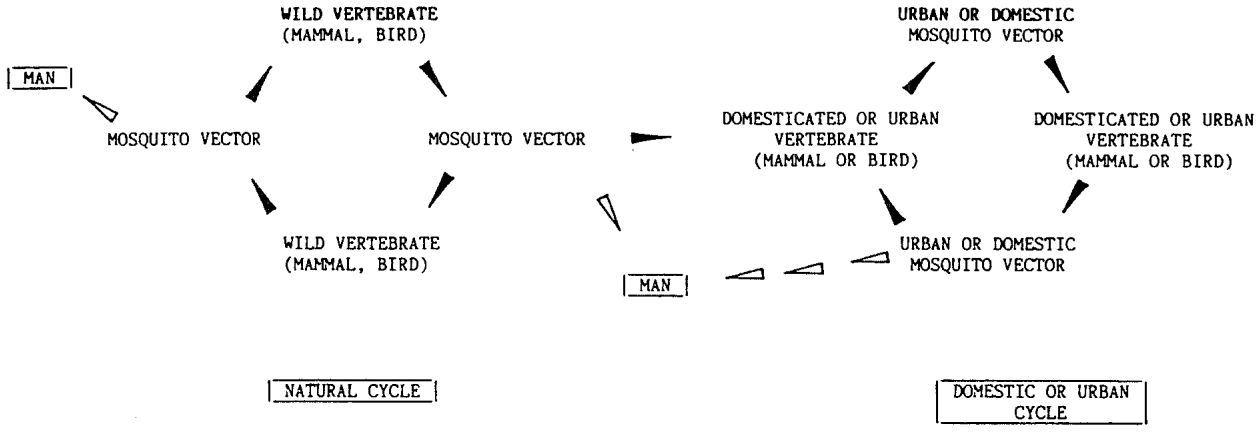
c) Arboviruses

'Propogative' transmission occurs where the pathogen simply undergoes multiplication within the vector before it can be transmitted. The arboviruses are an example of this type of transmission. The arboviruses are the most widespread and common of all the vector-borne diseases in Australia. They generally survive through transmission cycles involving wild mammals or birds and mosquitoes. In some circumstances, transmission cycles can emerge which utilise domesticated animals and urban mosquito species (urban transmission) (Figure 3.3). Man appears to be an incidental host in most instances. One exception is dengue virus, as man is the only host in Australia.

The arbovirus cycle can be briefly summarised as follows. The virus is passed on to a vertebrate by the bite of a vector. Within a short time the virus replicates near the site of the initial bite and spreads through the vertebrate, infecting all tissues. Many viruses have particular affinity for certain tissues (e.g. muscle, nervous tissue, the brain). During this phase, each successive replication cycle results in the liberation of large numbers of virus particles into the bloodstream. The period when the virus is found in the peripheral bloodstream is termed 'viraemia'. As the infection progresses, the vertebrate responds by initiating an immune response and forming specific antibodies. These antibodies eventually neutralise all the viral particles in the bloodstream, effectively ending the spread of infection and leading to recovery. The viraemia may or may not be accompanied by overt disease symptoms. Any vertebrate which recovers from the viraemia will retain life-long immunity against the virus, and can play no further part in the transmission or maintenance of that particular virus. Continued transmission is therefore dependent on the influx or recruitment of susceptible vertebrates.

During the viraemic phase, any mosquitoes feeding on the vertebrate will ingest virus particles with the blood. If the virus particles can infect the mosquito through the gut, it will begin replication. It should be noted that many mosquito species will not support the replication of particular arboviruses. Eventually, after a period of about ten days, the virus concentration within the mosquito will be sufficient for the infection of the salivary glands. Once the critical concentration of virus within the salivary glands has been reached, the virus will be shed in the saliva to subsequent blood meal hosts for the remainder of the vector mosquitoes life. The period between first ingestion of the virus and when it may be transmitted is termed the extrinsic incubation period.

FIGURE 3.3 : ARBOVIRUS TRANSMISSION CYCLES



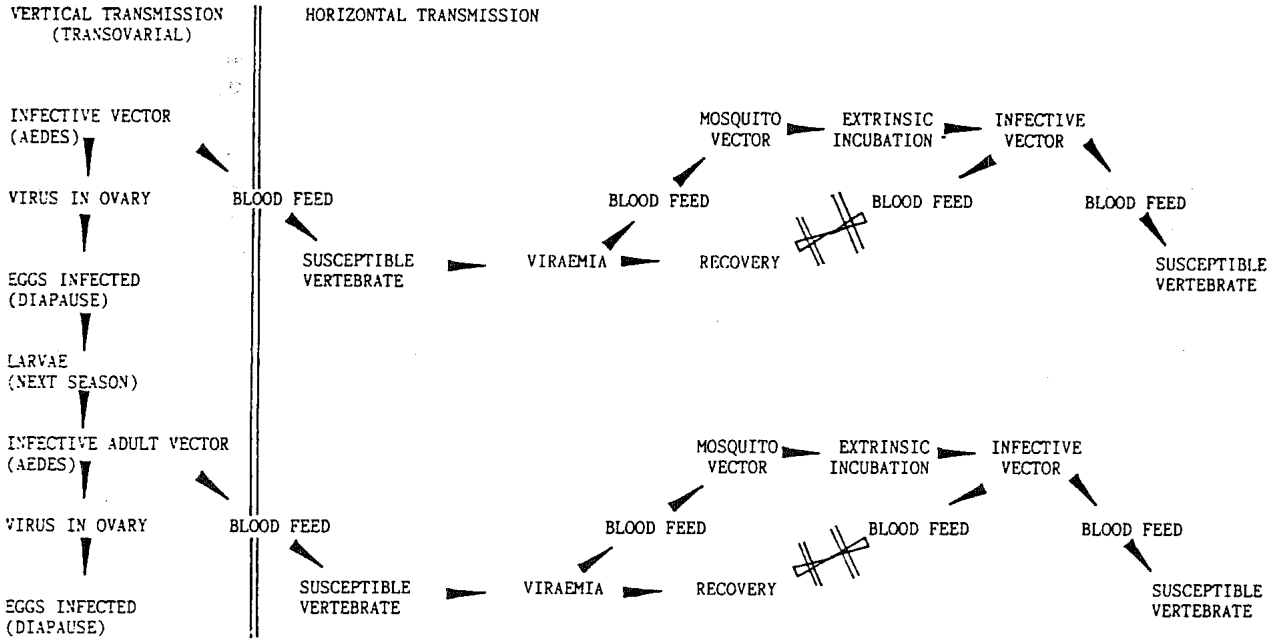
This mode of transmission, from vector to vertebrate to vector and so on, is termed 'horizontal transmission'. A second form of transmission occurs where the infective female passes the virus directly to its offspring via the ovary. Thus the virus passes from one generation to the next and this mode of transmission is termed 'vertical' or 'transovarial' (TOT) transmission. TOT has been well known for tick-borne arboviruses. Among mosquitoes it appears to be a feature of *Aedes* species. TOT was considered to be a possible mechanism of virus survival through adverse seasons, but was very difficult to prove. However, the discovery that La Crosse virus was transovarially transmitted in the vector *Aedes triseriatus* gave new impetus to the study of this form of transmission in mosquitoes. TOT has now been shown to occur experimentally and in the field for a number of viruses and *Aedes* species. Figure 3.4 is a diagrammatic representation of the dynamics of arbovirus transmission, showing the role of TOT in survival of the virus through time.

Most arboviruses display a marked seasonality in activity correlated largely to the activity patterns of the major vector species. In general, for part of the year, the virus cycles are prevalent over a widespread geographical area, though it may not be active in any single location each year. For the remainder of the year, the virus is cryptic and cannot be detected. There are four possible explanations for the observed patterns of virus activity.

Firstly, the virus may survive in small residual foci where continual horizontal transmission takes place. When conditions are again favourable to the virus, horizontal spread and migration of infective vertebrates or vectors will allow the virus to enter the 'epidemic' phase. Some suggestions have been made that wind-borne vectors may carry the infection over ocean barriers, and that this may be an annual occurrence.

Secondly, the virus may survive in immunologically protected sites within the vertebrate, and may be released at some future time under stress or other factors.

FIGURE 3.4 : SCHEMATIC REPRESENTATION OF THEORETICAL ARBOVIRUS TRANSMISSION



Thirdly, the virus may survive adverse periods as latent infections of the eggs of certain species of *Aedes*, infected by TOT. This has been demonstrated for at least one virus, and evidence is accumulating that this may be a more generally applicable theory than has hitherto been realised. Under this mechanism, 'horizontal' transmission is the mode of transmission for epidemic cycles of the virus, whilst TOT is crucial for the maintenance of the virus through adverse periods. The maintenance or survival vector (the TOT vector) would be a distinct species from the epidemic vector. It seems that the innate ability to pass the virus transovarially is genetically controlled, and influenced markedly by environmental factors. For example, environmental temperatures can affect the proportion of the mosquito population which can pass the virus transovarially.

Fourthly, the virus may survive through adverse periods in overwintering or aestivating adult females.

VECTOR COMPETENCE

Successful and efficient transmission of vector borne disease depends on a number of factors. These factors include: effective contact between the vector and vertebrate host; duration of infectivity (both in the vector and the vertebrate); thresholds of infectivity (e.g. viraemia levels of the vertebrate in relation to the minimum concentrations needed to infect the vector); pathogenicity and stability of the disease agent; host (vector and vertebrate) susceptibility; vertebrate host population immunity levels; rates of migration and recruitment among vertebrate hosts; host behaviour; and climatic regulation of vector populations.

For pathogens with restricted host ranges (e.g. filariasis, malaria, dengue), the vector's specificity in feeding preference becomes crucial to the success of transmission. For pathogens with broader host ranges, feeding preferences are less important.

Vector competence is a general term describing the intrinsic capacity of a species to be the vector for a particular virus or pathogen. Vector competence appears to be genetically controlled as highly susceptible and refractory strains can be artificially selected in laboratory models with known vectors and particular viruses. Some mosquito species are characteristically refractory to some or all arboviruses.

The infection thresholds can be important in determining vector competence. The infection threshold measures the minimum concentration of pathogen necessary to ensure that the vector is infected via the oral route. Generally, the lower the infection threshold, the greater the vector capacity. This is not always the case as TOT, or even high viraemia levels in particular vertebrate hosts can allow species to be efficient vectors within specific vector/pathogen cycles.

There are, in addition, a number of intrinsic barriers to the infection of the vector by the virus which have been described. The first is a mesenteronal barrier which prevents the virus from penetrating the insect gut after it has been ingested in a blood meal. There are observations suggesting a dose dependent barrier to virus transmission where, in generally competent species, low initial infection doses will allow virus replication which never reaches the concentrations necessary for infection of the salivary gland. There appears to be, in addition, a salivary gland barrier which prevents the virus, having reached high concentration within the body of the vector, from infecting the salivary gland, whilst other barriers have been postulated, these two appear to be the most important.

Overall, the vector status and the success of transmission cycles depend on the innate ability of the vector to replicate and transmit the virus, and detailed biological, climatological and seasonal circumstances pertaining at the time.

In examining the role of a mosquito species as a vector in a particular disease transmission cycle, several steps are necessary. Initially, the species may be implicated as a vector on circumstantial grounds ('suspected vector'). If laboratory analyses or field isolations confirm that the mosquito can transmit the disease, its status is changed to being a 'potential vector' of the disease. If subsequent field analyses indicate that the species is actively transmitting the disease during an outbreak or epidemic, its status will be further upgraded to being a 'confirmed vector' of the disease.

In Chapter 4 vector-borne diseases in Western Australia will be examined.

CHAPTER 4: VECTOR BORNE DISEASE IN WESTERN AUSTRALIA

This chapter is divided into two parts. The first deals with malaria, historically a significant disease of the north. The second looks at the health problems associated with the arboviruses, a more common and widespread problem.

PART I : MALARIA

Malaria has historically been a significant vector-borne disease throughout that part of Australia north of the 19th parallel (the malaria receptive zone). Outbreaks have been recorded in all the northern states, and W.A. is no exception. Most outbreaks have been relatively small with few cases recorded. However some were quite severe.

The most severe outbreak recorded in W.A. resulted in over 200 fatalities (15 Europeans and over 200 aborigines) in the Fitzroy Crossing area in 1934. This outbreak was initially thought to be a form of influenza, and the outbreak was not contained until after the disease was correctly identified. The potential vector species in the area during the outbreak were *Anopheles annulipes* s.l. and *Anopheles amictus*, neither of which is recognised as an efficient vector (see below). It appears that conditions in 1934 produced very large populations of *Anopheles* species, resulting in very high rates of transmission. These conditions were absent in the following years, and transmission on the same scale was not repeated.

Australia is currently recognised as being malaria free. There has been no indigenous transmission of the disease on the Australian mainland since 1962, though many imported cases (cases contracted outside Australia in malarious countries) from malaria endemic areas occur each year. Introduced cases (cases resulting from transmission by vectors infected from imported cases) occur from time to time, but indigenous cases (further transmission resulting from vectors infected from an introduced case) are rare. There are occasional malarial outbreaks in the Torres Strait generally as a result of the movement of indigenous people from the malarious areas of New Guinea (Papua New Guinea).

The most widespread and common *Anopheles* species in Australia are relatively poor vectors of malaria. In endemic malaria areas, the efficient vectors preferentially feed on man, bite indoors, often rest indoors and are fairly long lived. This is not true of the common Australian *Anopheles* species which opportunistically feed on mammals and generally feed outdoors. Man is not the preferred host, though he may be badly bitten by some species. This is not to say that these species cannot transmit the disease. Under conditions of poor housing, where there is close contact between human and *Anopheles* populations, the introduction of malaria carriers could result in significant transmission of the disease.

Anopheles farauti No. 1 is recognised as a very efficient vector in New Guinea, and is suspected as the major vector in Australia, though it has a limited distribution. In W.A. *An farauti* s.l. has only been collected on two occasions, both from the Ord Valley (1975 and 1984). The situation has recently been somewhat complicated as *An farauti* s.l. was shown to be a species complex (see Chapter 13) consisting of at least three genetically distinct sibling species (species No's 1, 2 and 3). Of these *An farauti* No. 1 appears to be the only species present in the malaria endemic regions of New Guinea, and is the predominant vector. All three members of the complex occur in Australia, and it is not known whether species No.2 or No.3 also occur outside Australia. There are no data available to determine the relative vector abilities of the other two species in the complex and we do not know which of the three occurs in W.A.

The vector capacities of the Australian Anophelines can be summarised as follows. The principal vector species is *An farauti* s.l. *An bancroftii* is considered to be a secondary vector in some outbreaks. *An hilli* is an incidental vector as it has been found infected in nature on one occasion, but has never been a primary vector in any outbreak. *An annulipes* s.l. is implicated as a vector on circumstantial grounds, but has never been found to be infected in Australia. It is therefore only a suspected vector. *An annulipes* s.l. has also been shown to be a sibling species complex with at least six member species. No data is available to clarify the vector status of the other species, particularly *An amictus* and *Anopheles meraukensis*.

Other factors contributing to the reduction of the receptivity of malaria in W.A. are the gradual introduction of scheme water supplies into the northern communities, the draining and removal of swamplands adjacent to urban areas and the rising standard of living with the expectations of pest free urban environments. All of these have decreased contact between the vectors and man.

The use of anti-malarial drugs and the rapid quarantine of cases have also contributed by removing the pool of malaria parasites. Further backup measures in the form of vector control would reduce the possibility of malaria becoming reestablished.

This does not, however, mean that malaria can be ignored. The features of the Fitzroy Crossing outbreak demonstrate the nature of the malaria problem in Australia. If malaria is reintroduced, and not recognised for what it is, there is a potential for a serious outbreak of disease, even in the absence of efficient

vectors. Once the disease is recognised, however, the combination of vector control, quarantine and anti-malarial drugs should quickly bring the outbreak under control and break the transmission cycle. In addition, the seasonal prevalence of vector populations means that transmission is seasonally limited.

Whilst the chances of malaria becoming re-established and causing severe outbreaks are remote, three factors should be considered as contributing to this possibility. Firstly, most medical practitioners in the malarial receptive zone and elsewhere see few cases of malaria and the lack of experience with this disease may increase the chances that the disease may go unrecognised. Secondly, the ever increasing movement (by air) of people from the malarious areas of Asia, Africa and New Guinea into the receptive zone of Australia constitutes a significant risk. These people may travel during the incubation period of the disease, arriving in the receptive areas just when overt disease commences. Thirdly, the problem of widespread resistance to anti-malarial drugs in *P falciparum,* the malaria parasite causing the most severe disease in man, may cause problems in control of the outbreak.

One of the major factors assisting in the diagnosis of malaria is if the patient has a recent history of travel in malarious countries. This significant pointer will not apply in introduced cases, thus complicating correct diagnosis. It is important that the potential risk from this disease is recognised, and that appropriate levels of vigilance be maintained.

PART II : ARBOVIRUSES

Several arboviruses cause significant human disease in W.A. and elsewhere. The most significant of these viruses are two alphaviruses (group A viruses: Ross River virus [RRv] and Sindbis) and three flaviviruses (group B viruses: Dengue, Kunjin and Murray Valley Encephalitis [MVEv] viruses). There are many other arboviruses which have no clinical disease of man associated with them. The epidemiology and ecology of each of the significant arboviruses is discussed below.

a) Ross River virus

Ross River virus causes a disease known as 'epidemic polyarthritis' (EPA). It has also recently become known as Ross River fever. EPA, however, is more descriptive and is a more precise name for the disease. This widespread disease was recognised early in the century and was linked to the alphaviruses in laboratory tests. It was not until the isolation of RRv from Townsville, Queensland in 1963 that the causative agent was discovered.

The symptoms of EPA are fever, polyarthralgia (arthritic symptoms in several joints) and rash. The arthritic syndrome may persist for several months. This is the most widespread and important of the Australian arboviruses. EPA is the only arboviral disease which is seen every year throughout Australia. Outbreaks can be quite large depending on climatic influences on vector populations. Though the disease is never fatal, it can be very debilitating. The economic impact of this disease is significant through its effects on the efficiency of the workforce.

In W.A. the disease is common in coastal areas north of Bunbury. This coincides with the distribution of the major vector *(Ae vigilax).* Scattered cases are also recorded far inland throughout the state and cases have been recorded from various parts of the Perth metropolitan area. The majority of infections are in people aged between 20 and 40, with relatively fewer cases in children or adolescents. Table 4.1 presents an analysis of the cases of RRv infection diagnosed by the State Health Laboratory Services since 1975. It

TABLE 4.1 : DIAGNOSIS OF ROSS RIVER VIRUS INFECTIONS IN W.A., 1975 TO 1985

Year	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1975	4	5	4	1		2							16
1976		2	3	3	1								9
1977		1	1					1					3
1978			1	1		2		1				2	7
1979	7	4	6	2	2	1		5		2	3		32
1980	1	1	5	3	1	1		1		1	3	2	19
1981	5	3	19	24	5	5	2	2		1	2	6	74
1982	7	7	23	30	22	6		1			3	4	103
1983	7	9	3	3	1	1	1			1	8	13	47
1984	16	38	33	19	16	13	40	14	1	1	5	6	202
1985	15	8	16	15	6		2	1	5	4	3	3	78
TOT	62	78	114	101	54	31	45	26	6	10	27	36	590

should be noted that these numbers are an underestimate of the actual number, as many doctors do not rely on serological analysis by the Health Department for diagnosis. EPA is a notifiable disease in W.A.

Almost all the EPA cases occur between December and June of each year, with the highest number of cases in the February-April period.

RRv has been isolated on six occasions from mosquitoes captured from Derby and the Ord Valley in the Kimberley region . These isolates were from *Cx annulirostris* and *Ae normanensis.*

The major vectors are *Ae vigilax* in coastal areas, and *Cx annulirostris* in more inland sites. *Ae normanensis* is implicated as a possible vector in the north, and the recent isolation (in Darwin) of the virus from *Ae notoscriptus,* the domestic container breeding species, indicates that there may be some potential for domestic transmission cycles. The virus has also been isolated from *Ma uniformis* and *An amictus* in the studies in Queensland, and from *Aedes alternans, Ae sagax, Ae bancroftianus, An annulipes, Coquilletidia linealis,* and *Culex australicus* in south east Australia.

The main vertebrate reservoir hosts for RRv are mammals, in particular the large marsupials. Man can also act as a host during epidemic transmission.

b) Sindbis virus

Sindbis virus has been implicated as the causative agent of disease in the case of a child with fever and vesicular rash at Mildura, Victoria. Sindbis is associated with more severe disease in Africa, but has not, as yet, been associated with any disease in W.A.

Sindbis virus has been isolated from a number of localities in Australia, including the Ord River area of W.A. The primary vector species is *Cx annulirostris* and the reservoir hosts are birds. *Ae. normanensis* was the source of two isolates of this virus from the Ord study site. In Queensland, isolations have also come from *Culex squamosus* and *Cx quinquefasciatus.*

c) Dengue virus

Dengue virus infection was recognised in the Kimberley region (with the southern most cases at Carnarvon) from the turn of the century to about the Second World War. The most recent outbreak in Australia was in Queensland in 1981-84. The dengue cycle involves primarily urban mosquitoes and man, though there are observations in both Africa and Asia which suggest that there may be sylvan transmission cycles which involve primates and forest mosquitoes.

Four serotypes or strains of dengue virus are known, and can be identified in laboratory tests. The usual disease resulting from infection with any of these serotypes is characterised by a severe fever which lasts for several days, followed by recovery. The recovery period may be as long as several months. Alternatively, the virus can cause a haemorrhagic syndrome (Dengue Haemorrhagic fever - DHF) or a shock syndrome (Dengue Shock syndrome - DSS), which is characterised by severe internal bleeding leading to kidney failure and is often fatal, particularly among children. The reason why some infections result in shock syndrome is not fully understood, though it is thought to be related to a second infection with a different dengue serotype within five years of exposure to dengue 2. The theory is that the antibodies to the primary infection enhance the virulence of the secondary infection, resulting in a more severe disease.

The most significant vector is *Aedes aegypti,* with a few related species being of some importance in the south west Pacific region. Of the species occurring within Australia, only *Ae aegypti* is a vector. This species was widely distributed throughout W.A. prior to and during the Second World War, but has since disappeared. The most recent confirmed collection was from Broome in 1967. Recent and wide-ranging surveys in both W.A. and the Northern Territory under the Mosquito Eradication Campaign failed to locate the species. In Australia, *Ae aegypti* appears to be restricted to Queensland where it remains widely distributed.

In the absence of the vector, dengue is not currently considered to be a threat in W.A.

d) Kunjin virus

Kunjin virus is closely related to MVEv, however it was not associated with any disease for a long period. There were some indications that the virus may have been involved in some cases of Australian Encephalitis (AE) in the eastern states during 1974. Antibody to the virus was widespread in humans. Two laboratory infections have been reported, each being a mild febrile illness.

Of the eight widely scattered cases of AE which were seen in W.A. early in 1978, one was serologically confirmed as being caused by infection with Kunjin virus. This confirmed that Kunjin could produce the classic encephalitis symptoms of AE in some cases, though the majority of infections appear to be subclinical. There was also some evidence from the 1974 epidemic of AE in south east Australia which suggested possible Kunjin virus involvement, and there is a subsequent report of disease due to Kunjin infection in south-east Australia in 1984.

Cx annulirostris is the main vector of Kunjin virus, and the normal vertebrate reservoir hosts are birds. *Ae tremulus* was the source of a single isolate of the virus from the Ord study site, and the virus has also been isolated from *Cx quinquefasciatus* and *Cx squamosus* in Queensland.

e) Murray Valley Encephalitis virus

MVEv is part of the Japanese B/West Nile complex of flaviviruses. It is the major agent causing the disease AE (formerly known as Murray Valley Encephalitis), a serious and sometimes fatal infection. AE occurs in infrequent epidemics in south east Australia (Table 4.2), with occasional cases recorded between epidemics. Studies in W.A. have confirmed that the dissemination of MVEv is an annual event in the Kimberley region. Since 1978, this has been accompanied by the occurrence of scattered cases of AE in some years.

TABLE 4.2 : RECORDED CASES OF AUSTRALIAN ENCEPHALITIS IN AUSTRALIA TO 1987

YEAR	STATE W.A.	N.T.	QLD.	N.S.W.	VIC.	S.A.	TOT*	
1917			44	70			114	
1918			5	49	13		67	
1922			75				75	(49)
1925			11	10			21	(16)
1951				10	34	1	45	(19)
1956					3		3	
1969	1						1	(1)
1971			1	1			2	
1974	1	5	10	5	27	10	58	(13)
1978	8						8	
1979	2						2	
1981	8	1	2				11	
1984	2						2	
1986	1		1				2	
1987	1	1					2	
TOT	23	7	150	145	77	11	413	(98)

* : The number in parentheses is the number of fatal cases in each year.

Infection with MVEv leads to disease in relatively few individuals. Estimates of the ratio of clinical manifestation to infections vary from 1:500 to about 1:3000. For those who exhibit clinical symptoms, onset is characterised by the sudden appearance of headache, fever, nausea and sleepiness. The general symptoms include delirium, limb and neck pains, and weakness of the limbs. The clinical progress of the disease is rapid.

The outcome of infection with the virus is variable. Based on the analyses of previous epidemics, about one third of those exhibiting clinical disease can be expected to recover fully. A further third can be expected to recover, but with sequellae ranging from paralysis to emotional disorders. For the remaining third the disease is fatal. In the most recent epidemic event in 1974, the fatality rate was lower than in previous epidemics (12 of 58 cases) and it is thought that improved care facilities and life support techniques have increased the survival rate. There have been no fatal cases of AE from W.A. since the 1974 epidemic. One fatal case was thought to have originated at Kimbolton station, near Lake Argyle, in 1969. Figure 4.1 shows the distribution of cases of AE in the N.T. and the north of W.A.

MVEv has been isolated from mosquitoes collected in the Ord study site, and at Derby and Balgo Mission in W.A. Most isolations are from *Cx annulirostris* with the exceptions being one from *Cx quinquefasciatus* and three from *Ae normanensis*. The isolation of MVEv from *Ae normanensis* indicates that this species should be further investigated to determine its vector status and particularly whether it may support TOT of MVEv.

The normal maintenance transmission cycle of MVEv involves birds and mammals, and *Cx annulirostris*. Man appears to be an incidental host.

FIGURE 4.1 : AUSTRALIAN ENCEPHALITIS CASES IN NORTH WEST AUSTRALIA

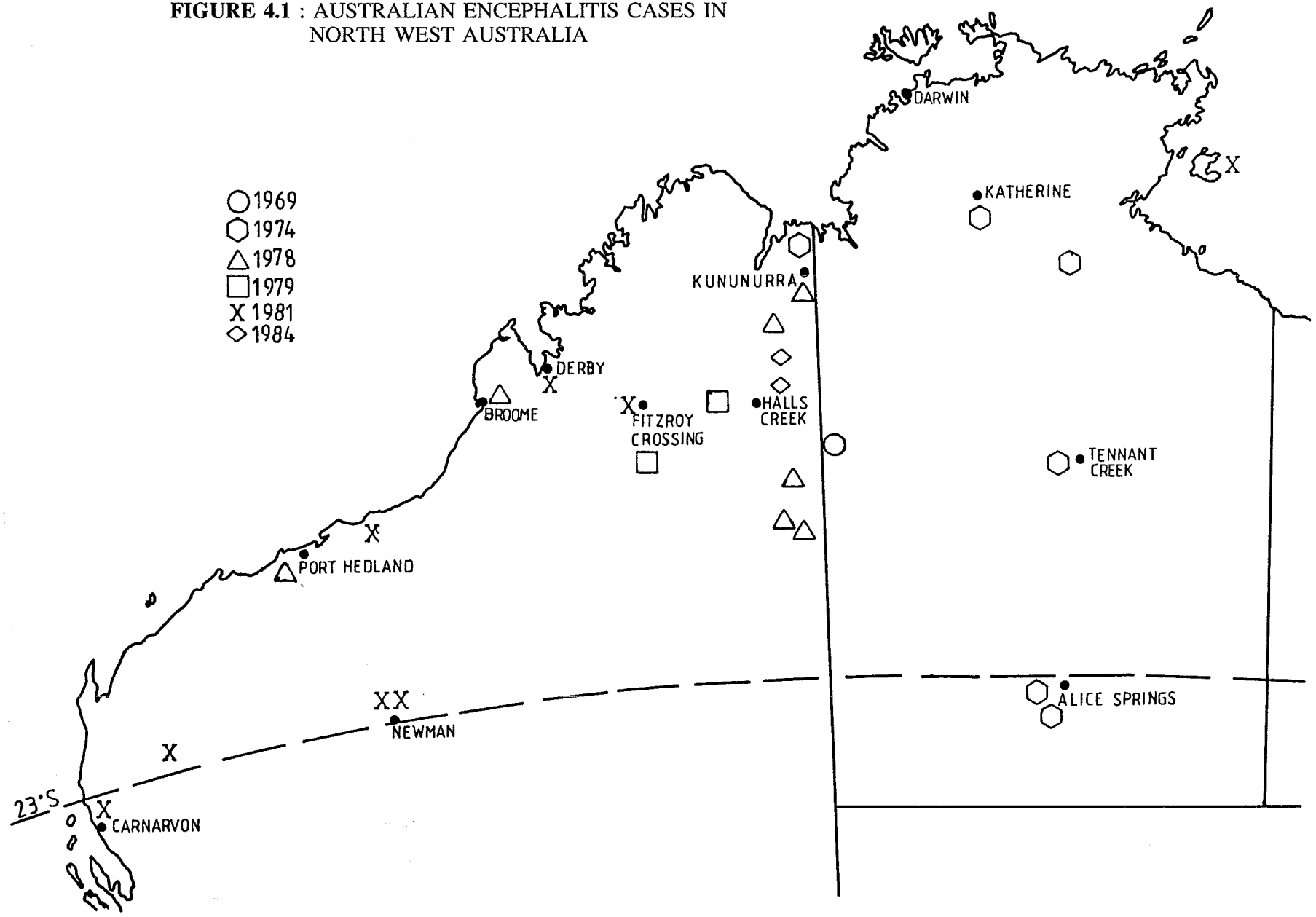


TABLE 4.3 : RECORDED ACTIVITY OF MVE VIRUS IN WESTERN AUSTRALIA, QUEENSLAND AND THE MURRAY VALLEY SINCE 1960

LOCALITY	QLD	W.A.	VIC/NSW
START DATE	1960	1972	1974
YEAR			
1960	B		
1969		A	
1971	A, C,		A
1972		B, C	
1973		B, C	
1974	A, B, C	A, B, C	A, B, C
1975	B, C	B, C	
1976		C	
1977		B, C	
1978		A, B, C	
1979		A, C	
1980		B, C	
1981	A	A, C	
1982		B, C	

A : Human cases of A.E.
B : Virus isolations from mosquitoes.
C : Serological evidence from sentinel animals.

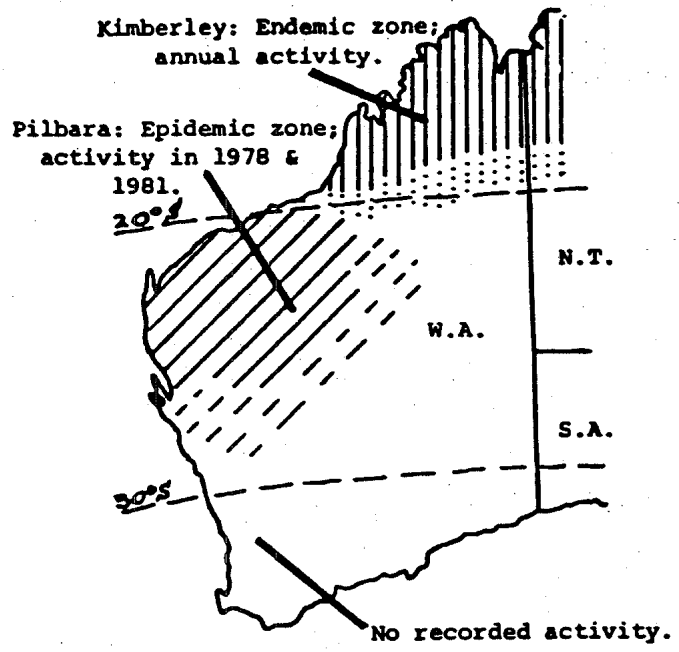
There have been three major longitudinal studies of arbovirus ecology in Australia. The pioneering studies by Professor Ralph Doherty and his group at The Queensland Institute for Medical Research since 1960 have set the background for our knowledge of the general arbovirus fauna of tropical Australia, in particular Queensland. The research programme at the University of W.A. (in conjunction with the Health Department of W.A.) has analysed arbovirus activity in the Ord valley and, more recently, throughout the Kimberley and Pilbara regions of W.A. This study was initiated by the late Professor Neville Stanley and Professor Hugh Paterson. Following the last epidemic event in 1974, a study of the arboviruses of the Murray Valley was initiated by Dr. Ian Marshall of the Australian National University, Canberra.

In order to place the W.A. experience in perspective, Table 4.3 presents an analysis of the recorded activity of MVEv in these three research programmes for the period, 1960 to 1982. The analysis shows that the W.A. study is the only one where activity of MVEv has been recorded each year in one form or another (the ENZOOTIC zone).

In the Kimberley, MVEv activity is highly seasonal and appears to be largely confined to the February-May period at the end of the wet season. This coincides with the peak populations of *Cx annulirostris*. Isolates have been made from mosquitoes collected in other seasons (e.g. in June and November/December) in some years, and human cases have been seen outside this peak transmission period.

Activity in the Pilbara is restricted to occasional dissemination and cases (every 3-5 years), whilst activity further south is even less common (the EPIDEMIC zone). The most southerly confirmed case was recorded from Carnarvon (see Figure 4.1). There is some serological evidence that the virus may have been active slightly further south of Carnarvon, but that the activity was much reduced compared to the northern areas. Figure 4.2 is a map of W.A. showing the perceived activity zones for MVEv.

FIGURE 4.2 : ACTIVITY ZONES FOR MURRAY VALLEY ENCEPHALITIS VIRUS IN WESTERN AUSTRALIA



CHAPTER 5: A REGIONAL SUMMARY OF MOSQUITOES AND MOSQUITO-BORNE DISEASE IN WESTERN AUSTRALIA

This discussion may be used as a rough guide to regional mosquito problems in W.A. It should, however, be remembered that the distributions of mosquitoes as recorded tend to reflect the activity of medical entomologists rather than being direct evidence of the presence or absence of particular mosquito species. To illustrate this, the Ord valley has been the site of intense study since 1972, yet new species have been recorded in the area as late as 1984. That is, despite twelve years of very intensive collection, some species remained undiscovered. The same will be true of every single site within W.A.

PART I : THE KIMBERLEY REGION

The Kimberley region is a vast ecological cline, ranging from subtropical wetlands with small pockets of monsoon rainforest in the north, to arid desert in the south. It has a marked monsoon climate with a defined wet season (December to March) and dry season (June to September). The intervening periods are transitionary with marked build ups of humidity and thunderstorms preceding the wet, and a gradual (or sometimes sudden) trailing off of the rains preceding the dry.

DISEASE TRANSMISSION

Disease transmission has been discussed in some detail in Chapter 4. A brief resume here will give a regional perspective to the problem of mosquito-borne diseases.

a) Malaria

Malaria has historically been a significant disease in the Kimberley. The most important outbreak of the disease occurred in 1934 when over 200 deaths were recorded in the Fitzroy Crossing area. The prime vectors in this outbreak (based on subsequent observations of the *Anophelines* in the area) were *An annulipes* s.l. (probably species D) and *An amictus*. It appears that this outbreak was the result of a unique combination of weather patterns and unprotected human populations. With the increased quality of housing, and improved sanitation procedures in the north, the potential for resurgence of this disease is low.

The recent collections of *An farauti* s.l. from the Ord valley is of some concern as species belonging to this species group are recognised as the major vectors of malaria in the Australasian region. The numbers collected, however, remain very low (some 7 individuals in 14 years of intense study) and it appears that these collections may represent the western limit of that group of species' distribution within Australia. The species of this group are generally confined to the wetter portions of the tropics, and it is possible that they may occur in the more northern parts of the Kimberley, e.g. Mitchell Plateau, though limited collections there have not revealed their presence as yet.

b) Arboviruses

The Kimberley region is an enzootic zone for a large number of arboviruses, the most significant of which are MVEv and Kunjin, both of which are known to cause AE in humans. The major vector for these viruses is *Cx annulirostris*, the most common and widespread mosquito in the Kimberley. These viruses are active every year, with the transmission period being at the end of the wet, from about March to May. Human cases of AE occur in scattered but widespread outbreaks every couple of years. *Ae normanensis* is also a suspected vector, and may be involved in the maintenance cycles of these viruses through TOT.

RRv, the virus causing EPA, occurs throughout the Kimberley each year. RRv is transmitted by *Ae vigilax* and *Cx annulirostris*. Recent isolations of RRv from *Ae normanensis* and *Ae notoscriptus* suggest that these species may be suspected vectors.

Dengue was historically significant in the region, but is no longer a potential threat as the vector, *Ae aegypti*, has disappeared.

PEST ACTIVITY

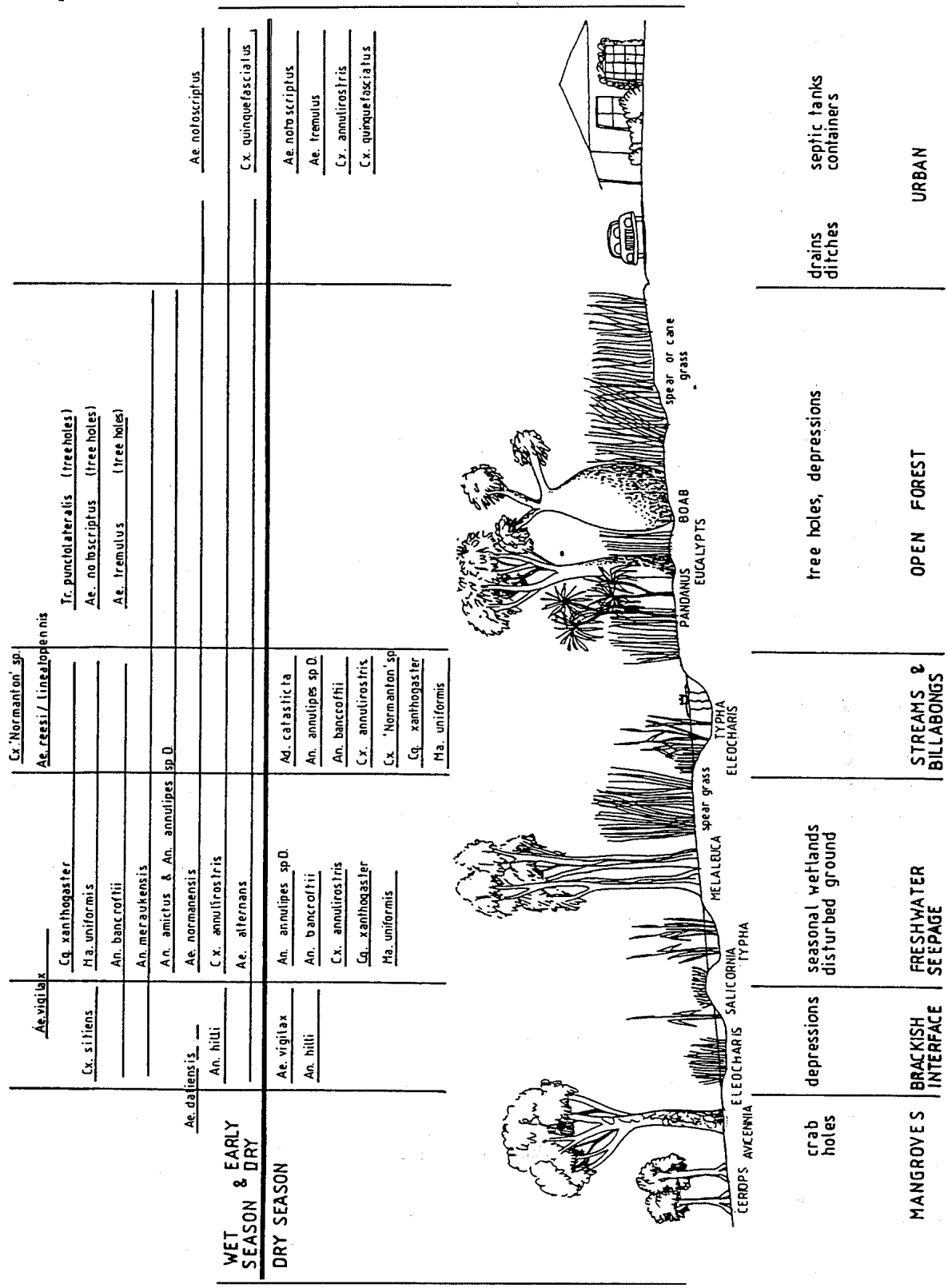
Pest mosquito species in the Kimberley region are numerous. The pests active at any site are dependent on the particular habitats present in the area. The discussion will be broken down into broad habitat types. It must be remembered that these habitats are often found in very close juxtaposition and therefore the species characterising the two will be mixed. Some species, in addition, spread beyond their usual habitats and can be found in a variety of sites. The discussion below is a brief overview of the types of problems seen, but cannot be taken as a complete guide to what can be expected at any site. Further collections and analyses will undoubtedly result in a refining of this scheme. Local variations in the breeding of species are certain to be defined with further study. Figure 5.1 presents a generalised view of mosquito breeding in relation to habitat in the Kimberley region. (This figure is based on the chart, prepared by Peter Whelan, on mosquito breeding sites in the Darwin area.)

a) Coastal species

Species breeding in coastal waters are those tolerant of salt or brackish waters. The most significant pest and vector species at the coast is *Ae vigilax*. This species breeds in very large numbers in salt or brackish waters left stranded after the highest spring tides of the year in October to April. It may also breed if these sites are filled by unusual circumstances, as during unseasonal rains. During the wet season proper, the dilution and flushing of the habitat tends to prevent the breeding of large populations of this species.

Lesser pests, though they can be locally very significant, are *Ae alternans*, *Ae funereus*, *An hilli* and *Cx sitiens*. Of these, *Ae funereus* has only been collected from one site at Wyndham, though the other species are more widespread.

FIGURE 5.1 : BREEDING SITES OF THE COMMON MOSQUITO SPECIES IN THE KIMBERLEYS



There is also a major coastal problem with biting midges *(Culicoides* species - commonly called sandflies in Australia) breeding in mangroves. These species generally have synchronised emergence with the tide cycle, and very large and regular fortnightly or monthly population peaks occur, coinciding with the particular phase of the tide. These species are generally crepuscular biters, and are a particular problem as their bites generally cause a more severe reaction in people. They are not associated with any disease transmission in Australia, though dermatological reactions can be a significant medical problem in some individuals.

b) Permanent and seasonal wetland species

The most common of the species inhabiting the more permanent wetlands in the Kimberley is *Cx annulirostris*. This species breeds in the vegetated margins of water bodies which remain fairly open. It is often found in association with *An annulipes* (species D) and *An amictus*. Both of the latter species can also be significant, as local pests. *Ae normanensis* can sometimes be found in the more permanent water bodies, hatching being triggered by the changes in water levels following rains.

Dense reed swamps are the source of *An bancroftii, Cq xanthogaster* and *Ma uniformis*. All these species can be significant rural pests, though *Ma uniformis* does not disperse far from the breeding site. *Aedes reesi* and *Aedes lineatopennis* also appear to be associated with these reed swamps, though actual breeding has not been defined in the Kimberley.

c) Temporary ground waters

Species breeding in temporary ground pools are mainly the *Aedes* though *Cx annulirostris* and the fresh water *Anopheles* species *(An annulipes* s.l., *An amictus)* occasionally occur in these sites. The main *Aedes* species are *Aedes alternans, Ae bancroftianus, Ae normanensis* and *Aedes sp#159* in the wetter portions, and in addition, *Aedes eidsvoldensis, Ae pseudonormanensis* and *Aedes sp#85* in the drier areas. *Ae alternans* numbers are rarely high, but because of their size, painful bite and diurnal biting habit, this species is always noticed when it does bite man.

d) Tree holes

Three tree hole breeding species, if localised, can be significant pests. These include *Ae notoscriptus, Ae tremulus* and *Tripteroides punctolateralis*. The latter species is not a very significant pest, but is very noticeable as when seeking a blood meal, it follows the CO_2 stream to its origin and tends to bite on the nose. *Ae tremulus* usually feeds in the first hour of the day and can be a significant pest in some areas during the February-May period.

These tree hole breeding species have adapted to breed in urban container habitats, thus increasing the degree of man-mosquito contact.

e) Urban species

The main urban species in the Kimberley region is *Cx quinquefasciatus*, a species breeding in fresh to polluted peri-urban water bodies. It will breed successfully in septic tanks, drains, drums, water troughs, and any small, relatively permanent container. Other container species are *Ae notoscriptus* and *Ae tremulus. Ae katherinensis* and *Tp punctolateralis* can also be found in domestic container habitats on occasion.

Some rural species can also take advantage of the more permanent urban sites such as drains, disturbed ground pools, and long lasting containers. The most important of these are *Cx annulirostris, An annulipes* s.l. and *An amictus*.

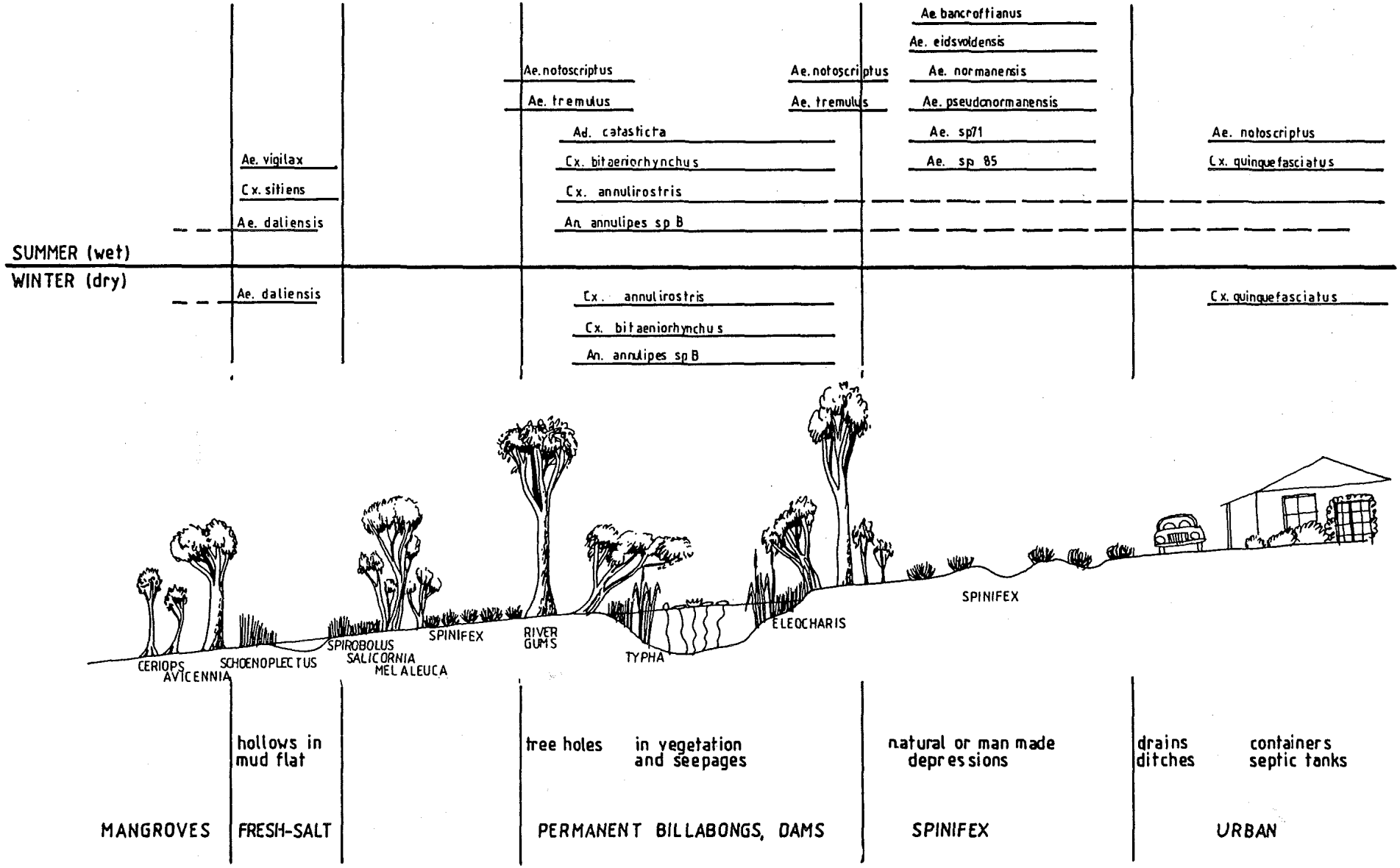
PART II : THE PILBARA AND THE SUBTROPICS

The Pilbara and subtropical regions are generally much drier than the Kimberleys. There are some permanent water sites, many of which are man-made (e.g. dams) and many of which result from the use and disposal of water in the towns and mining ventures in the region.

This region has a strange mixture of species. There are some elements of the southern fauna which have extended northward and are found in the southern edges of the subtropics (e.g. *Ae alboannulatus, Ae camptorhynchus* and *Ae sagax)* and some elements of the northern fauna which have extended southwards into the northern portions of the region (e.g *Ad catasticta, An amictus, An annulipes species D)*. The fauna is, however, dominated by arid zone species.

Figure 5.2 presents a diagrammatic representation of mosquito breeding in relation to habitat type within the subtropical zone.

FIGURE 5.2 : BREEDING SITES OF THE COMMON MOSQUITO SPECIES IN THE PILBARA



DISEASE TRANSMISSION

Malaria has never been a major problem in the subtropics of W.A. There is some concern that the increased movement of people from the region to the malarious areas of Asia, particularly the holiday resort areas, may lead to the importation of malaria into the area, and may allow some transmission. Whilst the possibility that the disease will become established in the area is very remote, care should be taken to guard against its reintroduction.

The main arbovirus seen in the Pilbara is RRv. This virus causes annual outbreaks of disease with numerous cases throughout the Pilbara. The highest numbers of cases occur near the coast. The known vectors are *Ae vigilax* and *Cx annulirostris*, though several other species are circumstantially suspected as vectors.

AE, caused by infection with MVEv, has also been recorded from this zone. It appears that suitable conditions occur every 3 to 5 years, when activity of the causative viruses becomes apparent, and occasional cases are recorded. The most southerly cases have been recorded from Carnarvon and Minilya Station. The main vector species is considered to be *Cx annulirostris*. Serological evidence suggests that MVEv activity can occur as far south as the Murchison River if climatic conditions are suitable.

PEST ACTIVITY

a) Coastal species

The main coastal pest species is again *Ae vigilax*. The breeding of this species is largely confined to the residual tidal pools left stranded by the highest of the spring tides. These sites are also the breeding sites for *Ae alternans* and *Cx sitiens*, both of which can be significant local pests.

As in the Kimberleys, a major coastal pest problem results from, not mosquitoes, but biting midges (Ceratopogonidae), particularly members of the *Culicoides ornatus* complex of species. These are locally known as sandflies and can be very severe pests near the coast, particularly near to mangroves.

b) Permanent and seasonal wetland species

The species breeding in permanent and seasonal wetlands, dams and springs, are generally the same as those seen at similar sites in the north. The fauna is dominated by *Cx annulirostris*. This species is often found in association with another member of the *An annulipes* complex - species B. *Culex bitaeniorhynchus* is also common in some of the more permanent sites as is *Ad catasticta*. *Ad catasticta* is ornithophilic (has a preference for birds as blood meal hosts), and rarely bites man.

c) Temporary ground waters

Again, these sites are the breeding grounds of the *Aedes* species, though *Cx annulirostris* and *An annulipes* species B also will utilise these sites if they persist for sufficient time. The main *Aedes* species are *Ae bancroftianus, Ae eidsvoldensis, Ae normanensis, Ae pseudonormanensis, Aedes sapiens, Ae sagax, Aedes sp#71* and *Ae sp#85*. These are not evenly distributed throughout the region, and because of the ephemeral nature of the breeding sites, generally only cause sporadic pest problems. There are general guidelines for predicting when pest problems may occur. For instance, 8-10 days following cyclones or heavy inland rainfall, plagues of flood water *Aedes* can be expected with some certainty, though they may be quite short lived.

d) Tree holes

The same species occur in the subtropics as are found in the Kimberley - *Ae notoscriptus, Ae tremulus* and *Tr punctolateralis*. Because of the more ephemeral rainfall, these species rarely cause significant pest problems.

e) Urban sites

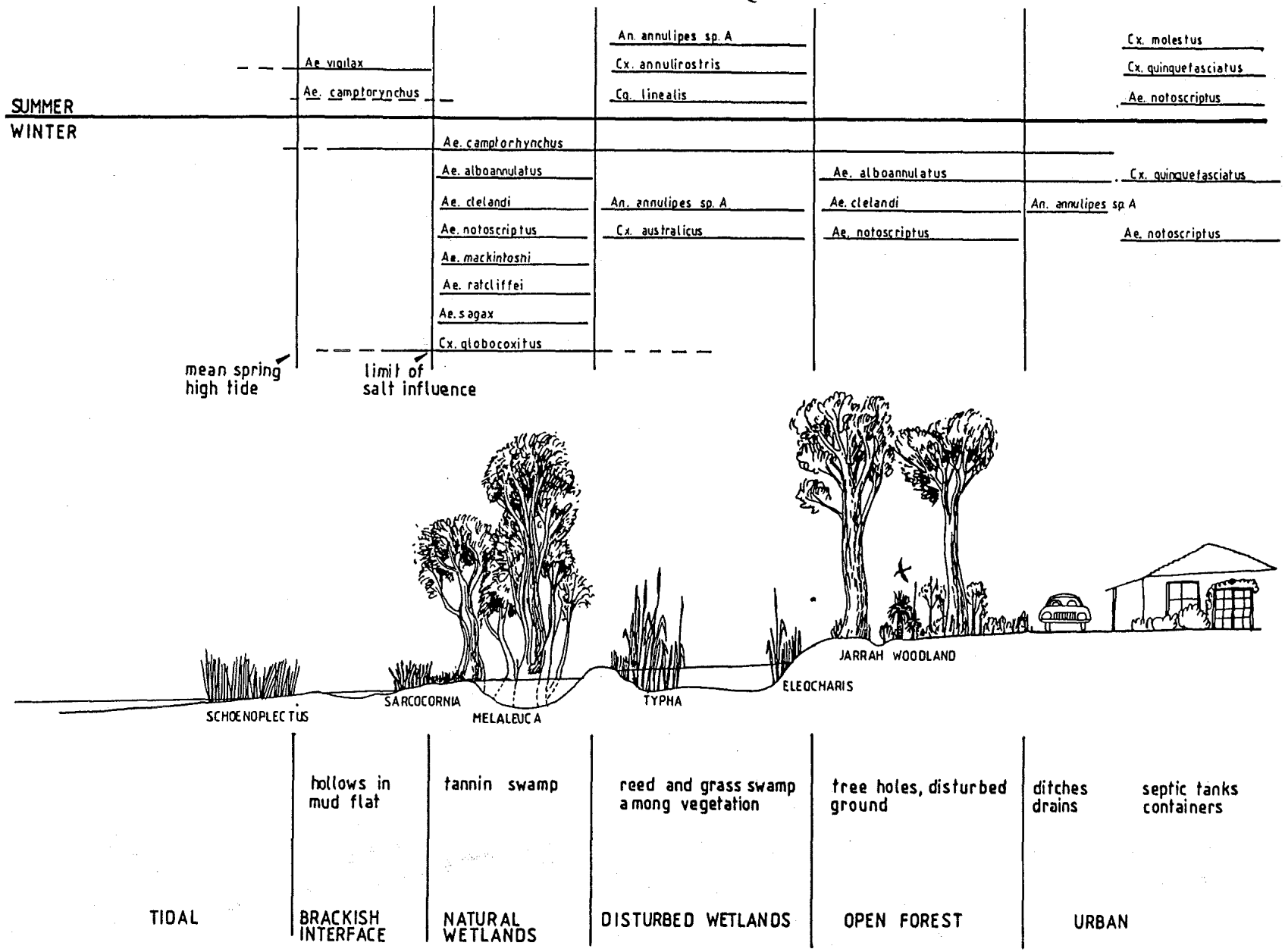
Again, the same species dominate urban collections in the subtropics. *Cx quinquefasciatus* is the dominant species breeding in fresh to polluted urban waters. *Cx annulirostris* and *An annulipes* species B may colonise the more permanent fresh water urban habitats. Some of the temporary ground pool *Aedes* may be found in disturbed ground pool sites which are filled by rains. *Ae notoscriptus, Ae tremulus* and *Tp punctolateralis* may be found breeding in urban container habitats.

PART III : THE SOUTH WEST

The south west mosquito fauna contains many of the same widespread, common species which are found throughout Australia. There are, in addition, some arid zone species, and a number of unique species which are restricted to the wetter parts of the south west corner.

The breeding sites of some of these are shown in Figure 5.3.

FIGURE 5.3 : BREEDING SITES OF THE COMMON MOSQUITO SPECIES IN THE SOUTH WEST



DISEASE TRANSMISSION

The only significant mosquito borne disease in the south west is EPA caused by infection with RRv. EPA is seen in sporadic annual cases with a widely scattered distribution. EPA generally occurs in the summer/autumn period. The majority of cases occur in coastal areas, where the major vector species is *Ae vigilax*, though some cases have been recorded from inland sites where the vector is thought to be *Cx annulirostris*. Other species, e.g. *Cq linealis* and *Ae camptorhynchus*, are suspected vectors of the virus.

PEST ACTIVITY

This discussion concentrates on those species which are known to bite man. If very common species are mentioned which do not attack man, they are indicated as such in the text.

a) Coastal sites

Ae vigilax is the most significant coastal pest species in the summer months. This species breeds in the tidal pools left by the spring tides. In winter and spring, these sites are the breeding grounds of *Ae camptorhynchus*, the second most important pest species in the south west. *Ae vigilax* occurs in the coastal areas north of Bunbury whilst *Ae camptorhynchus* extends further south as well. *Aedes ashworthi*, a coastal rock pool breeder, is also a local pest at times.

Culex globocoxitus, a species which generally does not feed on man, is also a very common species breeding in these sites in winter and spring.

b) Permanent and seasonal wetlands

The species breeding in the more open but vegetated sites are dominated by *Cx annulirostris*, *Cx australicus* (a bird feeding species) and *An annulipes* species A. In the more natural sites, characterised by deep *Melaleuca* swamplands and associated seasonal wetlands, the mosquito fauna includes many of the typical south west fauna: *Aedes clelandi*, *Aedes hodgkini*, *Aedes mackintoshi*, *Aedes ratcliffei*, *Aedes turneri*, *Aedes stricklandi* and *Ae sagax*. Some of these species are also found in the eastern states, and some may be rare in most localities. The *Aedes* species listed above can be found as larvae through the winter, and adults are prevalent for a month or so in April. *Ae camptorhynchus* is also often found breeding in the more open sites.

Many sites have been disturbed to varying degrees, and some have become overgrown with bulrushes (*Typha* species). These sites are the source of large numbers of the summer pest species, *Cq* 'Ben Lomond' sp. Large numbers of *Cx annulirostris*, *Cx australicus* and *An annulipes* species A also breed in these swamplands in the summer.

c) Temporary ground pools

This segment of the fauna is dominated by *Ae alboannulatus*, *Ae camptorhynchus* and *Ae clelandi*. In the more arid areas *Ae sagax* can be a significant pest following heavy rains in spring/summer.

d) Tree holes

The main tree hole species in the south west is *Ae notoscriptus*. *Ae tremulus* is not as common in the south as elsewhere. Another minor species inhabiting tree holes is *Tripteroides atripes* which, like its close relative *Tp punctolateralis*, will alight on the nose when biting man.

e) Urban sites

The major urban species in the south west are *Cx molestus* and *Cx quinquefasciatus*. Both these species breed in polluted domestic waters. *Ae notoscriptus* and *Cx quinquefasciatus* are the most common container breeding species in the region. *Tp atripes* can sometimes be found breeding in domestic container habitats. Container habitats include gutters, drums, and rainfilled containers of all sorts.

Many of the ground pool *Aedes* species also occur in temporary ground pools within urban areas. The main species are *Ae alboannulatus* and *Ae camptorhynchus*.

SECTION 2
MOSQUITO MANAGEMENT - THEORY AND PRACTICE

CHAPTER 6: THE THEORY OF MOSQUITO MANAGEMENT

Prior to the advent of the first chemical insecticide (DDT) mosquito problems were managed through a combination of avoidance, biological control (mainly the use of predatory fish [particularly the mosquito fish *Gambusia affinis*]), some chemical control (generally spraying the breeding grounds with light oils) and environmental sanitation (a process of physical elimination of the problem species' breeding grounds within reach of the area needing protection).

The introduction of the chemical insecticides was spectacularly successful in terms of rapid and seemingly complete control, and the immediate reaction was that these chemicals could be used to eliminate all the problem mosquito species. For many years, chemical insecticides remained unchallenged. Because of their relative cheapness and ease of use, they were applied in great quantities throughout the world. Problems arose, however, when insecticide resistance among some mosquito species became apparent, and when the effects of the insecticides on the other inhabitants of the ecosystem were documented. Even so, insecticides are still seen as the method of choice in most control operations today. However, for reasons discussed here and in later chapters, the use of insecticides is often not the best option for ongoing management programmes.

It is now recognised that the hoped for eradication of entire species is not possible. The spread of insecticide resistance among pest and vector mosquitoes, and the high cost involved in development and registration of new insecticides has reduced the effective arsenal of chemicals which may be applied for mosquito control. A more balanced approach to mosquito control is now evolving.

This approach, integrated control, relies on a mix of biological, physical, cultural and chemical control measures, much the same as was practised prior to the development of DDT. Integrated control aims at giving the best combination of methods to give maximum long term control at the cheapest overall cost. More attention is also being given to the possibility of preventive planning, that is, using our knowledge of pest situations to ensure that man's activity in modifying the environment does not result in the creation of new, or exacerbation or maintenance of existing, significant pest breeding areas. Integrated control can easily be compared to the concept of integrated pest management (IPM) in agriculture. However, the short term economic thresholds which apply to IPM are not as apparent in the case of public health pest and vector control.

The overall aim of mosquito management operations is to reduce the numbers of the pest or vector species to a level where the impact on the adjacent human populations is kept to an acceptably low level. The long term aim should be to maintain the mosquito populations below this threshold.

The strategies and procedures for mosquito management in a given situation will depend on the nature and extent of the problem, the environmental constraints, and the budget available for control operations. Currently, the first option considered for control is usually that of application of chemical insecticides. This is often a short sighted approach, and consideration should be given to alternatives as part of an overall, long term management plan.

Long term effects of insecticides on non-target organisms, persistence of insecticides within the environment, the possibility that resistance will develop in the pest or vector and the balance between the initial, relatively low cost of chemical control and the continuing expense of regular or repeated applications should all be considered in formulating the mix of control options. Public concern over environmental pollution and disquiet over possible health risks associated with insecticides will increasingly become factors in the planning of mosquito pest or vector management programmes.

TYPES OF MOSQUITO RELATED PROBLEMS

As mentioned previously in Chapter 3, problems caused by mosquitoes relate to the females' requirement for blood in order to mature egg batches. Pest species bite in large numbers, or are persistent through time, and reduce the quality of life for the residents of an area. Vector species are important as they may pass on diseases significant to man. In either case, the aim of the management programme is to reduce the mosquito populations to a level at which the interaction with the local human population does not result in complaints, or where the transmission of the disease is prevented.

Both types of problem may be further analysed in a general qualitative manner. Is the problem a permanent feature throughout the year? Is it seasonal? Annually recurrent? Predictable? Is it a rare event due to a unique combination of environmental factors? With the transmission of diseases, what are the risk factors associated with the disease? Is the disease fatal or relatively benign? Does the disease have a wild or domestic vertebrate host cycle or is it strictly a human disease? Does the activity (pest, vector or disease) constitute an emergency situation?

Answers to these questions allow prioritisation, indicate the type of action required, and will affect the avenues for management which are considered.

ANALYSING THE PROBLEM AT HAND

EFFECTIVE MANAGEMENT RELIES ON A DETAILED UNDERSTANDING OF THE PROBLEM - THAT IS, THE PROBLEM MUST BE DEFINED IN A RIGOROUS AND QUANTITATIVE MANNER. In practice, this is rarely done as time and manpower constraints are limiting. However such a rigorous approach is essential to ensure that any effort and financial commitment are used most efficiently.

Defining the problem at hand is usually accomplished through surveys of both adult and larval mosquito populations. Survey techniques and guidelines for the interpretation of the results are presented in Chapter 7. Surveys may be broken down into three categories.

a) The initial survey

The initial survey aims to define the situation prior to implementation of management operations and serves as a guide to where these operations should be applied to be most effective. The methods should include both adult and larval sampling. If high numbers of adults cannot be correlated to identified breeding sites, or explained otherwise, this may indicate the presence of unsurveyed breeding areas. In addition, knowledge of the preferred breeding habitats of the dominant species in adult collections can be used as a guide to the habitat types to search.

The overall aims of the initial survey are:

1. To define what species are active in the area and to determine which are the main pest/vector species.
2. To determine the relative abundance of these species throughout the area involved.
3. To define and map the breeding grounds, and to determine the relative importance of each.
4. To obtain data on the local dispersal ranges of the pest/vector species.
5. To define the seasonal limits of activity of the main pest/vector species.
6. To obtain as much biological information on each species as possible (e.g. life cycle, larval development time, longevity, adult resting sites).

In some cases, if chemical insecticides have been widely used in the area before (e.g. agricultural pest control), it may be necessary to determine the mosquito population's susceptibility to the chemicals which may be used for adulticiding or larviciding.

The initial survey should cover the entire period during which the problem is apparent so that the predsposing conditions are understood. Some cases will require a full twelve month monitoring cycle, allowing the seasonality and possible succession of pest species to be defined. This does not mean that control operations cannot be undertaken during this time, though the effects of any control measures must be taken into account when analysing the results.

The initial survey should give a quantitative analysis of the mosquito populations which can be used as a base line for analysing the effectiveness of a management programme. The results of monitoring can be plotted on a graph to give a quick visual guide to population fluctuations.

b The operations survey

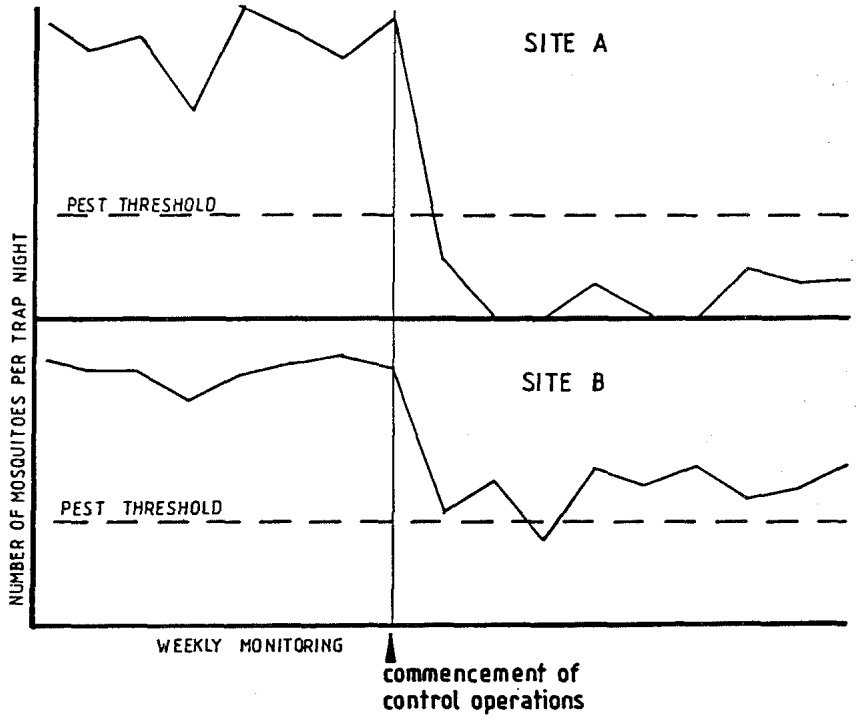
This survey is undertaken during the management operation and, again, should include both adult and larval analyses. The aim of this survey is to monitor population levels of the pest and to chart the effectiveness of the control measures. It may, in addition, reveal inadequacies in the current management scheme, and indicate when and/or where the overall plan needs to be modified. The survey consists of rapid and continuous monitoring of the entire control area during the control operations, and the results are used to

fine tune the control programme to maximise effectiveness. The types of survey (adult, larval) and the types of collection will depend on the methods used for control. That is, the survey results must be relevant to defining success in terms of management procedures.

Figure 6.1 is a fictitious plot of adult catches at two survey sites in an operations survey for a management programme. Site A shows that the populations recorded are very much reduced following initiation of control operations, and that the operation is highly successful at that site. Site B, on the other hand, indicates that there has been significant reductions in numbers, but that the populations remain above an acceptable level. That is, the control operation has not been fully successful at site B, and either some breeding area has been overlooked or has not been treated effectively.

Further surveys near this site are required to determine the cause of the discrepancy, and to alter the treatment regime to effectively reduce populations.

FIGURE 6.1 : MONITORING OF PEST POPULATIONS - OPERATIONAL SURVEYS



c) The evaluation survey

The evaluation survey is carried out immediately following control operations and is aimed at reviewing the success of these operations by comparing the results with collections immediately before the operations commenced. The survey should quantify the nett reduction in pest (vector) mosquito numbers, and may also indicate any area where further attention may be necessary in subsequent campaigns.

All three types of survey are often carried out in a continuous series, as a monitoring programme. The initial survey should cover the entire area applicable to the problem. The obvious starting points are the sites where complaints or cases originate and any known or potential mosquito breeding sites in the vicinity. The analyses of the adult mosquitoes at these sites should give some indication of the probable breeding sites and the dispersal capacity of the species. This then defines the types of water body to be searched, and the distance from the urban area which needs to be surveyed.

These results should then be analysed and appropriate sites chosen for a monitoring programme. Sites should include locations at the urban area to monitor pest levels there, as well as at the most significant breeding areas (or locations between these breeding areas and the urban boundary). These sites should then be fixed and used as standard monitoring sites for the operations and evaluation surveys. By keeping these locations constant (to the extent of using the same tree and placing traps at the same height; or always sitting in the exact location for man biting catches) the results from one catch date to the next may be compared, and any fluctuations observed are indicative of population changes. Care should always be taken to ensure that other extraneous factors such as wind or rainfall, have not artificially depressed mosquito numbers on the night of the catch.

WHERE DO YOU CONSIDER CONTROL OPERATIONS?

Control operations are centred on the human population at risk. Obviously, all pest or vector mosquito breeding within the urban area must be reduced. The problem is how far beyond the urban boundary do you extend control operations? The most significant mosquito characteristic to consider when deciding what area must be controlled is the dispersal capacity of the main pest or vector species. If all mosquito breeding sites within the normal dispersal range of human habitation are controlled, then the numbers of mosquitoes reaching the area concerned will be minimal. Any mosquitoes reaching the area will have flown much further than they would normally disperse and are likely to be few in number and hence not significant as either pests or vectors. This is the buffer zone concept. A distance of about 1.5km is a sufficient buffer for some species, though it has recently been shown that 5km is probably inadequate as a buffer for *Cx annulirostris,* and even more so for *Ae vigilax.*

This buffer distance may have to be extended if it traverses a major, extensive breeding ground, or where there is continuous lush vegetation or other feature which can form sheltered flyways connecting more distant breeding grounds with the human habitation.

MOSQUITO CONTROL ALTERNATIVES

Mosquito control operations can be carried out against both adults and larvae. The types of control options for adults and larvae are as follows:

LARVAE	PHYSICAL	environmental management or environmental sanitation (modification of breeding grounds to reduce breeding, or the elimination of breeding grounds).
	CHEMICAL	1) The application to the breeding area of chemicals which are lethal to the mosquito larvae. 2) Recently, artificial insect growth regulators, substances which interfere with normal development and prevent emergence of adults, have become available. These are currently not scheduled for release in Australia.
	BIOLOGICAL	The use of other species (predators, pathogens or other insects) which will control, compete with or prevent breeding of mosquito populations.
ADULTS	PHYSICAL	Placing physical barriers to prevent or reduce man-mosquito contact (e.g. mosquito mesh on windows, altering habitats to reduce dispersal).
	CHEMICAL	The use of toxic chemicals to kill the adults, either as space sprays for flying insects or as surface preparations for resting insects. Some chemicals are also repellents and may be used to deter mosquitoes.
	BIOLOGICAL	Several means can be used to reduce the fecundity and impact of pest populations. These include species competitors; strains of vectors which are refractory or with greatly reduced vector capacity; carriers of lethal or deleterious genes; sterile male release.
	CULTURAL	Reduction of man-mosquito contact through avoidance or changing social customs.

The different control options are discussed in Chapters 8 to 10 inclusive.

CHOOSING BETWEEN CONTROL ALTERNATIVES

Earlier in this chapter, it was mentioned that the choice of control measures in any situation will depend on the nature and extent of the problem, any environmental constraints, and the available budget. As such, no concrete advice may be given as to the correct method to choose as this will be different in each case. There are, however, a number of observations which can be made which will give some guidelines for evaluating the different options.

Obviously, in an emergency situation such as severe disease transmission, the aim is to reduce the adult mosquito populations to a very low level immediately (usually through adulticiding) and to seek out the major breeding areas for treatment with chemical larvicides to reduce the risk of a resurgence in vector numbers. A similar approach may be used in the case of rare, unpredictable population explosions of pest species. These options are generally seen as a short term, rapid solution to a short term or emergency situation.

In general, these are once off situations where the usual environmental constraints are of less significance as the environment will recover. If the situation is more permanent or recurrent, reliance on chemicals incurs an increasing annual outlay for chemicals, and the possible cumulative adverse effects on the environment and non-target species should be considered.

In more permanent or recurrent problem situations, the options considered could include some longer term solutions such as removing breeding areas, or the stocking of problem areas with appropriate biological control organisms. These may be more expensive in the short term, but incur minimal ongoing expenses. There may be, of course, conservation or other reasons which will prevent consideration of such options as breeding habitat removal or alteration.

A possible approach may be to devote a portion of the annual control budget for the more permanent control options to gradually remove the source of the pest populations, whilst still using chemicals and other means for immediate control.

Management programmes relying solely on insecticides have no further backup if the operation is not successful. For example, adulticiding generally requires suitable environmental conditions for application. If these conditions are not met when the adults are first emerging or when the population is first active, dispersal of the adults will greatly reduce the effectiveness of the control operations. Retreatment cannot always be successful, and each treatment adds significantly to the expense.

Control of larvae at the breeding sites has many advantages. The population is confined by the size of the breeding ground. If the control option is not successful in reducing the numbers sufficiently, adulticiding can always be used as a backup procedure.

Therefore, it is wise to consider all options, and to attempt control of the earliest stages in the species life cycle as this allows for control of later stages should the first attempts prove unsuccessful. Similarly, all other means should be considered before chemicals as these, though effective, are the last line of defence.

ASSESSING THE SUCCESS OF CONTROL OPERATIONS

In any control programme, there is a need to be able to assess the success of the control operation. Earlier, we discussed how monitoring programmes and surveys are used as tools in the definition of the problem and in the direction of control operations. This data can also be used to determine the overall success of a control operation.

The first objective of any control operation is to set goals for the level of control which you wish to achieve. In the case of disease transmission, the goals should be to prevent any further human infections from occurring. For pest problems, the goals should be to reduce the pest populations to levels where the impact on the human population is at acceptable levels.

Setting of acceptable levels of pest activity is difficult. In general, the tolerance of different people to attacks by mosquitoes varies greatly, and there are marked differences between populations. Thus residents in the tropics generally accept that mosquitoes are a major part of the local environment, and seem to be more tolerant of their presence. The same is generally true of residents of rural or semi-rural dwellings. Urban dwellers, on the other hand, tend to be less tolerant of the pest activity. This is true whether they live in a large urban area such as Perth, or in one of the provincial towns such as Port Hedland. Local knowledge and experience is the only way of determining the tolerance limits of the people affected by the problem, and the acceptable pest population levels should be set below the average tolerance level.

Having determined what the problem is and set goals for the control operation, you must determine what type of data will give you information on its effectiveness. That is, a choice must be made as to which of the available survey and monitoring techniques will give the most relevant measure of the population fluctuations, and which will shed the most light on the success of the control operations.

In the final analysis, the success of any control operation must be measured in the context of the original problem. Did the operation achieve the desired level of control? Did it prevent further disease transmission? If not, why? Were the additional infections contracted in areas not within the scope of the control operation? If the desired level of control was not achieved, were there any indications as to where additional measures were needed to improve the overall success of the programme?

PUBLIC RELATIONS IN MOSQUITO CONTROL

In many instances, the pest problems experienced by residents can be traced to breeding within their own dwelling. A public education campaign may be used to increase public awareness of these breeding sites and indicate some simple measures which can be carried out by the individual householder to reduce the levels of pest populations within the area.

A similar approach may be necessary for chemical control operations. There is growing disquiet in the community to the widespread use of pesticides. This has, in some instances, led to the disruption of routine

control operations. It may therefore be necessary to have some form of public education campaign to explain mosquito control operations in order that they are acceptable to the public at large.

In the case of disease transmission, self protection is generally the best protection. The emergency control of vector populations is a major means of reducing the spread and transmission of disease agents, but personal protection is a necessary and very important adjunct to these measures. Information about personal measures should be readily available to the public.

PREVENTIVE PLANNING AS A CONTROL OPTION

Australia is the driest continent on earth. This is the reason, perhaps, why the people of Australia prefer to live adjacent to water (be it the sea or fresh water sites). Generally, these aquatic habitats are low-lying, and tend to be used as the outfall for storm water drainage. As such, there is much room for adverse environmental impact leading to the establishment of very significant and productive mosquito breeding areas.

The majority of significant pest problems in W.A. are the direct result of man's interference with the environment. Poor positioning of roads, inadequate provision for drainage, insufficient consideration of the nett outfall of drainage systems, all can lead to, or exacerbate, pest mosquito breeding. Waste water treatment and the discharge of effluent also contribute to these problems.

Given the fact that we can now identify many of the problem situations which result in significant pest breeding, it then becomes clear that some planning constraints could be imposed to prevent the recurrence of many of these problems. Some factors to consider are the enforcement of adequate buffer zones (based on the dispersal or pest range of major pest species) around known breeding areas. The provision that drainage systems should be extended into defined waterways, and end in such a manner that there is no possibility that they will create new breeding grounds should also be strongly considered. The location of roads in relation to surface drainage patterns, and the provision of well planned and adequate drainage under the road are also important.

If development around potential problem areas is considered, careful thought must be given to the overall and long term costs of mosquito management. Should the developer be required to rectify any problem mosquito breeding grounds as part of the development? Is it the responsibility of the local authority? If the problem areas are not rectified at the very beginning, the cost of control will eventually fall on all ratepayers, regardless of the degree to which they are affected by the pest species.

CHAPTER 7: SURVEY TECHNIQUES - DEFINING THE PROBLEM

Mosquito surveys involve the collection of data about the mosquito populations in a given area which can then be used to define the possible avenues for a mosquito management programme. It follows that the type of information needed may differ according to the type of pest or vector problem experienced. In emergency situations, the crucial need is for a rapid mapping of the actual and potential breeding grounds so that control procedures may commence as soon as the breeding sites are defined. Similarly, adult surveys will indicate the need for adulticiding in different areas.

For long term, or seasonally recurrent problems, the survey should indicate the most likely sources of pest mosquitoes. A monitoring programme at these sites will both indicate when control operations should commence, and evaluate the effectiveness of the programme.

Ask yourself why the survey is being carried out. What kind of information will give you the best understanding of the problem? Decide what kind of information you need, and choose those survey techniques which will provide data to answer your needs. There are a number of basic steps which should be followed when undertaking a survey.

PREPARATORY INFORMATION SEARCH

The first, preparatory stage, involves the collection of information and relevant data about mosquitoes in the area. Has any previous sampling been done in the area? Have any control options been tried? Have breeding areas been defined? All relevant information should be gathered together and reviewed.

The types of information which should be obtained are:

1. Reports and results of previous surveys, monitoring, control operations or complaints from the specific area.
2. Topographical, vegetation and soil maps of the area, with the largest scale available so that even small features are shown. Where possible, the maps should cover all locations for some distance (10km is a useful guide) beyond the limits of the area to be protected.
3. If possible, aerial photographs. These can indicate further wetland habitats by vegetation zones. Defining the vegetation zones is easier with coloured photography, though black and white photographs are also useful.
4. Record the availability, location and types of mosquito control equipment.
5. Contact any relevant authorities (Health Department; Conservation and Land Management; Environmental Protection Authority) to determine any environmental restrictions in the area, and to obtain any other relevant information.
6. Equipment necessary for the identification of the mosquitoes.
7. Relevant climatological and environmental data (e.g. tide tables) which may be locally significant.

VECTOR CONTROL MAP

The results of the data search can then be used to create a map of actual or potential breeding areas, in relation to human activity in the area. An appropriate buffer zone can then be imposed onto the map to give some indication of where the main sampling and survey sites should be located (Figure 7.1). This map can then be upgraded and modified as the surveys are carried out and new information is gathered.

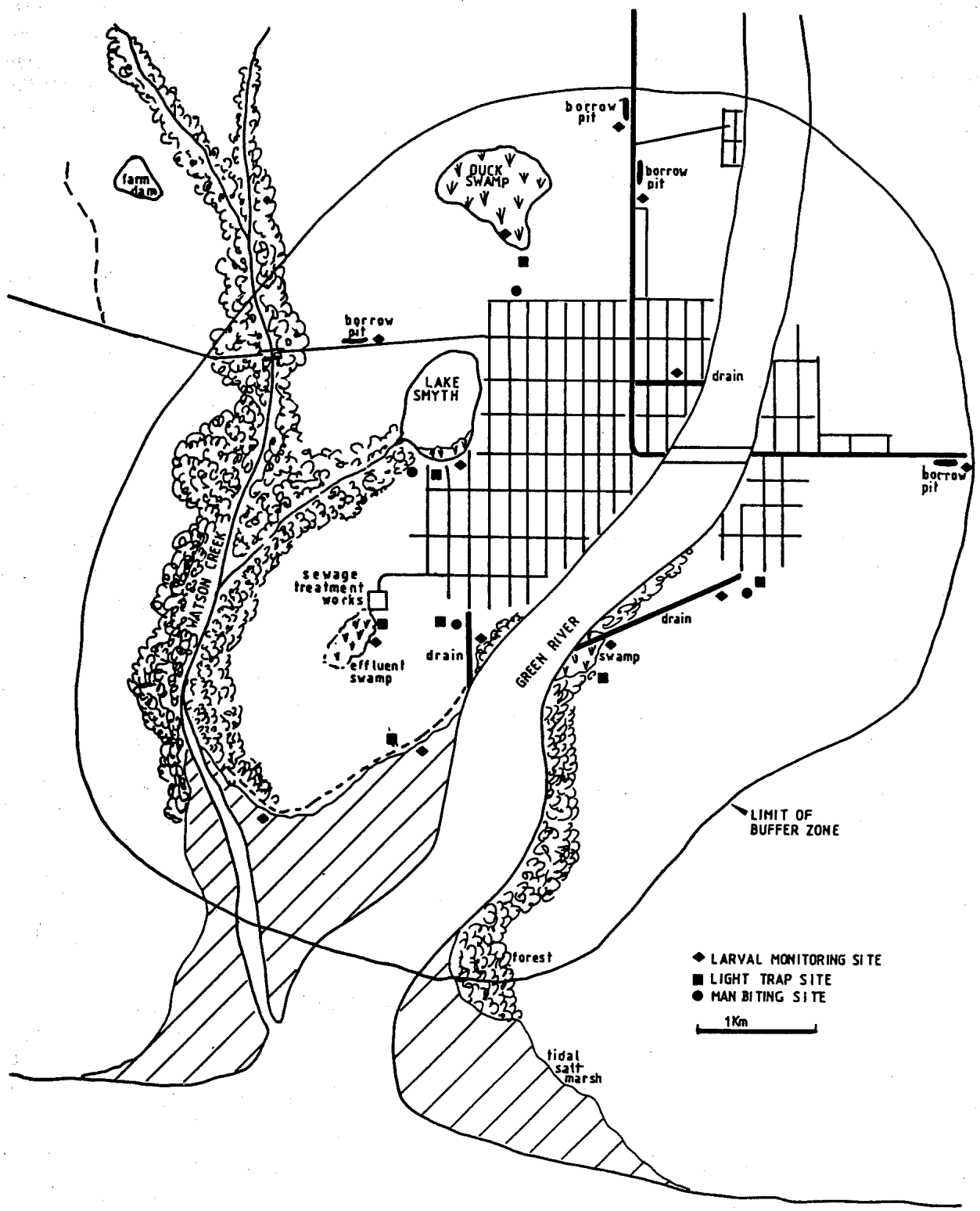
The map should include all relevant information: residential areas, recreation areas, roads, railways, land-use, concentrations of animals, areas of disturbed ground, storm drains, sewage treatment works, wetland habitats (dams, lakes, streams, swamps, borrow pits, depressions; with permanent sites separated from the more seasonal ones) and any coastal areas influenced by tidal inundation.

The location of the buffer limit is determined by the mean dispersal range of the main pest (vector) mosquito species. The buffer will have to be extended if it traverses important or extensive breeding grounds which lie largely outside the buffer zone or where there is dense vegetation forming a continuous sheltered dispersal route from distant breeding areas to the protected zone (Figure 7.1).

For the map to be accurate major features will have to be checked against recent reconnaissance data and the map modified to reflect the current status of the habitats. Many features may have been altered since the compilation of the information on which the vector control map was based.

This vector control map then forms the basis for determining the initial sampling points in the survey. As further data are added to the map, additional sampling sites will become obvious.

FIGURE 7.1 : VECTOR CONTROL MAP



MOSQUITO SAMPLING - LARVAE

The initial surveys of an area must begin by determining the relative importance of the wetland habitats (of all types) as mosquito breeding areas and should be completed within a few weeks. Adult monitoring may be used to confirm the results of the larval surveys. In some cases, the results of some adult collections can be used to locate less obvious breeding sites, though there are some species which have very cryptic larval habits, and location of the breeding areas is exceedingly difficult. It is known that males do not disperse far from the breeding grounds as this is where the newly emerged, virgin females are concentrated. Therefore, catches with a high proportion of males can often be an index of the proximity to breeding grounds. Similarly, sites where very large numbers of adults are collected distant from any known breeding area may also indicate the presence of as yet undefined breeding grounds.

a) The initial survey

The first thing to remember in undertaking a larval survey is that each species has its own habitat preference, and that the distribution of larvae is not necessarily continuous or random. The local factors which differentiate breeding areas from adjacent, barren wetlands may not be obvious to the casual or inexperienced observer. It is therefore necessary to sample widely in all habitats and to sample as many points within the one habitat as it is possible to maximise the value of the data collected.

If possible, the entire margins of all the potential breeding areas should be traversed and searched for larvae. Mosquito larvae are often concentrated at the margins of water bodies in sheltered or vegetated sites, and indeed may be very localised within a large area of essentially homogeneous habitat. Any relevant data (water entry and exit points, areas of high larval concentration) should be added to the vector control map. If such a detailed survey is not possible, a number of points along the margin should be chosen and surveyed fully.

All vegetation and habitat types should be sampled in order to build up an overall view of the ecology and breeding preferences of the species. If the particular habitat is extensive, sample at a large number of points within the habitat to maximise the chances of finding any breeding.

b) Sampling techniques

All larval sampling techniques involve the collection of a water sample and checking for the presence of larvae. Initial surveys are generally more qualitative in nature, and search simply for the presence or absence of species. As such, large containers (buckets, trays) or fine mesh sweep nets (made from bolting cloth - used for sifting flour) can be used to sample large volumes of the habitat. Small habitats may be sampled with enamel dippers or white painted 10 oz. soup ladles. Figure 7.2 shows some equipment used for larval sampling. The results are then recorded as presence or absence for each species, though some subjective index of abundance may be made.

A more quantitative approach is to take a number of samples from the immediate area, being sure not to sample the exact location twice. By retaining the same sampling container (bucket, tray, dipper) and keeping both the sample volume and the number of replicate samples constant, the average catch can be used to give a measure of the relative abundance of the species at different sites.

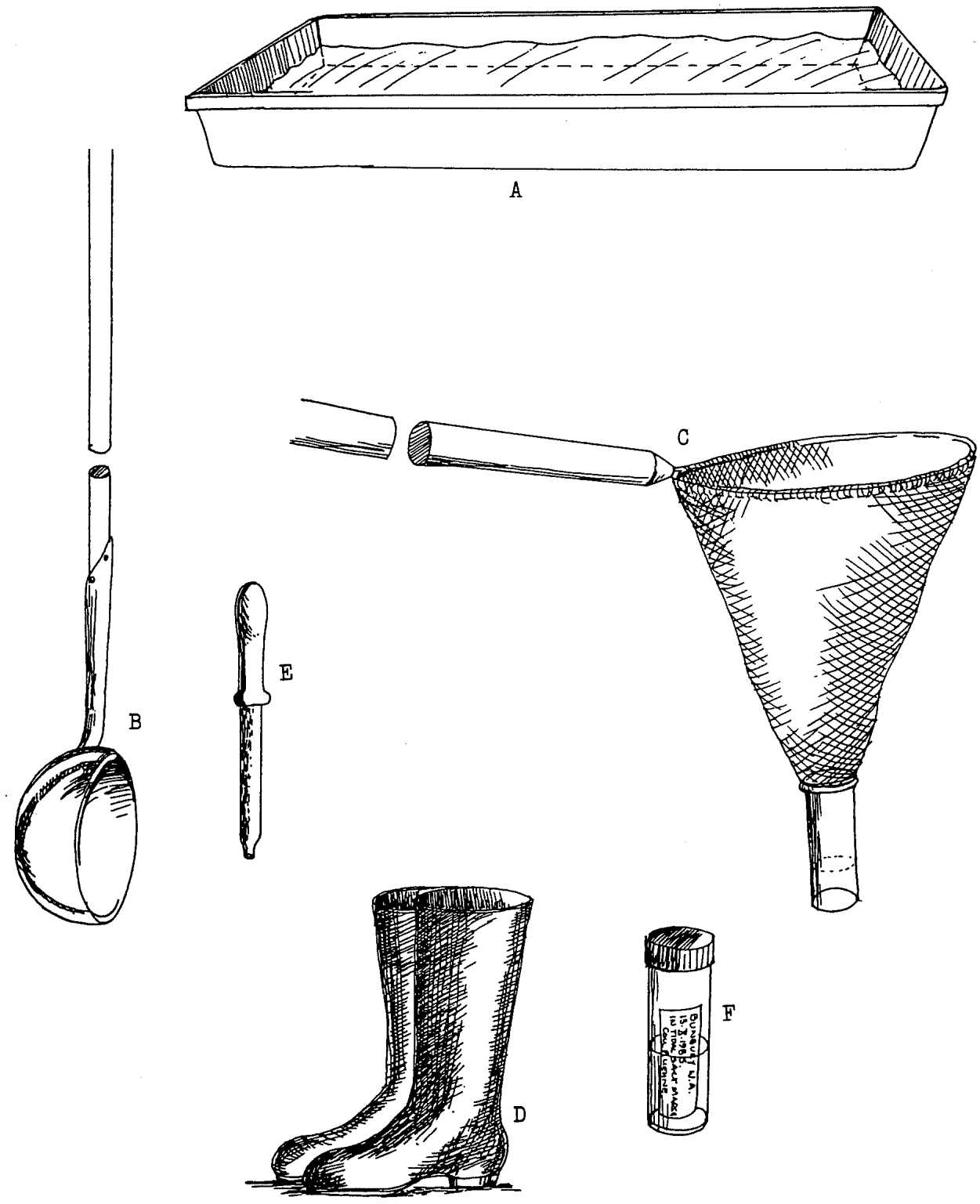
Each collection must be recorded in detail. It is often easiest to use a standard form for recording all relevant habitat variables so that there is no possibility of omissions (Figure 7.3), and to ensure that all collectors provide the same data. Larvae are often closely associated with particular vegetation groupings, and the gradual accumulation of this data will present a detailed picture of the species breeding preferences.

The larvae are removed from the sample with a small pipette and placed into 70% alcohol. It is preferable not to use methylated spirits as this will eventually blacken the specimen and render it useless for identification. Care must be taken that the larvae are treated gently as the loss of hairs from the surface will hinder identification. The sample should be labelled immediately in pencil, and the label placed inside the container with the specimen.

All the fourth instar larvae collected should be identified. The earlier instars are not easily identified to species level and are often recorded at generic level only.

If pupae are collected, these can be retained in a small amount of water from the breeding site within a simple cage (a jar with a mosquito mesh lid is sufficient) and allowed to emerge. The adults should be kept for at least 24 hours to allow full hardening of the cuticle to occur (they may be fed on a weak sugar solution soaked into a cotton wool pad placed on the mesh lid) and then killed and identified. If the adults are killed immediately after emergence, they will shrink and identification may be impossible.

FIGURE 7.2 : SOME LARVAL SAMPLING EQUIPMENT



A. ENAMEL TRAY - USED FOR LARGE DIP SAMPLES OR FOR SORTING SWEEP NET SAMPLES
B. LADLE - SMALL DIP SAMPLES
C. SWEEP NET - NON-QUANTITATIVE BUT EFFICIENT SAMPLING
D. GUM BOOTS, WADERS
E. DROPPER FOR SORTING LARVAE
F. CATCH SAMPLE WITH LABEL INSIDE TUBE - LARVAE IN ALCOHOL

FIGURE 7.3 : MOSQUITO LARVAL COLLECTION FORM

DATE: .....

TOWN:..... NUMBER/STREET: .....

LOCALITY:..... SITE:.....

TERRAIN: FLAT HILLS SWAMP

BREEDING FOUND: container - swamp - depression - crab hole - tree axil - sewerage pond - river - creek

WATER INFLUENCE: rain - stormwater - tidal - effluent - spring

WATER TYPE: fresh - brackish - salt - stagnant - polluted - semi-shaded - open sunlight - shallow - deep

WATER DEPTH: 2cm - 10cm ; 10cm - 50cm ; over 50cm

BREEDING IN VEGETATION: grass - reeds - water lilies

algae.....

VEGETATION DESCRIPTION: young/old - green/dry - standing/lodged -

open/thick - short/tall - reeds/grass -

leaves/decaying debris

LARVAL DISTRIBUTION: at edge - widespread

OVER HEAD VEGETATION: paperbark - mangroves - forest - open

SUBSTRATE: mud - silt - sand - gravel

PREDATORS PRESENT: fish - water beetles - water bugs - dragonfly larvae

REMARKS:–

AREA OF BREEDING:–

NUMBER OF DIPS	NUMBER OF LARVAE			TOTAL	AVERAGE NO. PER DIP	SPECIES
	INSTAR 1ST, 2ND	INSTAR 3RD, 4TH	PUPA			

c) Interpretation of results

If the sampling procedure is not standardised (using the same type of sampling container and the same number of replicates) comparisons cannot be made between sites. In large habitats, it is often important to wait until the first larva is seen in a sample before commencing the standard series of replicate collections. The average catch per sample can then be calculated, and can give a measure of relative larval density between sites. This index can then be coupled with a measure of the area of the potential breeding habitat to give an index of the importance of each breeding area.

Obviously, a site measuring 1m by 1m with a mean larval density of 39 per sample is a much lesser problem than a site measuring 18m by 1500m with a mean larval density of 1.5 per sample. The overall productivity of the latter site constitutes a very much higher risk.

It is most important that the survey use standardised techniques for gathering data. If the sampling methodology varies between samples, no evaluation of relative importance of sites, of seasonal trends, or confirmation of the impact of a management programme can be made. In the long term, this availability of standardised data can provide strong supporting evidence of the nature and degree of the original problem, and the impact of the management programme.

d) Monitoring programmes

When the results of the initial surveys are analysed, more permanent sampling points can be chosen for the monitoring programme on which the operations and evaluation surveys are based.

The sites to choose for the ongoing monitoring programme are those which have the highest relative larval densities, and those which constitute the most important breeding grounds. The sampling points should then be fixed. Care should be taken that there is permanent year-round access to the monitoring sites. The sites should be entered on the vector control map.

These sites should then be sampled regularly (weekly if possible) for a twelve month period to build up a picture of the annual pattern of breeding. Each weekly collection should be recorded on the standard form so that any environmental variables (such as changes in vegetation, tide, salinity, water depth) can be related to the observed larval densities.

Quite simple methods are available for measuring environmental variables, for example, habitat temperature can be measured by leaving a maximum/minimum thermometer on site and recording the weekly maximum and minimum temperatures.

An analysis of the breeding density relative to the habitat changes can give some indication of which environmental variables are significant in controlling the amount of breeding in the area.

It should be remembered that these sites may not be representative of all breeding sites throughout the year, as seasonal variations may lead to previously minor sites becoming major sources of pests. It is therefore important that a routine survey is undertaken of all sites at each season to determine whether any important sites are being overlooked.

e) Precautions

Continued sampling in a single site may, through depletion of larval numbers or actual physical damage to the site, lead to an alteration in the nature of the habitat. It is therefore important that the habitat is disturbed as little as possible during the monitoring programme.

MOSQUITO SAMPLING - ADULTS

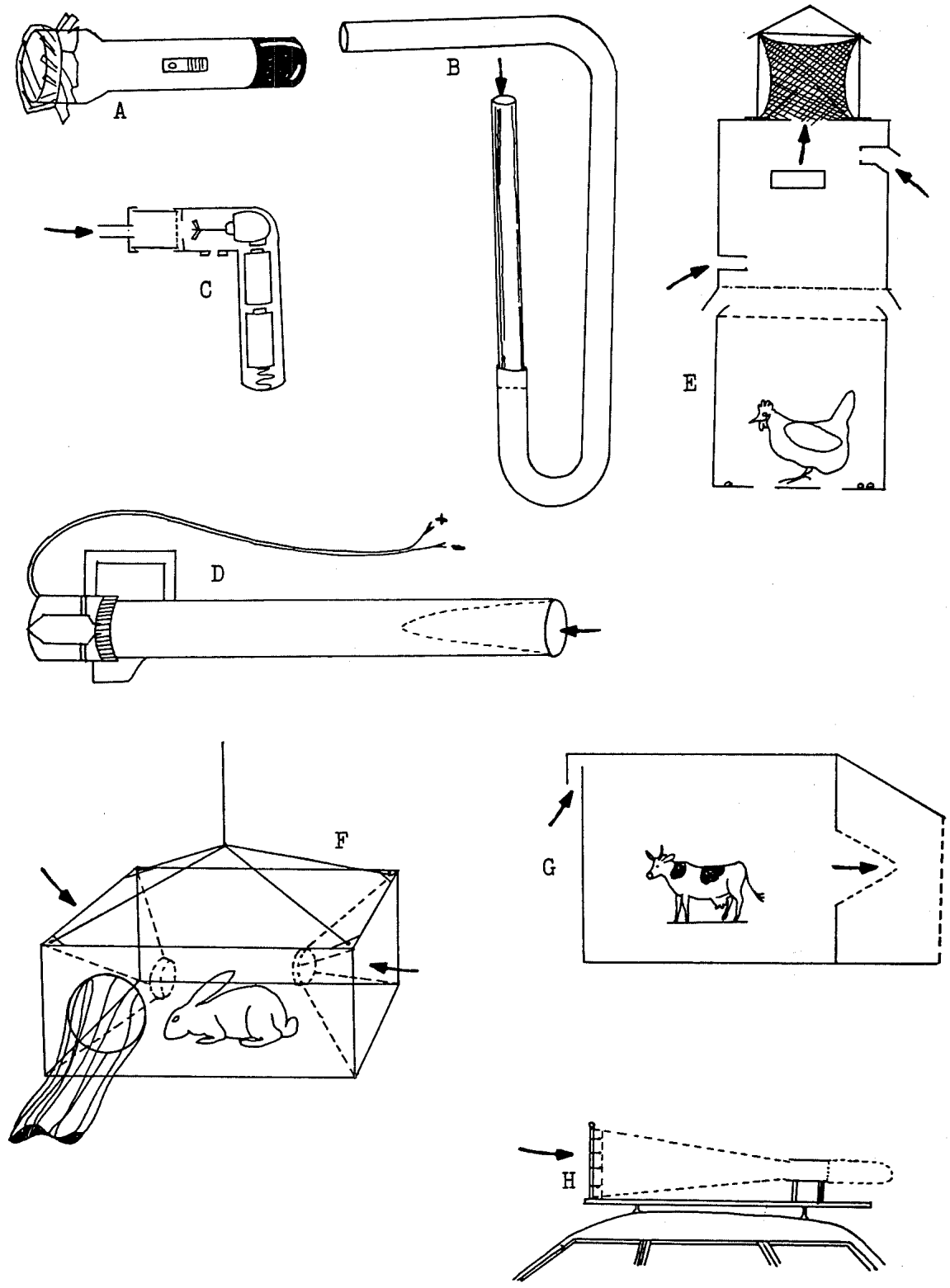
Many different methods can be used to sample adult mosquito populations. Each has its own bias, and each presents slightly different information about the pest mosquitoes. It is therefore wise to consider a number of different methods in initial surveys in order to build up a complete picture of the pest biology and activity. After a time, when sufficient data is available for comparisons between methods, a fairly consistent relationship between different methods may become apparent. At this stage, the easiest method which provides the most relevant information should be chosen and others may be discontinued. Similarly, if a method gives only limited information about the species, it need only be used for a short time to confirm that aspect of the pest's biology.

You need not choose the most efficient trapping method, as a less efficient method may give as accurate a pattern of pest population fluctuations with less effort needed for sorting and identification of samples.

a) Adult sampling methods

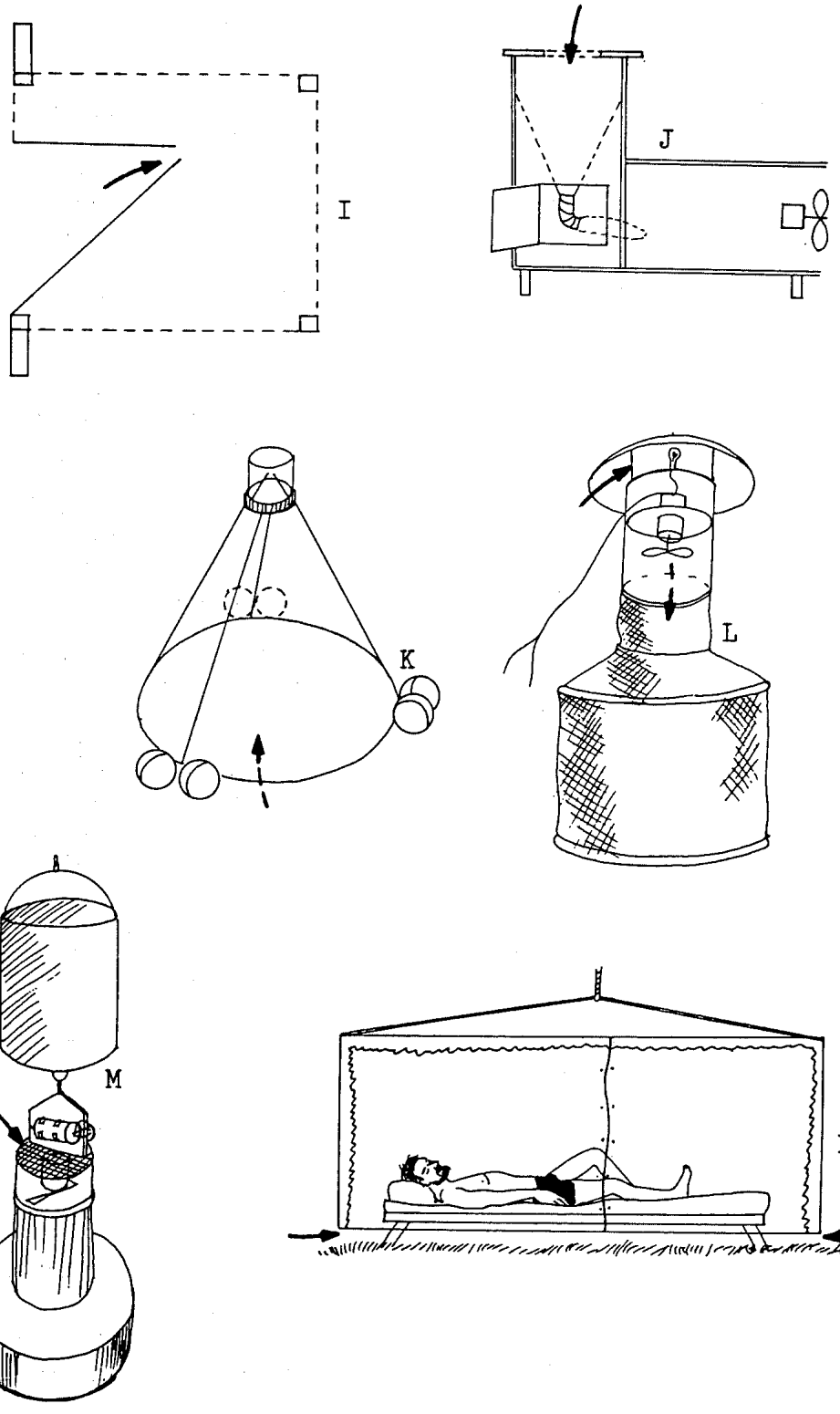
1. Man biting technique: This method involves the collection of those mosquitoes which actually bite man, and is usually carried out using a mechanical aspirator (or sometimes a mouth aspirator - see Figure 7.4) to collect mosquitoes biting the exposed leg of the collector. This method should not be used if there is a risk of disease transmission, but remains a crucial part of defining which are the major pest species to target

FIGURE 7.4 : SOME ADULT SAMPLING TECHNIQUES



A. TORCH WITH RED CELLOPHANE FOR MAN-BITING CATCHES
B. MOUTH ASPIRATOR - THE MOSQUITOES ARE BLOWN INTO A HOLDING CAGE
C. SMALL MECHANICAL ASPIRATOR
D. LARGE MECHANICAL ASPIRATOR
E, F, G. VARIOUS ANIMAL BAITED TRAPS (G. STABLE TRAP)
H. TRUCK TRAP

7.4 (CONTINUED) : SOME ADULT SAMPLING TECHNIQUES



I. WINDOW TRAP
J. SUCTION TRAP
K. EMERGENCE TRAP
L. CDC LIGHT TRAP
M. EVS/CO_2 LIGHT TRAP
N. NET TRAP

for control operations. The collections are made for a standard period (usually 15 to 20 minutes) from sunset, and the results usually presented as the hourly man-biting rate (the number biting per hour). Different people show different attractiveness to mosquitoes, and the results from two collectors are not reliably comparable. The advantage of this method is that it gives a direct indication of those species biting man. The disadvantages are that it is painful, anti-social (it requires the collector to be in the field during the early evening), and may carry some risk of disease transmission.

2. Animal collections and animal baited traps (Figure 7.4): These methods of sampling collect mosquitoes which are drawn to the bait animal. The main disadvantage of such collections is that bait animals do not necessarily sample those species which feed on man. Animal collections utilise a tethered animal, and the mosquitoes are collected using an aspirator. The results can be recorded as catch rate per unit time. Animal baited traps use a cage to trap those mosquitoes coming to obtain blood from the bait animal. These are usually left out overnight and give a nightly catch rate for the bait species. The mosquitoes are attracted to the animals by the carbon dioxide which they exhale, and this may be simulated by placing dry ice (solid carbon dioxide) in a trap similar to the animal baited trap.

3. Window traps (Figure 7.4): These traps are fitted into window openings and collect mosquitoes as they enter or leave houses. They give a measure of those species which will enter houses and feed indoors. This is a method which is used widely in malarious regions, and is particularly applicable to the analysis of vector diseases where there is no alternative host to man. As such, the method has limited applicability to the Australian situation, but may give further information on pest behaviour.

4. Net traps (Figure 7.4): Net traps are used to enclose a sleeping person and collect all the mosquitoes which come to feed during the night. The mosquitoes which come to feed are restricted from escaping and can be collected from within the net trap. The same restrictions apply as for man biting collections. The traps are generally kept in place overnight, and the mosquitoes removed in the morning. The results are recorded as catch per night.

5. Resting collections: These collections are made by using a large mechanical aspirator, or a sweep net to collect the adults from their normal day resting sites in the environment. The data from natural resting sites are difficult to standardise, and generally only give qualitative information on the location of the resting sites. This may be avoided by constructing artificial resting sites which can be repeatedly sampled to give a more standard collection. Resting catches may collect naturally blood fed specimens. The blood filled abdomen can be smeared onto a filter paper and precipitin tested to determine the source of the blood. This will give an indication of the natural host range and blood feeding pattern of the species.

6. Spray catches: A special case of resting catch is the spray catch. In this type of catch, the inside walls of a house are sprayed with a knock down insecticide and all the mosquitoes thus killed are collected. This gives a measure of the degree to which species enter and rest in houses, and is generally used as a guide to malaria control operations. Again, this has little relevance to most Australian mosquito problems. The technique, however, can be adapted to natural environments such as trees by placing sheets beneath the tree to collect any killed insects.

7. Truck trapping (Figure 7.4): These collections are made using a fine meshed, large funnel shaped trap mounted on the roof of a car. Flying insects are collected as the vehicle moves slowly through the countryside. The results give a fairly unbiased representation of those insects active in the area and can indicate activity times for the species sampled. If vehicle speed, wind speed and relative direction, time or run (relative to sunset) are kept constant, these collections can be fairly standard and may be compared from day to day. These collections have some disadvantages, particularly in that they sample a lot of 'junk' insects, some of which may damage the more delicate mosquitoes. Truck trap catches require a lot of sorting.

8. Suction traps (Figure 7.4): Suction traps consist of an electrical fan which sucks air through a filter which, in turn, retains the insects. The suction trap may be fixed and run nightly in the same location, giving standardised samples. This is a fairly unbiased collection technique and is particularly useful in long term monitoring programmes where the catch rate may be very low per individual night, but where any significant shift in overall population levels becomes immediately apparent by the slight increase in mosquitoes captured.

9. Light traps (Figure 7.4): Light is a general attractant for insects, and can be used to collect mosquitoes. There are a great number of light traps available. The basic features are a light source and a fan to suck the insects approaching the light into a holding bag or cage. The size, power supply and light source vary according to the design of the trap. These traps can collect very large numbers of insects. Advantages of this type of collection are: the traps are easy to set and run, and will function well unattended. The traps can be used to collect live insects, a necessary feature in the study of disease transmission. Light traps often will collect males, and may therefore be used to indicate the presence of breeding areas. These traps will sometimes collect females which have taken a recent blood meal and these can be used to determine the

blood host range. The major disadvantages of the traps are that the specimens can sometimes be damaged by beetles or moths which are attracted into the traps; the traps often will collect many insects other than mosquitoes, and this may necessitate some sorting of the catch; and the actual numbers caught may be quite high, resulting in a great deal of time for sorting and identification.

10. Encephalitis vector survey/carbon dioxide trap (EVS/CO2 trap) (Figure 7.4): This is a modified light trap design which utilises CO_2 as a primary attractant, with a very small (grain of wheat) light to focus the insects into the path of the down draft caused by the fan. Because the light is so small, the trap collects mainly those individuals actively seeking a blood meal (i.e. initially attracted by the CO_2 gradient), and thus captures mosquitoes with very little 'trash'. This trap has become the standard method for sampling adult mosquito populations over the past few years. Advantages of the trap include sturdy portability and trash free catches. The main disadvantages are that the trap collections are generally very large, necessitating much time spent in sorting and identification. Also, the trap collects mainly adult females and rarely males. The final disadvantage is that the trap requires dry ice to work and will not collect any insects without the bait. There must therefore be a ready source of CO_2 to utilise this type of monitoring programme. This can, in some cases, be overcome by making CO_2 blocks from gas cylinders using portable dry ice making machines.

11. Emergence traps (Figure 7.4): Emergence traps are simply large cages placed on the surface of the breeding habitat, which collect the newly emerged adults. The trapping method gives an index of productivity of a breeding site as it is based on suspected or confirmed presence of larvae. It does have some application in the study of arboviruses as it provides a collection of virgin, unfed mosquitoes which may be checked for the presence of transovarially transmitted virus.

b) Sampling procedure

The comparability of the results between different sites depends on the degree to which the collections are standardised. That is, the same trap type must be used and be set in a similar manner for the same length of time. For example, the traps should all be set at about the same height above the ground, and should all be set before sunset and retrieved after it is light. Care should be taken not to leave the traps for too long a period after light, as the sun may kill the insects and they may shrivel and be difficult to identify.

Once the catch has been retrieved, the insects should be killed. This can be done by using the commercially available killing agents (ether, ethyl acetate, chloroform), by placing the catch bag into the freezer compartment of a refrigerator (though this can damage the insects) or into the supply of dry ice, or by using commercially available insecticides (transfer catches out of catch bags before using insecticides so as not to contaminate the catch bag and possibly affect later catches). The best form of insecticide to use is the pest strip variety, as the insecticide is not carried in a fluid form. Spray insecticides should be avoided as the carrier fluid may discolour the insect and make identification difficult.

Any environmental variables which may affect the catch (wind, cloud cover, rain, temperature, moon cycle) should be recorded. For man-biting catches, additional data (collector, catch period relative to sunset, closeness of breeding areas, closeness of other people or animals) should also be recorded, and provision made for calculating the hourly man-biting rate. It is a wise practice to use a standard form (e.g. Figures 7.5 and 7.6) to record the collection data so that no relevant information is overlooked.

c) Survey techniques

The initial adult survey should include trapping points at all the major breeding sites, at the urban area where the pest problems are felt, and at strategic points in between (e.g. vegetation belts, possible dispersal paths). The analysis of these results should allow the choice of permanent sites for ongoing monitoring.

The choice of long term monitoring sites for adults should reflect the status of the pest breeding areas. Sites near to the major breeding grounds should be monitored. Sites in any dispersal pathways and at the urban boundary closest to the breeding areas should also be chosen.

The success of a long term monitoring programme depends on the reproducibility and comparability of the monitoring results. It is therefore important to choose sites carefully. Avoid windy sites as strong winds will invariably diminish mosquito activity. Once a site is chosen, it should be carefully marked and sampled in the same manner on each occasion - to the extent of placing the trap on the same branch of the same tree.

d) Interpretation of results

Once all the mosquitoes captured in each collection have been identified, the results can be compared. Remember that only collections using the same method are comparable directly. If there is a trap failure, the result must be ignored (though it may give a qualitative answer about which species are active in the area). Note should also be made of traps which are running slowly or intermittently as the resulting collections will not be standard.

FIGURE 7.5 : ADULT MOSQUITO TRAP RECORD FORM

TOWN:..... LOCALITY:.....

TRAP TYPE:.....

Trap Location:..... Wind Speed:.....

Date Set:..... Wind Direction:.....

Time Set:..... Rainfall:.....

Hours Operational:..... Temperature:.....

Approximate proportion of mosquitoes in catch:-.....

Species		No. Females	No. Blood Fed	No. Males
Anopheles	Culicines			
TOTAL				

Collection Date:.....

Collector:.....

FIGURE 7.6 : ADULT MOSQUITO SURVEY FORM – MAN-BITING COLLECTION

INDOORS/OUTDOORS:

TOWN:.....

COLLECTION SITE:.....

SEASON:..... wet – dry
fine – rain
cloudy

No. of Collectors:.....

Collection Method:.....

Parous Rate:.....

Distance to nearest major breeding site:.....

Locality:.....

Temperature:.....

Humidity:.....

Wind Speed:.....

Wind Direction:.....

Building: Low level – piers

screened – unscreened

faulty

Time	Collection Period	Species		No.	No. man/hr.
		Anopheline	Culicine		
6-7 pm					
7-8					
8-9					
9-10					
10-11					
11-12					
12-1 am					
1-2					
2-3					
3-4					
4-5					
5-6					

Total.....

Total per man per hour:.....

Collection Date:.....

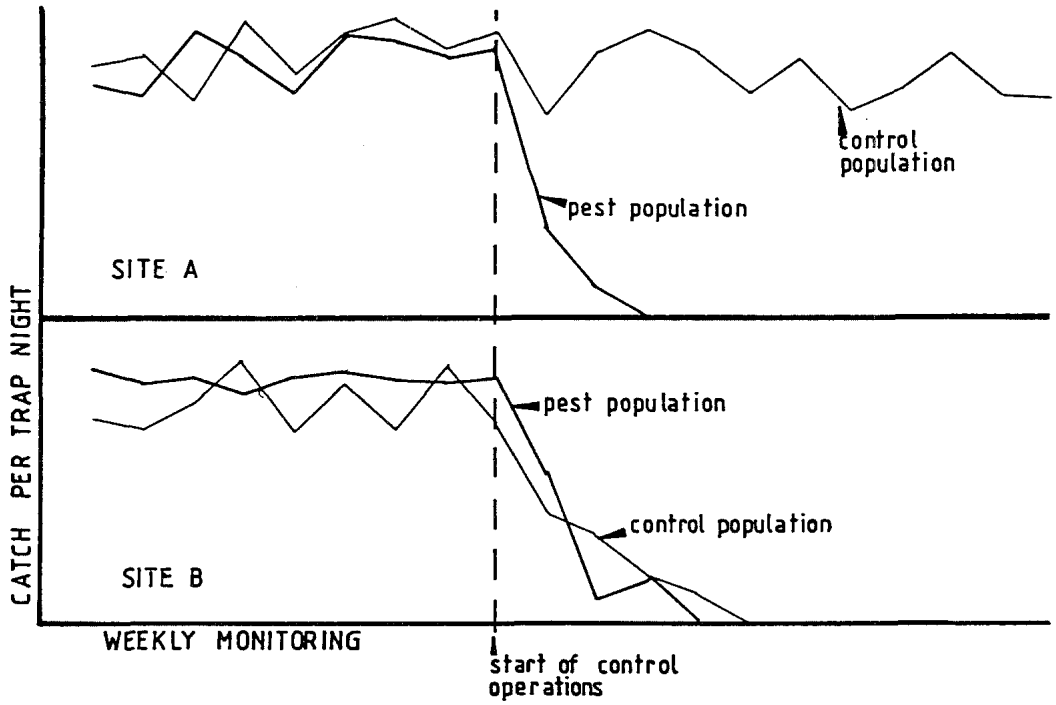
Signature of Collector:

.....

Having identified the mosquitoes, the results of collections at each site may be tabulated or graphed to show trends in numbers of each species through time. These graphs may then be compared between monitoring sites and an explanation sought for any differences between graphs from two sites. The answer may lie in the distribution of breeding grounds, or in the location of the main dispersal pathways, or changing environmental conditions.

Control sites should be used, particularly during the first management operations. The control site is a location distant from any insecticiding or management procedures, where the natural population levels can be monitored. A comparison of the results between this site and the managed site will confirm the effectiveness (Figure 7.7 - site A) of the management scheme. If the plots at both sites are the same (Figure 7.7 - site B), it indicates that the population decline may be part of a natural cycle and not necessarily the result of the management scheme as practised. The use of control sites is not feasible in many situations, but if possible, they should be used to confirm the effectiveness of insecticide application.

FIGURE 7.7 : THE USE OF CONTROL SITES IN MOSQUITO MANAGEMENT PROGRAMMES



Always remember that different catch methods cannot be compared directly. The same is true of man-biting catches from two different collectors. If you wish to make such comparisons, the two traps should be run side by side for a number of nights and the collection results for each species compared. A statistical analysis is necessary to confirm that the relationship is consistent. For example, you may wish to compare the hourly man-biting rate at dusk with an overnight light trap collection to determine whether the light trap data can be used to predict the man-biting rate.

Another feature which may be correlated to catch rates is the level of complaints. It may be possible to determine the minimum light trap catch rates which coincide with complaints of pest activity. In this case, the monitoring programme may be used to predict when populations are reaching this 'pest threshold', and preventative control operations can be implemented.

e) Choosing between adult monitoring methods

The prime reason for undertaking an adult monitoring programme is to obtain relevant information about the pest/vector in question. In the initial stages of the investigation when little is known, many different types of information need to be gathered. Which species bite man? Do they bite in- doors? What is the seasonal variation in the pest/vector populations? Do the species disperse far from the breeding ground? Do they feed on animals other than man? How long do they live under the local conditions?

In order to answer these questions, a variety of collection methods may need to be employed in the initial stages. Once the specific data are available, some of the collection methods, unless they yield other valuable information, can be omitted.

In the long term, it is necessary to pose the question as to what exactly is the monitoring programme trying to achieve. It is then necessary to look at the different methods available, and choose the most appropriate for the programme. One method may give excellent results but may be very time consuming (e.g. because of the numbers captured) or may be costly to run. An alternative method may only give 80% of this data, but may only require 10% of the effort or cost of the former method. If the 80% data are sufficient to answer the questions posed originally, then the second method is the one to choose.

For example, EVS/CO_2 traps are highly efficient, often capturing many thousands of mosquitoes in a single night. These traps are often used in monitoring programmes because of their efficiency. However, in a long term analysis of vector populations to determine when numbers are reaching critical levels for possible disease transmission, a suction trap which collects from zero to five individuals per week under normal conditions and ten to twenty at critical population levels may be a simpler, much less time consuming method to use.

CHAPTER 8: PHYSICAL AND CULTURAL CONTROL

PART I : PHYSICAL CONTROL

In general, two main types of physical control are practised. The first, and most important is the management of breeding grounds (source reduction). The other physical control methods are those which act on the adults, and prevent them from reaching man. There is a vast array of measures which can be invoked to physically control mosquitoes in any particular problem area. This review will not go into details of the engineering design of the various procedures, but will concentrate on the features required to control mosquito populations, and will point out which features, if they are poorly designed, can exacerbate the problems.

In order to determine the potential for physical control options, the problem must be defined in some detail. Possible avenues for control must be evaluated in the light of the biology of the pest in question and the nature of the pest problem to be controlled. The considerations which must be accounted for are discussed in Chapter 6.

It should be remembered that the sites must be defined in terms of the potential for mosquito breeding. Therefore, what appears to a civil engineer to be an insignificant water body, may in fact be highly significant in terms of mosquitoes. Among the most common and widespread mosquito breeding areas are borrow pits and the outfalls of drains where the water is left to disperse through 'natural surface flow'. Similarly, the physical control options can be defined in a similar manner - in terms of the pests' biology. Thus a drain which appears to the engineer to be insignificant, can have the desired result at a fraction of the cost of a larger scheme.

When confronted with a problem, the first questions to ask about the breeding areas are: Is the site a natural site? Is it man made? Has it been disturbed to any degree, and if so, to what degree? Does the site have any intrinsic ecological or aesthetic value which may preclude the implementation of physical control options? Are there any legal or other restrictions as to what can be done at this site? What sort of interactions does the site have with adjoining habitats, and what effects will the removal of the breeding area have on these habitats? The answers to these questions will, to a large degree, determine the applicability of physical control measures to any breeding area.

If the option of physical control of a natural wetland is considered within the context of an overall management scheme, advice will have to be sought from the relevant state authorities, particularly the Environment Protection Authority and Department of Conservation and Land Management.

The final decision as to whether any physical control option will be chosen to remedy the situation will depend both on the answers to the above questions and the relative ease and cost of physical control measures as opposed to other forms of control. Do not reject physical control options out of hand. They may not be as expensive as you think since the form of the control needs only to be sufficient to prevent breeding and need not be on a grand scale. Costings should also look at the relative long term costs of alternative methods.

SOURCE REDUCTION (PHYSICAL CONTROL OF LARVAE)

Source reduction measures include all the methods which can physically remove or alter the larval habitat such that breeding is restricted or completely prevented. The measures must be allied to the biology of the species to be controlled.

The following discussion lists the main techniques used in source reduction, and presents the main considerations for analysing the design and applicability of each method.

A. REMOVAL OF LARVAL HABITAT

a) Filling

Filling operations may simply be a levelling of an undulating disturbed area such that no ponding occurs, or it may entail the importation of large amounts of fill to remove larger sites (e.g. sanitary landfill). The basis of the measure is to remove any low-lying areas which may hold water and become breeding grounds. As such, the method involves a once off cost, and should, if carried out correctly, require no maintenance.

Occasionally, natural silt laden streams may be redirected into a problem area and the natural deposition of silt be used for rectification of the problem. This can be simulated through the use of hydraulic pumping of silt laden water into an area.

Filling is a method which is suited to problems where there is a vast area of disturbed ground, such that the actual breeding areas are individually small and discrete, but cumulatively are significant. Other control operations (e.g. larviciding) would therefore be both time consuming and expensive, and a simple fill

operation would remove the breeding. Obviously, the use of filling as a control method for large breeding areas depends on the availability of special equipment, the availability of a suitable source of fill, and budgetary constraints.

Prime considerations when considering a fill operation are: What is the source of the fill? Will the removal of the fill from the original site result in a new breeding area at that site? Is there any possibility that erosion may result at either the control site or at the origin of the fill? If sanitary land fill is used, will any leachate from the dump site spill into natural habitats, either directly or through the soil?

Erosion and subsequent deposition of silt often results in the disruption of natural drainage patterns and the formation of marshes or swamps which can become major breeding areas. This should be avoided at all costs. The problem of organic and industrial pollution is also a serious one. Such pollutants generally reduce the viability of any water body and reduce the diversity of aquatic species (including predators). Some mosquito species (e.g. *Culex quinquefasciatus)* are adapted to such polluted habitats and may prosper as a result. Some considerations must also be given to the type of soil cover, vegetation and landscaping of the completed landfill operation.

Fill should be considered for any depression, natural, man-made or artificial, (e.g. abandoned septic tanks or wells) which cannot be dealt with by other means.

b) Draining

As above, drainage of the breeding site must be allied to the biology of the particular pest. That is, if larval development time is short, the drainage of the site must be rapid to prevent any emergence. If development time is longer, the drains may be smaller and the drainage time increased, with the critical feature being that the site is emptied within the larval development time before emergence occurs. The rule is to use the minimum structure necessary to achieve the desired result.

Drains may be as small as a simple hand made ditch which may have a depth of only ten centimeters or they may be on a much grander scale. The type of drain considered will therefore reflect the size and importance of the breeding area to be controlled. Various types of drains can be used (open ditches or subsurface drainage), each with its own cost structure, advantages and disadvantages.

Prime considerations in drainage programmes are: What will be done with the spoil? What design features should be incorporated into the drain? Will there be any problems with erosion and/or siltation? What is the likely need for maintenance of the drains? Where will the drain outlet be, and what are the likely effects of the water at the outlet?

The drains should be designed so that they are self regulatory, particularly when there are significant flows. The base of the drain should not be broad and flat (as this will favour siltation and swamp formation) but should have a defined steep sided central runnel to ensure that the water is always concentrated into this channel and is always flowing. This design has two advantages. Firstly, the drain will tend to clear itself of silt during flows. Secondly, the floor of the drain will be less hospitable to plants, and so it will not be colonised readily. Plants in the floors of drains tend to trap silt and can lead to rapid blockage of the drain and swamp formation.

The spoil from drains should be removed from the site or placed in discrete locations where it does not impede normal surface water flows. It follows that in larger operations (depending on the characteristics of the site) a combination of fill and drainage will allow the spoil to be used to fill minor sites whilst the major ones are treated by drains.

A major consideration of a drainage programme is the outfall of the drain. It should be directed into a defined drainage line (creek, river) or to the sea. Some features to consider are: What is the quality of the water in the drain? Will there be a silt load and what effect will this have at the outfall? Is it necessary to incorporate silt traps which may have to be periodically cleaned? Will the increased water input into the outfall site have a significant impact on the ecology of that site? Storm and road drainage often carries a great deal of fertilizer and other nutrients, and continues to run throughout the year. This continual input of nutrient rich water can alter the natural ecology of water bodies leading to very lush and dense swampland mosquito breeding sites which can be exceedingly difficult to manage.

The maintenance of drainage systems can be minimal or complex, depending on the local climatic conditions and the design of the drain. The local conditions (topography, climate, water table) may, because of seasonal flooding or peak flow levels, result in the drainage system being larger than is dictated by purely mathematical considerations.

The general maintenance considerations for drainage systems are the rectification of erosion, removal of silt or other blockages, removal of vegetation, rectification of scour holes or depressions in the bed of the drain and ensuring that the outfall is kept clear.

c) Pumping

In some instances, a site may not be amenable to either filling or draining, and pumping may be seen as an option. The water may be used for irrigation or infiltration into the surrounding soils. This is an expensive option, but may be applicable in some instances.

B. MANAGEMENT OF WATER BODIES

a) Large man-made impoundments

These include large dams, farm dams, ponds, and moderate to large impoundments such as sewage treatment ponds. The design features which must be incorporated into these impoundments are discussed below.

There needs to be some provision of silt controls so that there is no siltation at the point of water entry as this may lead to formation of swampy marshland suitable for mosquito breeding. The amount of vegetation in the impoundment must be kept to a minimum. The impoundment should be steep sided and deep, with a relatively level floor. Mosquitoes generally breed in the vegetated margins of impounded water bodies, and the steep sides and deep level floor will help limit the impoundments suitability for colonisation by plants. Care should also be taken to minimise erosion of the banks.

Some species (e.g. *Anopheles* species) shelter among floating debris at the margins of water bodies. The management of the water levels to strand any flotsam on the banks, will therefore be useful to reduce breeding of these species. There is also a need for the initial clearing of the site to reduce the amount of debris upon initial filling of the impoundment. Fluctuations in water levels can also flush the larvae sheltering among the vegetation into the open water where they are more exposed to predators.

Any seepage of water through the walls of the impoundment should be stopped. Such seepage can result in significant breeding areas being formed adjacent to the impoundment proper.

Animal access to the margins of the water body should be restricted wherever possible as the disturbed edges (hoof prints, wallows) often form excellent breeding sites.

There should be provision for vehicle access to all margins of the impoundment so that control operations may be carried out in emergency situations.

Some impoundments (e.g. sewage ponds) must have provision for waste or excess water disposal. Sewage ponds can be a particular problem as the nutrient rich waters can lead to very lush and dense stands of vegetation which can support very large mosquito populations. The prime consideration in this case is how to dispose of the treated effluent without exacerbating the breeding of pest mosquitoes. Some solutions are flood irrigation, evaporation bays, infiltration into porous soils, discharge into rivers or into the ocean or reuse of the treated effluent.

b) Small man-made impoundments

In general, small impoundments all suffer from the same problems. They are generally seasonally filled sites which are dry for part of the year. The design of these is important for managing their suitability as breeding sites. If possible, you should avoid the creation of such sites at all costs. Borrow pits, small scale extractive mining, and drainage under roads, railways or other services should be designed so that they are free draining. If this is not possible, the pits should be deep and fairly steep sided, possibly so that they are perennial and may support permanent populations of predators (e.g. fish), whilst vegetation is kept to a minimum. Obviously this design criterion is somewhat the antithesis of child safety requirements. It is therefore even more obvious why the situation should be avoided in the first place.

c) Tidal areas

Tidal areas may be controlled in a number of ways. The salt marsh breeding grounds may be drained through a network of interconnected drains. The drains should connect all the low points with the open sea or to a major river. Thus, even though the entry of the tide may be facilitated by the drains, the run-off is fast and any mosquito larvae will be flushed from the breeding grounds as they drain.

An alternative is to use a series of bunds and tide gates to exclude the tidal inflows from known breeding areas. The same bunds and gates could be used to retain the tide waters where the hatching of the eggs is dependent on changes in water levels (e.g. the worst of the salt marsh pest species, *Aedes* species). These flooded areas can then be stocked with appropriate predatory fish to control the mosquitoes present. If the area is permanently flooded on a larger scale, the deep flooded area must be stocked with fish and must be prepared by removing all vegetation and debris. The water levels of the flooded tidal marshes must be maintained at a fairly constant level to prevent hatching of the pest mosquitoes. This may be done through active pumping, tidal inflows at high tides, or by the direction of storm or other drainage from the land into

the bunded area. If fresh water is directed into the impoundment, it may eventually become a fresh water environment in place of the old saline or brackish breeding zone. Care must be taken to ensure that the bund walls are stable, and that no seepage or erosion occurs.

A further solution may be to reclaim the area for urban or rural development. Again, the form of the bunds is important during the reclamation procedure, and provision must be made for internal drainage during the reclamation process.

d) Irrigation areas

Irrigation areas can be prime sources of pest and vector mosquitoes. Breeding can occur in the water impoundments, the irrigation canals, the irrigation bays themselves and also in the drains, outfall, and retention basins for the used irrigation waters. Most of the considerations applicable to irrigation areas have been discussed in the above sections. Irrigation bays should be kept level so that no ponding occurs when the irrigation water is released. The irrigation canals and drains must be kept free of weeds and the levee banks maintained such that there is no lateral seepage. The flow of fertilizers in the drains poses a considerable problem. Not only does it promote weed growth in the drains themselves, but also leads to increased nutrient loads at the final outfall from the irrigation system.

e) Environmental management

There are many minor alterations to the management or form of wetland systems which may be used to reduce the breeding of particular pest mosquito species. Each of the methods must be evaluated in the light of the biological requirements of the pest species which you are trying to remove. These methods must not be used without careful consideration of what the resulting habitat will be like. It is quite likely that the modifications may result in the replacement of the original pest by another, possibly worse, pest.

1. Varying the quality of the water: The quality of the water in a breeding habitat may be altered by directing fresh or saline waters into the site. Similarly, polluted waters may be used to alter the pH or organic content of some waters and render them unsuitable for the breeding of some species.

2. Vegetation control: The removal of vegetation to alter the levels of protection for the larvae, or to reduce shade cover, can be used to reduce the suitability of some sites for particular species. Vegetation control may be achieved by physical removal of plants, by herbicide application, or by varying water levels in impoundments to strand aquatic vegetation. This last method may be counterproductive in some instances as when the impoundment is refilled, the rotting vegetation will drift to the shore and lodge in the shallows where it becomes a ready source of nutrient for species which can resist the periodic drying out (e.g. the bulrush *Typha* species).

The addition of shade trees around some breeding areas may reduce the suitability of the site for species which prefer to breed in open, sunlit waters.

3. Flushing: It may be possible to design into impoundments a system allowing for periodic release of water to flush out possible breeding grounds below the impoundment.

4. Retention of water: The longer a water body is established, the more complex the associations of plants and animals which live within the water body become. This includes potential predator species. Thus, retention of water within temporary impoundments for longer periods of time may eventually lead to reduced breeding.

As mentioned above, any technique which aims to modify the breeding habitat, to reduce its suitability for a particular pest, will need to be evaluated in the light of the biological requirements of other pest species so that you do not simply replace one pest species with another, or permit breeding of a vector of disease.

OTHER FORMS OF PHYSICAL CONTROL (ADULT MANAGEMENT)

Other forms of physical control are those which place some physical barrier between the pest species and man. These include such measures as the simple provision of insect screening on houses. This is generally seen as the last line of defence, though perhaps the most crucial to your comfort.

The environment may be managed to reduce the amount of lush vegetation (flypaths) joining the urban area with the breeding ground. If this intervening area has low vegetation and is windswept, fewer mosquitoes will reach the urban area. Local climatic conditions such as humidity, wind speed and direction, and rainfall will be the most significant determinants of dispersal patterns, but management of the vegetation may be significant in some instances.

Urban lighting may be a non-specific attractant for mosquitoes, and the provision of lighting adjacent to known but distant breeding areas may reduce overall dispersal into the urban area in some cases.

PART II : CULTURAL CONTROL

We can avoid many mosquito problems simply through the way we live. Cultural control includes all those techniques which reduce the degree of contact between man and the pest or vector mosquito species. In the long term, success of cultural control measures depends on the knowledge and understanding of the general public. As such, it must be reinforced through public awareness campaigns.

a) Self protection

The most obvious measures for self protection are the avoidance of those areas where mosquito problems are likely. That is, keep clear of the pest breeding areas, particularly at dusk. Similarly, if problems are seasonally apparent, avoidance of outdoor activity at dusk during the peak mosquito season may be a way of alleviating the problems. The houses themselves should have well maintained and adequate screening in place. The avoidance of problem areas entails some recognition of the degree of risk of attack at any site.

It is best to avoid potential problem areas whenever possible when camping. These can be recognized by the presence of dense vegetation, swampland or marshlands or mangrove forests. People always wish to camp near to water, but may be increasing the risk of severe mosquito attack by doing so. Camping equipment should be well maintained with adequate screening.

The choice of clothing may be of help. Long sleeves and trousers reduce the area of skin exposed to the bites of insects, and consequently give some measure of protection. Light coloured clothing is less attractive to mosquitoes than dark coloured. The use of personal repellents (e.g. diethyl toluamide (DEET)) can further reduce attack rates (but see Chapter 9: Chemical Control).

b) Source reduction around the home

Many of the pest problems in urban area are due to domestic breeding. If the breeding sites can be located, simple measures can be used to remove them, or to reduce the likelihood of pest breeding.

All containers (tins, tyres, pot plant containers, jars, etc.) should be removed or holed such that they do not hold water, or filled with sand or an equivalent. Larger water pools (fish ponds, swimming pools) should be well maintained and, for fish ponds, well stocked with fish. If fish ponds or tanks are not stocked with fish, then they must be emptied.

Septic tanks and rain water tanks should be adequately screened to prevent access by mosquitoes. Alternatively, a film of light oil (e.g. paraffin, kerosene) may be applied to the surface of stored waters to prevent breeding.

Gutters should be kept clean and free draining, so that ponding does not occur.

Avoid leaking taps which can form ground pool breeding areas. Over-watering of gardens and lawns may add to breeding sites around the home.

In the tropics, where ant traps are used to prevent ants from climbing onto furniture, a small amount of salt should be placed in the ant trap to reduce breeding of domestic species.

The location and lushness of domestic gardens may also contribute to the pest attack rates in a particular area. The mosquitoes generally seek humid, sheltered sites as resting sites, and domestic gardens can provide such sites adjacent to the house. The types of features to avoid are the placement of dense lush growth abutting the walls of the house, particularly near doorways. The more open the garden, the less likely that it will be a harbourage site for mosquitoes.

Mosquitoes are attracted to light, and the use of 'non-attractant' yellow lights in exposed exterior positions is a means of reducing the influx of pests into the immediate vicinity of the house.

c) Planning

The location of urban developments, or the extension of urban areas should be evaluated in terms of the distribution and extent of adjacent breeding grounds. In general, it is wise to maintain an adequate buffer between any known breeding area and any proposed urban development. As a general rule, the buffer can be kept to about 1.5 to 2.0 km though in some cases a larger buffer of 5 km or more may be considered.

Continuous belts of dense vegetation which join breeding areas with the urban development should be avoided as these will provide sheltered flypaths facilitating dispersal into the urban area.

The considerations mentioned in the above discussions of physical control options should be kept in mind and used as a guide for the prevention of new breeding sites as a result of the poor location of services or of the inadequate planning of water use and disposal.

Planning may also be crucial in preventing development in known problem areas. If development of such areas cannot be prevented, then development plans should include rectification and elimination of pest or vector mosquito breeding within the 1.5 km buffer zone.

CHAPTER 9: CHEMICAL CONTROL

Chemicals are the primary means of mosquito control. This situation is likely to continue for the foreseeable future.

There is a diminishing arsenal of chemicals which can effectively be used for vector control because of the rise in insecticide resistance in mosquitoes. Many insecticides are also used against agricultural pests (at much higher dosage rates) and the threat that resistance will become more widespread among mosquitoes is acute. Cross resistance between distantly related chemical insecticides (e.g. DDT resistance can confer some resistance against the new synthetic pyrethroids in some species) is compounding this situation. This, coupled with the extremely high cost of development and testing of new chemicals, means that there will be few, if any, effective new insecticides coming onto the market specifically for vector or pest mosquito control. The market for these insecticides is simply insufficient to allow the high cost of development and registration to be recouped. It is therefore essential to use current insecticides sparingly and efficiently.

The State Government legislates which chemicals are registered for use in pest and vector control. In W.A. about 135 products are listed as registered for mosquito control. These 135 products have 15 active ingredients, of which only about 7 are regularly used in control operations. The insecticides registered for use in mosquito control in W.A. are listed in Table 9.1.

Chemicals can act against mosquitoes in several different ways and the chemicals can be grouped according to their mode of action. There are four main groups: repellents, insecticides, surface oils and growth regulators.

REPELLENTS

The repellents are a group of chemicals which repel mosquitoes and other biting flies. Many chemicals have been shown to have this capacity, but the most promising for mosquitoes and other biting insects is DEET (N,N,-diethyl-3-toluamide). Others include dimethyl carbate, dimethyl phthalate, ethyl hexanediol and butopyronoxyl. Recently several compounds belonging to the alicyclic carboximates and the heterocyclic amines have proven to be effective as clothing or skin repellents.

The effectiveness of the repellent depends on the particular chemical used, the dosage and formulation of the application, the climatic conditions, the activity of the human host and the species of insect against which the action is taken.

TABLE 9.1 : A LIST OF PESTICIDES REGISTERED FOR USE IN W.A. (AS AT JAN 1986)*,**

ADULTICIDES	Fenthion
	Maldison
	Chlorpyrifos
	Dichlorvos
	Fenithiothion
	Propoxur
	Pyrethrin
	Synthetic pyrethroids
	Deltamethrin
	Bioresmethrin
	Bioallethrin
	Permethrin
	Tetramethrin
	D-phonothrin
LARVICIDES	Temephos
	Bacillus thuringiensis var. *israelensis* (B.t.i.)
	Maldison

* 135 products were registered in W.A. as at Jan 1986, but all are various formulations of chemicals in this list.

** Methoprene and Arosurf (monomolecular surface film) are in use for mosquito control elsewhere in the world.

Pesticides may be deregistered at short notice. For information on current registrations you should check with Environmental Health Branch on 222 4980.

The repellents come in a variety of formulations (creams, lotions, pressure packs, etc.) and the most effective are those which are wiped onto the skin or impregnated into clothing. These are generally longer lasting and give more protection than the spray on equivalent. The repellent should be applied to all exposed areas of skin, though care should be taken in applying the chemical near to the eyes and mouth. Mosquitoes also feed by probing through clothing, and it may be necessary to apply some repellent to the clothing to ensure adequate protection. Jackets impregnated with DEET are being marketed in some tropical countries as a form of personal protection.

Recently, bed nets impregnated with repellents or synthetic pyrethroids, have been used to offer protection in malarious countries with a great deal of success. A variation on this is the impregnation of curtains with a similar insecticide or repellent.

Some repellent formulations may dissolve or weaken some plastics and care should be taken with their application.

There has been a series of recent reports which have defined a very small number of cases of encephalopathy in young girls following exposure to varying quantities of DEET. The problem was thought to be a hypersensitivity reaction to DEET, possibly complicated by an enzyme deficiency. In addition, a number of cases of severe toxic reaction and death following ingestion of large amounts of repellents containing DEET have been reported; and there have been some reports of skin hypersensitivity following prolonged exposure. As a result the N.H.& M.R.C. have issued a statement on the use of products containing DEET. The statement warns of possible reactions, and has ordered that all products with greater than 20% DEET carry a warning.

CHEMICAL INSECTICIDES

This group of chemicals includes all those chemicals which are toxic to mosquitoes. The chemicals can be grouped according to their chemical makeup and may be further classified according to their applicability to larval or adult control.

Chemical insecticides can be rated as to their toxicity to mammals including man. It is therefore very important that the operators know how to handle the chemicals safely and efficiently to maximise the benefits of control whilst minimising the possible adverse effects. It is therefore imperative that you READ THE LABEL - HEED THE LABEL to ensure that all safety precautions are taken.

Over time, the main aim of management programmes has been to maintain the desired level of control of pest/vector populations, whilst reducing the overall use of chemicals, and so the costs. As such, the control operation should aim to achieve the desired reduction in numbers of mosquitoes with the minimum application of insecticide. Care should be taken to adhere to the recommended application rates, as long term exposure to sub-lethal concentrations of insecticides may select for resistance to the insecticide in use. On the other hand, over application does not provide a 'better' result, and may have undesirable environmental consequences.

Chemical control procedures have a number of advantages: They can be relatively cheap for each application; Adulticides give a positive and very rapid knock down of the adult population; Both adulticides and larvicides can be applied relatively quickly and easily to problem areas, and it is possible to assess the potential problem of each area and plan individual treatment regimes.

There are also a number of disadvantages which can be allied to this form of control. Firstly, the use of chemicals is at best a short term control option which will incur recurrent costs for insecticide and applications. The toxicity of these chemicals can pose a hazard to the operators, other people, and to other organisms in the environment. (The chemical residues may accumulate in the food chain.) The problem of the development of insecticide resistance in the target species can render the chemical ineffective and cross resistance among different classes of chemical insecticides is of particular concern. Finally, the success of any chemical control programme depends on the ready availability of stocks of the appropriate insecticides.

a) Types of chemicals

Table 9.2 presents a classification of the chemical insecticides based on chemical structure. It should be remembered that the different members of any group, though they are combined within the same class of chemical structure, can have very different toxicity, persistence, application and other characteristics. Each individual chemical and formulation should be considered on its own merits and used accordingly.

READ THE LABEL - HEED THE LABEL

b) Formulation and application of insecticides

Technical grade insecticides are usually viscous oils or solids which cannot be used in direct applications for control. The chemicals therefore have to be dissolved in carrier chemicals or be treated to give formulations which allow the chemicals to be applied easily and efficiently. The various formulations

TABLE 9.2 : CLASSES OF CHEMICAL INSECTICIDES

CHEMICAL GROUP	EXAMPLES	COMMENTS
PLANT DERIVATIVES	pyres	Relatively short lived, broad spectrum insecticides; with low mammalian toxicity.
SYNTHETIC PYRETHROIDS	permethrin, bioresmethrin, capermethrin, bioallethrin.	Synthetic chemicals based on pyres, having similar toxicities but are longer lasting. Highly toxic to fish.
ORGANOCHLORINE COMPOUNDS (OCC)	DDT, lindane, chlordane, dieldrin, aldrin, heptachlor.	Broad spectrum insecticides, stable, persistent. Toxicity to mammals varies according to the chemical - moderate to high toxicity range. Are not used or registered for mosquito control in Australia.
ORGANOPHOSPHORUS COMPOUNDS (OPC)	Maldison, temephos, diazenon, fenthion, dichlorvos.	More selective insecticides which are shorter lived; toxicity varies, though the newer OPC compounds have lower mammalian toxicity.
CARBAMATES	propoxur, bendiocarb, carbaryl.	Activity of these compounds is generally similar to the OPCs. Toxicity readings for mammals vary from chemical to chemical, range from relatively toxic to less so.

(Based on a table prepared by P. Allen of the S.A. Department of Agriculture.)

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relate to the type of application, the stage at which control is directed, and the species concerned. It should be remembered that some formulations are specifically designed for particular application techniques and, as such, they cannot be used with other equipment.

Some formulations can be mixed with water and sprayed in a liquid form. These are emulsifiable concentrates (EC), wettable powders (WP) and miscible oils (MO). These can be applied with hand operated or motorised knapsack sprays, by drip feed into running drains or creeks, or by the use of any available liquid spray equipment. Some have been used in makeshift slow release blocks by combining the liquids in plaster of paris blocks.

Dusts and granule preparations can be mixed with other carriers (e.g. sand, fertilizers) and applied using granule spreaders or by hand. Motorized granule guns can be used to throw granule preparations over quite long distances.

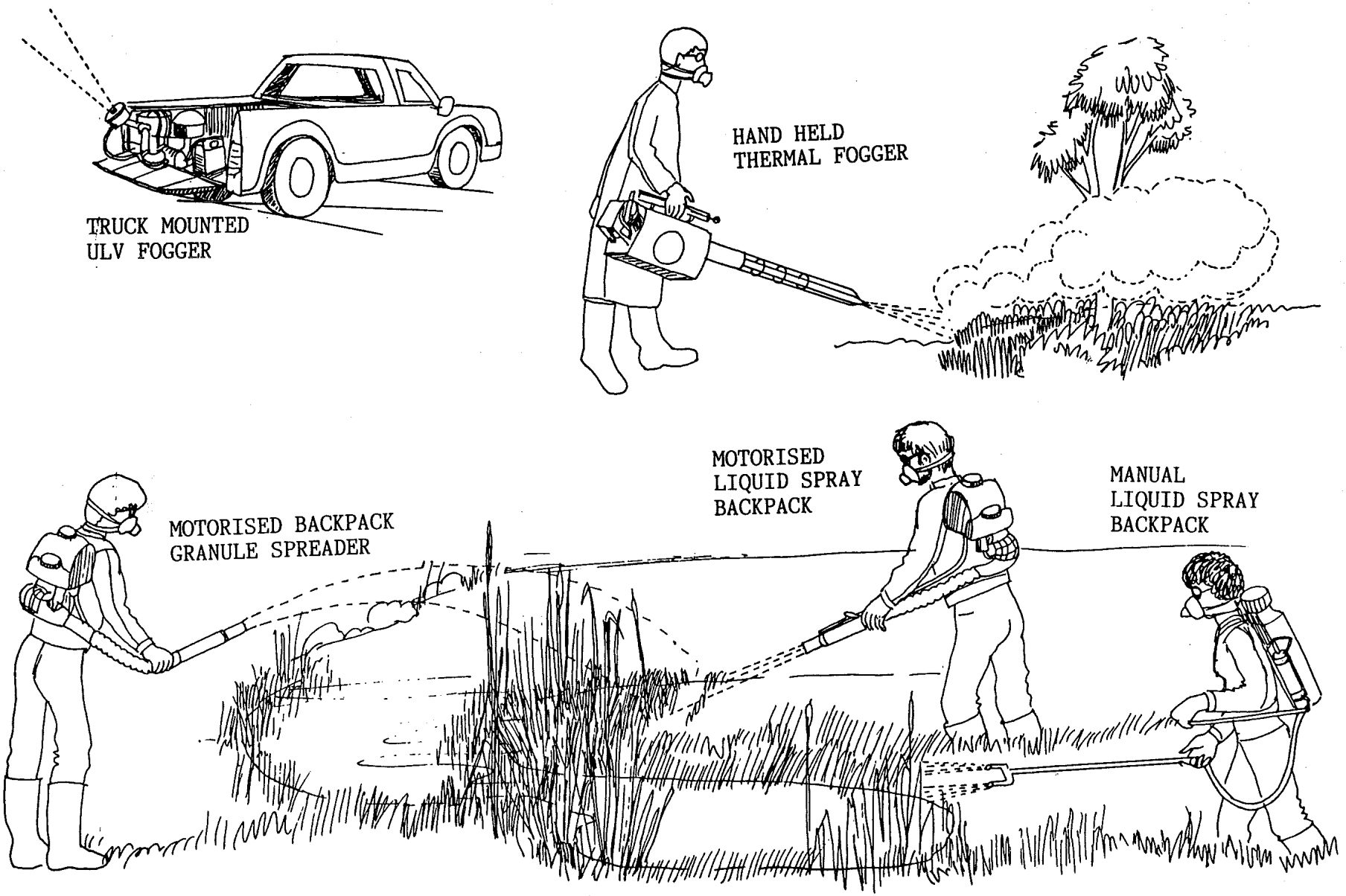
Oil preparations can be used in thermal or cold fogging machines, and there are special formulations which can be used in ULV (ultra-low-volume) fogging machines. Often the ULV formulation is the technical grade insecticide (viscous oil). ULV applications can be made from the ground or from aircraft.

The insecticide may also be prepared for personal application as in insecticide spray cans, lotions and creams.

Some of the equipment used for the application of chemicals in insecticiding programmes is shown in Figure 9.1. Note the use of protective clothing. Also shown is some of the ground application equipment, though most of the insecticides may also be applied from the air using appropriate equipment. Table 9.3 presents a list of those insecticides commonly used for mosquito control in Australia.

The choice of insecticide and method of application will depend on a combination of factors. Prime considerations are the size and nature of the area to be controlled, the stage of mosquito which is to be controlled, the availability of equipment and insecticides, and the degree of risk in the situation at hand. In emergency situations such as disease outbreaks, aerial applications may be called for to treat large areas very quickly.

FIGURE 9.1 : SOME TECHNIQUES FOR GROUND APPLICATION OF INSECTICIDES



It would be wise to consider the use of different and unrelated insecticides for both adult and larval control programmes to reduce the risk of development of resistance. It is unwise to rely solely on one insecticide for long term programs.

Currently, the chemicals most widely used for control operations in Australia are Temephos (granules or EC) for larval operations and Maldison ULV for adulticiding. Naled is registered but unavailable for ULV control in W.A. In addition, a ULV synthetic pyrethroid has been marketed in W.A. and this shows some promise for adulticiding. This is not a recommendation for these chemicals as opposed to any of the alternatives. The other insecticides may have advantages in your particular circumstances. You should evaluate your situation carefully and choose the appropriate mix of control measures to get the desired degree of control.

TABLE 9.3 : SOME INSECTICIDES REGISTERED FOR MOSQUITO CONTROL*

SITUATION	INSECTICIDE	TRADE NAME	FORMULATION
ADULTICIDES			
BROAD ACRE	Chlorpyrifos	Lorsban, Dursban	EC
	Diazenon	Gesapon, Neocid	EC
	Maldison	Malathion	ULV
	Naled	Dibrom	ULV
	Synthetic pyrethroids (numerous)	(numerous)	ULV**
HOUSEHOLD/INDUSTRIAL SPACE SPRAYS	Dichlorvos	Nuvan, Insectigas Vapona	EC, aerosol
	Pyrethrum	(numerous)	EC, aerosol
	Synthetic pyrethroids (numerous)	(numerous)	EC, aerosol
RESIDUAL SURFACE SPRAYS	Fenthion	Baytex	EC
	Naled	Dibrom	EC
	Propoxur	Baygon	EC, aerosol
	Trichlorphon	Diptrex	EC
	Synthetic pyrethroids (numerous)	(numerous)	EC, aerosols
LARVICIDES			
BROAD ACRE	Maldison	Malathion	EC
	Chlorpyrifos	Lorsban, Dursban	EC
	Diazenon	Gesapon, Neocid	EC
	Fenthion	Baytex	EC, granules, dust
	Temephos	Abate	EC, granules
	B.t.i.***	Vectobac, Teknar, Skeetal	WP, granules, liquid concentrate
SEPTIC TANKS	Chlorpyrifos	Lorsban, Dursban	EC
	Diazinon	Gesapon, Neocid	EC
	Temephos	Abate	EC, granules
	B.t.i.		

* : Based on the Table prepared by P. Allen for the Manual of the National Mosquito Control Course, Mildura (1986).

** : Diluted in diesel.

*** : B.t.i. *(Bacillus thuringiensis* var *israelensis)* is strictly a biological control organism, but the current formulations are used in a similar manner to insecticides so it is included here.

The insecticide should be applied in a manner which will be effective in obtaining the desired reduction in numbers. Larval control should be restricted to the breeding grounds, at the correct application rates. Care should be taken not to use excessive amounts of chemical and to restrict the spread of chemicals into non-control areas to prevent or reduce possible environmental pollution. This is particularly relevant when highly toxic chemicals are used.

Adulticiding operations should be similarly directed at the appropriate habitat. ULV fogging is effective only against flying insects, and so should be carried out at dusk or dawn, when the insects are actively flying. The success of the operation depends to a large degree on the prevailing weather, particularly wind speed as this can affect the dispersal and effectiveness of the spray pattern. At high wind speeds, over 15 km per hour, insect flight is affected and dispersal of the insecticide is too rapid for an effective kill. You need to be flexible and ensure that your adulticiding is effective. If possible, consider spraying at dawn when wind speeds are lower.

During the day adulticides may be directed into the day resting sites if these are known, (particularly if they are very restricted in distribution) and so may be quite effective. Surface treatment of resting sites with residual insecticides can be carried out at any convenient time.

Consider the biology of the species in your choice of spraying regime. For example, species with synchronous emergence may be managed by careful monitoring of breeding habitats, followed by adulticiding in the breeding area over the 2-3 days of emergence, before the insects disperse.

The effective area covered by any spray or control operation should be determined under the prevailing conditions. It may be that several parallel treatment runs are necessary to give an adequate coverage of the entire area to be controlled. The application rate of the insecticide depends on the particular formulation used and the stage at which the operation is directed. The number of variables involved in this are large, and the correct application rate can be determined from the data presented on the registered label. Always use the correct concentrations of the insecticide to deal with the problem at hand.

C: PRECAUTIONS.

All necessary precautions should be taken when applying insecticides. For the operator, care should be taken to avoid contact with the skin and particularly the eyes and mouth. Appropriate protective clothing should be worn at all times. The treatment for accidental poisoning is always present on the registered label. READ THE LABEL - HEED THE LABEL. Seek medical advise as soon as possible if accidental poisoning occurs.

Any spills should be cleaned and treated with appropriate care and containers should be disposed of in the correct manner as advised on the label. Contact the Pest Control Section, Health Department of W.A. for further information.

Make sure that the formulation is correct for the equipment to be used and the concentrations and application rates are correct for treating the problem at hand. Insecticide application should be restricted to the problem area. Any climatic conditions which may affect the success of control operations should be taken into account at all times. The equipment should be maintained so that no failures occur resulting either in the failure of control or in accidental spillage or overdosing of the environment.

Most of these precautions and safety aspects can generally be seen as being a common sense approach to the use of toxic chemicals. The aims are to reduce the use to a minimum, and to treat the chemicals with the appropriate amount of respect. Detailed texts on the safe use of pesticides are fairly common. The readers wishing further information are referred to 'A manual of safe practice in the handling and use of pesticides' (Dept. Primary Industry, Canberra - available from the Government Publications Office).

d) Toxicity of common insecticides

Most insecticides, whilst deadly to the mosquitoes, have varying toxicity to other invertebrates and to mammals. A measure of the relative toxicities of the different insecticides is a valuable tool in choosing a suitable chemical for control operations, particularly where some environmental constraints are apparent. Mammalian toxicity is crucial for all insecticides as a guide to the degree of operator risk. Obviously, precautions for the use of the more toxic chemicals are much more stringent than are those for chemicals of lesser toxicity, though any avoidable exposure to insecticides is advisable and should be prevented by use of appropriate protective clothing.

The toxicity is measured by testing a range of insecticide concentrations against a particular species and determining the concentration which will result in the death of 50% of individuals exposed. This is then adjusted for the body weight of the species, so that the final measure is presented as the LD50 (50% lethal dose) in milligrams of active ingredient per kg body weight (mg/kg). Thus the lower the LD50, the more toxic the insecticide.

Mammalian toxicity is usually carried out using laboratory rats as these are a relatively homogeneous population which allows the results to be reproducible. Thus a relative measure of toxicity between different

insecticides could be arrived at. In tests of mammalian toxicity, two measures are given, oral and dermal. Oral toxicity measures the toxicity of the chemical when ingested, whilst dermal toxicity relates to skin contact.

For larvicides, toxicity readings for the chemical against a variety of aquatic insects and other species (particularly fish) are crucial for determining the relative safety of the chemical in the habitat. The toxicity of larvicides is measured as the actual environmental concentrations which result in a specified mortality within a given time, and are usually recorded as LC50 (50% lethal concentration). For adulticides, the most common measures of toxicity relate to the effects on commercial insects, particularly honey bees.

Table 9.4 is a summary of the toxicity readings for the common insecticides used in mosquito control in Australia. Further information on the major insecticides used in mosquito control in W.A. are presented in Appendix E.

TABLE 9.4 : TOXICITY READINGS FOR INSECTICIDES USED FOR MOSQUITO CONTROL

INSECTICIDE COMMON NAME	MAMMALS** ORAL	MAMMALS** DERMAL	FISH***	HONEY BEES****
Chlorpyrifos	160	2000	toxic	high
B.t.i.	exempt	exempt	nil	low*****
Diazinon	300-600	>2150	low	high
Dichlorvos	80	107	N.A.	N.A.
Fenchlorophos	1740	2000	N.A.	N.A.
Fenthion	190-315	330-500	v.low	high
Maldison	1000	4400	low	high
Propoxur	90-128	800-1000	N.A.	N.A.
Pyrethrum	584-900	>1500	N.A.	N.A.
Synthetic pyrethroids	ca 800	ca 3200	v.toxic	high
Temephos	8600	4000	v.low	high-EC v.low-granules
Trichlorphon	630	>2000	N.A.	N.A.

* : Based on a table prepared by P. Allen of the S.A. Department of Agriculture.
** : Readings given as LD50 (lethal dose for 50% of exposed animals expressed as milligrams of active constituent per kilogram body weight of test animal in this case for laboratory rats.
*** : Relative toxicities at rates of application recommended for mosquito control.
**** : From 'A Manual of Safe Practice in the Handling and Use of Pesticides'.
***** : For *Bacillus thuringiensis* not 'var *israelensis*'.

SURFACE OILS

One of the first chemical methods used for mosquito control was the application of oils to the surface of breeding areas. Very light oils such as paraffin oil or kerosene were used to give a very thin coating on the surface which reduced the surface tension, thus preventing the mosquitoes from attaching to the surface to breathe. The mosquitoes were drowned as they could not obtain air. Obviously, this method does not work for *Mansonia* or *Coquillettidia* species as these do not rise to the surface to breathe. Recently, monomolecular surface films have become available for larval control in the United States, but have the disadvantage of being poor in localities affected by wind or wave action.

GROWTH REGULATORS

There is a group of chemicals which affect the growth and development of mosquito larvae. The main chemicals are methoprene (marketed under the name altosid) and diflubenzuron. Both chemicals interfere with the deposition of cuticle, and result in high larval and pupal mortality. Altosid was considered for release to the Australian market in the form of slow release briquettes. However, cost infrastructure have resulted in its withdrawal at the time of writing.

Insect growth regulators are still largely in the developmental phase, although two are marketed in various parts of the world. There has been some investigation of the effects on non-target species and the results indicate that there is some degree of mortality among other invertebrates (beetles, shrimp, midges, dragon flies, damsel flies, snails) in the habitat. The recommendations of the manufacturer state that altosid should not be applied to known fish habitat.

CHAPTER 10: BIOLOGICAL CONTROL

THEORY AND IMPLEMENTATION

Any species has predators, parasites and pathogens which will affect population size, but generally the two populations will be in equilibrium. When predators, parasites or pathogens are used as biological control agents to manage mosquito populations, this equilibrium is disrupted such that the mosquito population is reduced below the pest/vector threshold.

Under normal circumstances, mosquitoes choose sites for breeding which are relatively predator free. Often, the female will look for evidence of the presence of other mosquito larvae of the same species as a signal that the habitat is suitable. The presence of mosquito larvae may then act as an attractant for predators which can disperse from one water body to the next (e.g. predatory beetles or bugs). Predatory species are the most common group affecting mosquito breeding in any habitat and can be found in most breeding sites.

Pathogens and parasites of mosquito larvae are, on the other hand, dependent on the presence of ongoing mosquito populations for their survival. They are generally found in relatively low concentrations in a very small proportion of breeding sites. The numbers present are generally sufficient to affect a proportion of the mosquito population without eradicating it completely. If they are too efficient, the mosquito population will be eliminated and the parasite or pathogen will disappear also. Some manage to overcome this problem by affecting several insect species or entering a quiescent phase when mosquitoes are absent.

The classical biological control operation is one where the controlling agent is released within a limited period, and establishes a permanent presence which gives some measure of ongoing control (e.g. the introduction of the mosquito fish *G affinis).* If the controlling agent will persist for only a short to medium length of time (perhaps due to seasonal extinctions), periodic or annual inoculative releases can give a measure of ongoing control. If, on the other hand, the controlling agent has very little persistence, inundative releases are necessary to overwhelm the mosquito species whenever populations rise. In this case, the biological control agent is used in the same manner as an insecticide. An example of this kind of control is the use of B.t.i.

Natural predation or parasitism can be encouraged by choosing control methods which primarily affect mosquitoes and not their respective predators and/or parasites. This is often difficult as most insecticides will affect the mosquitoes and invertebrate predators.

Other methods, relying on genetic manipulation of the mosquito population have also been tried. This is achieved through such measures as sterile release programmes, or through the introduction of deleterious genes into the natural populations which then spread, reducing viability within the population itself. Similarly, an efficient vector may be replaced by a strain of the same species with limited vector capacity.

A further potential method relies on the introduction of a more aggressive mosquito species which has no pest or vector capacity, but which utilises the same breeding habitat. Thus the pest or vector may be excluded from breeding through competitive displacement.

As with the more traditional methods of control, the genetic and competition methods rely on a very detailed understanding of the biology of all the species involved (both the pest or vector and the respective competitor or genetically manipulated population of the pest). These types of control operation have many pitfalls and may be exceedingly expensive to implement. Success with these methods has never been widespread.

CHARACTERISTICS OF BIOLOGICAL CONTROL AGENTS

Any species which adversely affects the breeding of mosquitoes can be used as a biological control agent. The three groups already mentioned (predators, pathogens, parasites) form the majority of biological control agents which have been examined. Whilst any organism within a particular habitat may be encouraged in an attempt to reduce mosquito breeding at that site, the problem of finding an organism which can be used to treat a wide range of habitats is more difficult.

There are a number of considerations which must be taken into account when investigating a species as a potential biological control agent: Is the species fairly common? Does it tolerate a wide variety of habitat types (salt to fresh; shaded and cool to sunlit and hot; pristine to polluted)? Does the control agent affect other, non-target species? What is the probable persistence through time within any habitat? Can it be cultured easily? Can it be transported and dispersed easily? If it is cultured, what is the survival rate between culture and release? Can it be stored for prolonged periods before release? What would be the cost of culture, release and maintenance of the population?

Obviously, much detailed biological information must be gathered before the potential of biological control organisms can be evaluated. The characteristics of a Utopian biological control agent are that its

activity is restricted to mosquitoes and other pest species (e.g. midges, black flies, sandflies, biting midges); that it can establish easily within any habitat and maintain an adequate level of control; and that it is very simple and cheap to culture, store and transport. The full complement of features has never been found within any one potential biological control agent. Often, it is generally a consideration of the potential for mass culture, storage and handling characteristics, adaptability to a range of environments and the potential for control, rather than the restricted host range which directs attention to a particular control agent.

BIOLOGICAL CONTROL OF LARVAE

a) Predatory insects and plants

A very large number of observations have been made on the role that plants and insects play in predation on mosquitoes. Such groups as the dragonfly nymphs (Odonata), beetles (Coleoptera - Dytiscidae, Gyrinidae), bugs (Hemiptera - Corixidae, Notonectidae) are all important mosquito predators. There are also copepods which have some potential as mosquito predators. Predators can be locally significant but generally the predator populations follow and are in balance with that of the mosquitoes. Permanent water bodies with little variation in water depth maintain high predator diversity and numbers which keep the mosquitoes in check. The degree to which the populations are checked depends on the degree to which the mosquitoes can avoid the predators by hiding in vegetation or debris. Invertebrate predators generally cannot be used to prevent breeding of mosquitoes in temporary waters, though they become more significant as the breeding site persists.

There have been some trials and introductions of predatory mosquitoes as a form of biological control of container-breeding mosquitoes. Those species most often belong to the genus *Toxorhynchites* (since the adults feed only on plant nectar whilst the larvae are voracious predators). Populations of *Toxorhynchites* are generally quite small consisting of only one or two larvae per habitat. This is a natural consequence of the predatory nature of the larvae. If several larvae were confined within a single site, cannibalism could occur. The low number of predator larvae per habitat ensures maximum adult emergence.

Some plant species can produce toxins (e.g. *Chara)* and others entrap and feed on mosquitoes (e.g. bladderworts *(Ultricularia* species)). Mustard seeds have been found to exude a sticky, mucilaginous coat in water which can trap mosquitoes by their mouthparts when they investigate them as a possible food source. Information on the efficacy and potential of such plant species is scarce, and further work needs to be done to determine whether they are candidates for widespread use in mosquito control.

b) Predatory fish

Perhaps the most widely used fish for mosquito control has been the mosquito fish - *G affinis*. This species was introduced into W.A. from North America in 1934 by aquarists, and was subsequently widely released into natural habitats by health authorities. The species is voracious, feeding near the surface and taking a wide range of invertebrates. It is estimated that the adult mosquito fish can account for up to 100 4th instar larvae in a single day. It is a prolific breeder, attaining very high populations. Up to 300 live born young are produced each breeding cycle. However, cannibalism can be common.

G affinis has had a very major impact on the other inhabitants of fresh water ecosystems in W.A. It competes with and kills many of the small native fish species, and is responsible for dramatic declines in the species diversity within many waterways. The species is widely distributed in both standing and running water habitats in the south west corner of the State. Great care should be taken before this species is spread further because of its potential to devastate the local fauna (see Chapter 12), and because it is now clear that some of the native species have similar potential for mosquito control.

Other problems with *G affinis* are that it is not suitable for control of mosquito breeding in some temporary waters, and that it is susceptible to insecticides in some circumstances.

Other fish species have also been utilised for mosquito control elsewhere in the world. *Poecilia reticulata,* a guppy related to *Gambusia* has been used for control in some instances. It seems to be more tolerant of polluted waters than is *Gambusia.* The mainly herbivorous *Tilapia* species have been used to reduce populations by both, reducing the level of protection of mosquito larvae by removing the protective vegetation, and by direct predation. *Aplocheilus latipes* is a fast breeding species (up to 50,000 can be produced by the offspring of a single pair in 4 months) which can account for about 500 mosquito larvae per day. *A latipes* is more compatible with native species and is tolerant of a wide variety of habitats. It is less likely to have the same adverse impact as *G affinis.* These species are not available for control in Australia.

It has been suggested that 'annual fish', species having drought resistant eggs, should be considered as possible control agents for temporary and semi-permanent water bodies.

There are, in addition, a number of native fish species which feed on mosquito larvae. These may, individually or in combination, give a similar degree of control to that possible by introduced species. In the south west, *Galaxia species* (native minnows), are voracious feeders on insect larvae. The night fish

(Bostockia porosa) and the pygmy perch *(Edelia vittata)* are both potential control agents as both will feed on larvae, as will the various species of goby. Populations of all these species have been severely restricted by the introduction of *Gambusia.*

In the north, a variety of native species can be considered as having sufficient impact on mosquitoes to be classed as biological control agents. Of these, the rainbow fishes *(Melanotaenia* species) are perhaps the most efficient and widespread, though many small fish can account for some larvae predation.

No fish species should be introduced into a habitat, without a detailed evaluation of the impact of the species on the other fauna of the habitat. What is the current impact of the native fish species on mosquito breeding? Will the introduced species replace these native species? Will it be able to penetrate into protected mosquito breeding areas and enhance control significantly? Any consideration of extending the range of any native species, or introducing non-native species to any habitat should be discussed with the appropriate authorities and permission sought. The authorities which should be contacted are the Department of Conservation and Land Management (Wildlife Section); the Environmental Protection Authority (wetlands management); and the W.A. Museum.

c) Parasites and pathogens

1. Viruses: Though a number of insect pathogenic viruses are known, none have high infectivity. It is considered that there are currently no good candidates for production as control organisms.

2. Bacteria: Two bacteria are currently under consideration as control agents. *Bacillus thuringiensis* var. *israelensis* (B.t.i.) has recently been released onto the Australian market as a liquid suspension concentrate, a wettable powder or as a granular formulation. This bacterium forms a crystalline toxin which kills the larvae following ingestion. As such it is active against all the actively feeding larval stages (instars 1 to 3 and early fourth stage instars) but will not affect the late fourth stage larvae or pupae. This bacterium has been shown to be effective in infecting a very wide variety of mosquito species, and is particularly safe in the environment. The only species, other than mosquitoes, which are affected are some species of Diptera with aquatic larvae. A broad range of invertebrates, tested against the B.t.i., is not affected.

Some of the possible problems associated with the use of B.t.i. are that the bacterium has a tendency to settle out of suspension, so the preparation needs constant agitation during application. In general, the diluted suspension retains its activity for only 24 to 48 hours and should be applied within 24 hours of dilution. The effective field life of the applied organisms is negligible. Some estimates give the period as 24 hours. Therefore, the bacterium has to be reapplied each time there is an increase in pest populations. This bacterium does, however, signal a marked advance in the control of mosquitoes.

Bacillus sphaericus is currently being developed for commercial release. This spore forming bacterium also forms a toxin and to be effective, the bacterium must be ingested. The range of species affected by *B sphaericus* is less than that of B.t.i. However, it has been shown to have limited persistence in field trials. It is hoped that the product will be commercially available in the future.

3. Protozoa: Two species *Nosema algerae* and *Vavraia culicis* are obligate parasites of mosquitoes. *N algerae* is pathogenic primarily for Anophelines, whilst *V culicis* infects Culicines. These organisms can be mass cultured, and some field trials have been undertaken with variable results. Inoculation of the spores into a breeding site does not appear to produce an ongoing population of the parasite. On the other hand, parasitism can continue into the adult phase and reduce the viability of the adult. These parasites have been shown to be responsible for the disruption of disease transmission (malaria) in some cases. Further work and development is needed before these pathogens can be fully evaluated.

The microsporidian genus *Amblyospora* is currently under investigation, though the complex life cycle, may result in difficulties in culture and field application.

4. Nematodes: Several nematode parasites have been investigated as biological control agents. Of these one species, *Romanomermis culicivorax,* has been mass produced and has undergone several trials. This species parasitises a wide range of mosquito species belonging to several genera and has been shown to give some measure of ongoing control by becoming established at the release site. This species has particular habitat requirements: permanent or semi- permanent fresh water bodies with temperature ranges of 10 to 40 degrees Celsius, and having low salinity.

It would appear that these nematodes have some potential for use in conjunction with other control methods (both chemical and biological) as part of an integrated control scheme.

5. Fungi: Several fungi have been investigated as possible control organisms. Species belonging to the genus *Coelomomyces* were originally examined as possible agents. They are widely distributed throughout the world and cause significant mortality among mosquito populations where they occur. These fungi can be readily established into new habitats and persist through very long periods of time. It was discovered some

time ago (1974) that these fungi have an obligate intermediate host in a copepod (a small crustacean). Thus mass culture of the fungus requires consideration of both mosquitoes and the copepod, and long term field survival is similarly dependent.

Lagenidium gigantium produces spores which infect mosquito larvae (particularly *Culex* species). Infected larvae are killed within two to three days and the fungus produces a second generation of zoospores which infect other larvae at the site. The fungus is particularly interesting in that the spores formed in the dead larvae have some resistance to desiccation and may persist through periods when the temporary breeding site is dry, becoming active again on subsequent inundation. Thus it can be an agent which can persist through several seasons. The fungus is particularly suited to temporary to semi-permanent freshwater sites with low salinity and no organic pollution.

Leptolegnia spp. has recently been isolated and been shown to infect species of all the major genera. This species is currently undergoing further testing. *Tolypocladium cylindrosporum* has recently been isolated from several sites around the world. The fungus infects both adults and larvae, and is the subject of ongoing investigations. *Metarrhizium anisopliae* is a generalised insect pathogen which is being developed as a control agent for agricultural pests. Trials have shown that it will infect mosquito larvae through the spiracles. Death usually occurs before fungus spore formation, and hence the fungus cannot complete development and establish ongoing infections within the site. Further investigations and selection of specific strains may result in suitable characteristics for widespread use a biological control agent.

Perhaps the best of the fungal parasites is *Culicinomyces clavosporus*. This species has been isolated in Sydney, Australia and the United States. The fungus is easily mass cultured in liquid fermenters. This has allowed the production of large amounts of spores for extensive field trials. The results are promising, though the fungus rarely gives adequate control for more than one generation. The fungus has been tested in a variety of habitats, and seems quite tolerant of environmental quality variation. A new formulation of this fungus has revived hopes that it could be a significant biological control agent against mosquitoes. This fungus is one of the brightest hopes in biological control with wide application to a variety of habitats.

GENETIC CONTROL - BIOLOGICAL CONTROL OF ADULTS

a) Competitive displacement

Competitive displacement, that is, the introduction of a more aggressive mosquito species (preferably non-pest/non-vector) which utilises the same breeding habitat, may, in some circumstances, lead to the displacement of the original pest/vector species. This has been tried in some island situations but is not feasible for consideration in the context of local mosquito management on the Australian mainland.

b) Genetic manipulation

Genetic control methods rely on altering the biological characteristics or viability of the pest/vector population through creating a stock of deleterious genes or chromosomal abnormalities which can be released into a natural population. Control is achieved as these spread through the population. For example, a particular strain of a mosquito species may be highly refractory to certain virus diseases. If large numbers of this strain are released into a natural population, the results of interbreeding may reduce the overall susceptibility of the population to the virus and thus reduce the potential for disease transmission.

There are also techniques available to manufacture strains with severe chromosomal abnormalities (particularly chromosomal translocations) which can be fatal in the offspring of crosses with wild caught mosquitoes.

These methods rely on the continual release of very large numbers of genetically manipulated mosquitoes in order to swamp the natural population and cause the desired decline in numbers. The methods are costly and require very large artificial mosquito rearing programmes to ensure supplies of release stocks. As such, they are not feasible for consideration in the context of local mosquito management in Australia.

c) Cytoplasmic incompatibility

For a long time, it was recognised that there was some degree of cytoplasmic incompatibility between geographically distant populations of the same species. That is, when distant populations were brought together artificially, the resulting progeny showed marked disruptions to both sex ratios and fecundity.

This was first documented in the *Culex pipiens* group. The different strains were originally considered to be geographical variants of the same species. Some were subsequently elevated to the status of subspecies of *Cx pipiens*. Recent studies have shown that, at least for the four members found in Australia *(Cx australicus, Cx globocoxitus, Cx quinquefasciatus* and *Cx molestus),* these are indeed good biological species. The taxonomic separation of the group remains uncertain, and there are some observations suggesting that there is minor incompatibility between populations of *Cx quinquefasciatus* from Perth and

Darwin. This incompatibility was shown to be due to the strain differences in intracellular parasitic organisms (rickettsia-like organisms) in the ovaries and testes of the mosquitoes.

Because of the confusion and lack of recognition of species status among some members of the *Cx pipiens* group, many of the conclusions and potential for control using cytoplasmic incompatibility remains in doubt. Whilst it may be easy to cross the species within the artificial conditions of the laboratory, pre-mating isolating mechanisms (mainly mate recognition through behaviour patterns) may prevent the mating of the two populations in nature. It is therefore difficult to draw any real conclusions as to the wider applicability of the method.

d) Sterile release

Sterile male release has been successfully implemented to control a few agricultural and forestry pests. It has been contemplated as a possible mosquito control option. Female mosquitoes mate only once, and if this should be with a sterile male, the union would result in no offspring.

The males are often sterilized by irradiation. The males are then mass released into the natural population and the releases are continued on a regular daily basis until the desired level of control is achieved. In populations which are not geographically isolated, the release programme may have to be continued indefinitely.

The use of genetic, incompatible strains or sterile male release as control options really depends on the amount of capital available. The mosquito species must be readily cultured so that it may be bred up in sufficient numbers to make the control attempt feasible. The operation needed to produce the population for release is very large, and great care must be given to ensure that sufficient production continues throughout the course of the control operation. If the release population cannot overwhelm the natural population for a sufficient length of time, the attempt at control will fail.

Other problems arise when insect species are colonised, and when they are manipulated in order to irradiate them, or to introduce the genetic changes necessary to make them suitable as control agents. These procedures may inadvertently bring about changes to the behaviour, longevity or fecundity of the treated population and may result in reduced competitiveness in nature compared to their 'normal' or 'wild' counterparts. The females may prefer wild males to those of the release population. If this is the case, the control operation is less likely to succeed. There is much still to be learned about the biology, handling and treatment of mosquito species to ensure that such manipulations do not reduce their competitiveness.

CHAPTER 11: THE INTEGRATED APPROACH TO CONTROL

The integrated approach to control is one which entails the consideration and use of a combination of all relevant control options in order to bring about desired levels of control. Secondary considerations may be to combine the desired control levels with the least amount of environmental disruption, and with the greatest potential for long term success at maintaining the pest/vector populations at acceptably low levels.

For a long time, integrated control methodologies were ignored because of the success of residual and other insecticides in managing mosquito populations. These methods were very successful and had extremely favourable cost/benefit ratios. The appearance and rapid spread of insecticide resistance among pest and vector species, the documentation and growing concern about contamination of the environment, toxicity to the environment and man, the rapid escalation in costs for the development and testing of new insecticides, and their cost on subsequent release, have contributed to a resurgence of interest in the integrated approach to control. The cost/benefit analysis of the integrated approach may be somewhat worse than reliance on chemical insecticides in the short term, but will yield many benefits in the long term.

The main features of integrated control programmes are (given that all environmental constraints are observed): 1) utilisation of environmental sanitation procedures where possible; 2) implementation of any cultural control or other physical control operations which may reduce the impact of the problem species; 3) ensuring that the public are aware of personal protection measures; 4) investigation and maintenance of any natural predators, pathogens or parasites, and supplementation of these where applicable; 5) judicious choice and use of chemical insecticides to supplement both adult and larval control; and 6) increasing the level of public awareness of mosquito biology and control through education campaigns.

Many of these aims have been discussed in some detail in the preceding chapters. Some of the topics not covered previously are discussed below.

PUBLIC AWARENESS CAMPAIGNS

It may be necessary at some time to undertake a public education campaign to increase awareness of the public as to the biology and control of mosquitoes. All possible avenues for public education should be investigated to determine which are the most likely to contact the widest cross section of the population. The education campaign should be directed at that section of the population which is most affected by the pest/vector. Particular attention should be given to domestic species, as rectification of domestic breeding sites is largely the responsibility of the householder. Other information should be presented on the dispersal and harbourage sites of mosquitoes and other biting insect pests. If the public is made aware of the extent of the problem, and the proposed rectification measures, they will be more understanding and tolerant of the management programme.

It is possible that public disquiet at insecticide application may be sufficiently strong to prevent insecticide application. The same level of public opposition may be apparent in habitat modification schemes.

Public education is particularly important where human populations are sparse, and where amenities are fewer. In these regions, self protection and domestic environmental sanitation are often the only cost effective solutions to many of the pest or vector problems faced by residents.

Public education is also very important in the case of disease transmission. Outside the major population centres, the prevention of disease transmission is largely achieved through personal protection.

COST - BENEFIT ANALYSES

The cost of mosquito control cannot be measured in direct dollar terms. Indirect costs associated with environmental pollution or degradation, rehabilitation of the environment, and potential changes in the use of the affected area for other purposes must be considered. There is always a requirement that the short and long term implications (both cost and impact) be balanced against the rationale for initiating the control programme.

The cost of physical control operations will increase at a far greater rate than other options. As such, if physical control operations are both suitable and environmentally acceptable, they should be implemented as soon as is practical. It may be that they can be introduced gradually, as a component in a larger management programme.

In this context, it should be remembered that the most efficient and least disruptive time to undertake physical control and rectification operations is during the initial development phase. Before the residential areas are occupied, environmental sanitation procedures should be investigated and detailed designs formulated, any necessary approvals and authorisations obtained and the sanitation procedures completed.

If breeding areas which may affect the future residents are not rectified during the initial phases of development, major impediments to their final rectification may arise. The continual drainage of surface waters from urban gardens and roads into the site may result in extensive swamp formation with excessive weed and plant growth. Such sites can be exceedingly difficult and expensive to rectify. The sites themselves may take on local significance and be seen by sections of the public as important resources which should be maintained. With time, the sites become accepted as part of the local landscape, and this may limit the options available for management.

The problem also arises as to who is responsible for the cost of rectification. If the problems are not sorted out in the initial planning phase, the final cost must be passed on to the whole community, regardless of the degree to which the community is affected by the problem.

GUIDELINES FOR INTEGRATED CONTROL OPERATIONS

When considering a control operation, the first prerequisite is a detailed and quantitative definition of the problem. There should be detailed local data on the biology of the major pest and vector species which can be used to supplement the data available from other localities. It is this detailed understanding of the pest/vector species under local conditions which will allow the formulation of a realistic management programme.

Having defined the problem in some detail, the first questions to ask are: Are any of the significant breeding sites easily rectified so that breeding is prevented? Are there any overriding environmental restrictions (see Chapter 12)? Is it necessary to obtain permits for the alteration of the habitat? What will the cost of the operation be? Will the design of the operation be such that it will not allow the introduction or increase the populations of another species which may become a pest or vector? What will the ongoing maintenance costs be? Is there any possibility that the measures used to rectify the problem will result in the formation of new breeding areas and a further problem?

If these questions can be answered in such a manner that some or all the breeding areas can be rectified easily, cheaply and with little or no adverse impact on other habitats, physical control measures should be implemented. If the costs are high, a decision will have to be made as to whether the initial costs are prohibitive, remembering that if these options are adopted at a later stage, cost rises are likely to be significant.

If physical control of the breeding sites is not possible, or if problems still persist after these operations have been carried out, consideration should be given to other control means. Can the zone between the breeding areas and the urban area at risk be managed to reduce dispersal? Is this possible without major habitat destruction? What is the projected cost? Can the public be encouraged to adopt appropriate measures for personal protection and to implement measures which can prevent contact between man and vector/pest (e.g. insect screening of houses, exposed external lighting to be non-insect attractant). In practice, this latter course is very difficult as the public generally have an expectation of pest free environments.

Are there any biological measures which could be introduced to reduce the larval populations? Given the availability of equipment and chemicals, which chemicals are possible candidates for larval control operations? What is the likely impact of these on other inhabitants of the ecosystem or on related ecosystems? Do any of these preclude the implementation of chemical control procedures?

Finally, adulticides should be used to reduce the adult population. If possible, adulticides should be applied at the breeding area before the adults disperse. If this is not possible, applications closer to the urban area should be carried out.

The scheme above is not a direct set of guidelines. Rather it begins with those methods which give the most permanent reductions in populations and extends to those which are more temporary solutions. It does, however, give some indication of the hierarchy in methods. Those at the beginning are possibly more expensive in the short term but have little ongoing costs if designed and implemented carefully. The latter methods have low individual application costs but must be repeated whenever mosquito population density warrants. In addition, the further from the point of man-vector/pest contact at which control is implemented, the greater the margin for achieving the desired control. Other methods can always be implemented if the initial control measures prove inadequate, or in the case of an emergency.

Each pest or vector problem is unique and must be evaluated on its own merits. Often, the range of issues which need to be evaluated is beyond the scope of the local authority. Help can be sought from the relevant government departments (Health, CALM, EPA), experts from the W.A. Museum, or research workers in the various research institutions (universities, CSIRO). In addition, there are a number of environmental consultants, some of whom have particular expertise in the field of management of pest and vector biting insects, who may be used to evaluate particular or complex problems.

CHAPTER 12: ENVIRONMENTAL CONSIDERATIONS IN MOSQUITO MANAGEMENT

THE ENVIRONMENTAL PERSPECTIVE

Mosquitoes, like all animals, are part of the integrated complex of plant and animal communities which make up the ecosystem. Control of mosquitoes will have some impact on the ecosystem, if only through the reduction in their numbers. Generally other species will be affected as well. The extent of these effects will depend on the method used for control, and the rationale for its application.

The environmental perspective realises that several factors must be taken into consideration when analysing which control options are appropriate for the problem at hand. These include: 1) possible ecological disruption from primary or secondary effects of control measures on non-target organisms; 2) alteration of the aesthetic value (and possibly the economic value) of an ecosystem; 3) the need to meet requirements of the State environmental protection and wildlife protection legislation. Particular problems may occur where the habitats to be controlled are utilised by rare or endangered species, or by migratory birds.

POSSIBLE ADVERSE EFFECTS OF MOSQUITO MANAGEMENT ON THE ENVIRONMENT

a) Effects related to control of the larval stage

1. Physical control: These methods rely on alteration or destruction of the mosquito breeding areas. In either case, the measures which make the habitat unsuitable for mosquitoes will also affect its suitability for other species. Secondary effects may also occur, where the alteration of one habitat may reduce the viability of a related habitat. For example, estuarine tidal salt marshes are breeding grounds for mosquitoes and are also a rich source of nutrients for the surrounding waters, and are spawning grounds for some fish species. By draining or filling these marshes, the nutrient input for fish and other biota in the estuary may be altered.

Herbicides are often used to remove or reduce vegetation at the margins of aquatic habitats as a means of habitat alteration. Care must be taken to ensure that the formulation and application rates suit the situation at hand. Some herbicides have residual activity and are mobile in water and hence may spread beyond the areas where control is intended. Poisoning of non-target plants should be avoided.

It should be noted that not all the impacts of habitat alteration are negative. The new habitat may in fact be of greater aesthetic or functional appeal. Biologically, this is true as well. The new habitat may support a range of species excluded from the previous environment.

There are cases where habitat alteration has created conditions resulting in extended breeding of significant pests which previously formed minor elements in the overall fauna (e.g. the rise in populations of biting midges [*Culicoides* species] following some coastal canal developments). The possibility of this happening can be minimised by thorough investigation of the biology of local populations of mosquitoes and an awareness of the biological requirements of other pest/vector species.

2. Chemical control: The most obvious effect of insecticides is their toxicity to non-target organisms. There may also be problems from persistent chemicals which can be concentrated as they pass along the food chain. Persistent insecticides are now generally banned from widespread use in vector control in Australia. However, problems may result from over-application (or faulty application procedures). Many insecticides are available in a variety of formulations and care must be taken to ensure that application rates (and methods) are correct for the formulation you are using.

3. Biological control: Great care must be taken to ensure that the biological agent used for mosquito control is specific for mosquitoes. Those characteristics which are essential for good bio-control agents (e.g. hardiness, long survival, fast population growth rates; tolerance of a wide array of environmental conditions) will, if the predator or pathogen affects a broad range of non-target species, contribute to a major biological problem (for example, see the discussion of the impact of the mosquito fish, *G affinis*, in Chapter 10).

Care should be take to determine the specificity of the controlling organism, its likely impact on native species, and its survival capacity. You must not create a new pest problem in the attempt to control another.

b) Effects related to the control of adults

1. Physical control: Habitat management may be practised within the buffer zone to reduce the dispersal of mosquitoes. Generally, this would be achieved through vegetation control. Such management of the vegetation can, in some cases, result in reduced aesthetics of the buffer zone and may also impact adversely on other species utilising this habitat. The alteration of the aesthetics can also affect land values and, in some instances, revenues from tourism.

2. Chemical control: The direct toxicity of the insecticide to non-target organisms is again the potential problem. Particular care should be taken to avoid unintended kills of commercially important species (e.g. bees, parasitic wasps used as bio-control agents of orchard pests). Care should be taken to apply insecticides in the correct and most efficient manner. The timing and location of chemical control operations should be allied to the biology of the target mosquito species to ensure adequate control with minimum effect on the environment. Correct application rates should be strictly observed.

ENVIRONMENT PROTECTION AND WILDLIFE PROTECTION LEGISLATION REQUIREMENTS

Wildlife protection legislation can have significant impact on the possible introduction and spread of exotic (and native) species for the purpose of mosquito control. If the use of exotics is being considered as a bio-control option, it is essential to contact the Department of Conversation and Land Management (CALM) and the Environmental Protection Authority (EPA) to determine their attitude to your proposed programme. They may be able to advise on an alternative indigenous species.

The State has environment protection legislation which may have some impact on large scale habitat modification projects for mosquito management. It would be wise to check with the EPA whether such requirements pertain to your proposed programme. Many mosquito breeding sites are the result of man's modification of the habitat but may still be covered by legislation. These habitats may have developed their own unique qualities and intrinsic biological value necessitating their preservation.

ACCEPTABLE ENVIRONMENTAL IMPACTS FOR MANAGEMENT PROGRAMMES

Ecosystems have the capacity to recover from some adverse impacts. However, should the adverse pressure of a control programme be prolonged or repeated, the innate capacity for recovery is reduced. Similarly, the capacity for recovery is generally inversely proportional to the severity of the overall impact. The impacts acceptable under unique control programmes in emergency situations are generally greater than those which maybe acceptable under long term or repeated control programmes. This does not mean that the same degree of care in the choice of control regimes, and in the actual operation of the control programme is not necessary.

Always choose the control option with the least impact on the environment but which is compatible with the strictures of required control, cost and safety.

EVALUATION OF THE PROBLEM AT HAND

The aims and possible impacts of the management programme should be fully evaluated. The major factors to consider are the need for control, the means and costs for the various control options, the speed with which they achieve the desired result relative to risk, and whether the degree of environmental impact is acceptable.

Some mosquito problems can be avoided where the breeding areas are the result of man's alteration of the environment. These are preventable through adequate planning. Water conservation and reuse schemes may prevent some problems by reducing the amount of waste water. Similarly, planning to retain sufficient buffers between known problem sites and urban development could reduce the impact of mosquitoes breeding in these sites, preventing the need for an ongoing management programme.

The conservation value of the site needs to be assessed. It is always necessary to consult with the appropriate authorities (Conservation and Land Management - Fauna and Flora sections; Department of Conservation and the Environment) and to ensure that no special authorisation is required for control operations in particular habitats.

The types of questions which should be asked in developing a management programme with due consideration of environmental aspects are:

1. Defining the overall problem and rationale for control: Why do we need to attempt a control programme? Is significant disease transmission occurring? What is the risk to the population? Is it a nuisance problem? Is the problem permanent, seasonal or transient?

2. Recognising the major mosquito species: What are the mosquito species involved? What is known of each species biology? Where does it breed? How far will it disperse?

3. Defining the scope of the control programme: Where should control operations be implemented? Is larval control feasible? Is adult control necessary? Are both needed? What is the extent of the breeding area to be treated? Is the breeding area natural or man-made? How close are the breeding areas to the human population to be protected?

4. Evaluation of the environment: Are there any unique characteristics of the breeding site? Does it form a small portion of a continuum of related or similar sites? Does it support a unique biological community? What are the interrelations between this site and adjacent habitats? What other species are dependent on this habitat? Are nutrients or other biological materials transported into adjacent habitats? Are there any conservation or environmental restrictions in place?

5. Human use factors: Is the site a favoured recreation site? Does it have intrinsic aesthetic appeal which should be preserved?

6. Making a decision about the management programme: What are the options for an integrated control programme (see Chapter 11)? What are the short and long term costs of the programme? The aesthetic cost? The environmental cost? Will the measures under consideration affect the other species inhabiting the same habitat or adjacent habitats? Can the aims and requirements of CALM and the EPA be satisfied?

The final management programme will depend on the range of options available to achieve control, whilst satisfying any environmental restrictions, and remaining economically viable within the available budget. It is true to say that, in some instances, environmental considerations may be so important that the control operations cannot be carried out. It must be remembered that the evaluation of some problems can be quite complex, and it may be necessary to enlist the services of suitably qualified experts to evaluate and define the options available.

SECTION 3
MOSQUITO IDENTIFICATION

CHAPTER 13: MOSQUITO TAXONOMY AND A CHECKLIST OF THE MOSQUITOES OF WESTERN AUSTRALIA

PART I : TAXONOMY

Mosquitoes are true flies which are placed in the subfamily Culicinae of the family Culicidae. They can be separated from all other flies by the presence of a long proboscis projecting forward from the head. The proboscis is flanked by two sensory palps. Mosquitoes are also characterised by the presence of scales on the wing veins and on the various parts of the body. These scales vary in distribution, shape and colour, and this is used extensively in species separation.

Some 300 mosquito species occur in Australia. Of these, about 90 are found in W.A. representing nine different genera. Over half of the represented species (about 50) fall into the *Aedes* and of these 24 are in the subgenus *(Ochlerotatus)*. The next most prevalent genus is *Culex* with some 23 species. There are at least 12 *Anopheles* species. The other species are scattered through the remaining six genera, four of which *(Aedeomyia, Culiseta, Mansonia* and *Uranotaenia)* are only represented by single species. There are three *Tripteroides* species and two *Coquillettidia* species.

Many species are yet to be formally described. They are included in the keys so that they can be identified, and a very brief resume of biology and distribution is presented. Any such specimen should be referred to a professional medical entomologist for confirmation of identification.

TAXONOMIC TREATMENT

The atlas makes no attempt to analyse the relationships between species or genera. It is purely a practical guide to the identification of species and thus an aid for indicating possible options for management. The genera are presented in alphabetical order, as are the subgenera and species within the separate genera. Whilst this ignores the evolutionary relationships between the various taxa, it allows for rapid and easy location of information about individual species.

The male terminalia and the pupal stages have not been included in this analysis of the mosquito fauna of W.A. The male terminalia are among the most significant morphological features used by taxonomists. The male and female genetalia fit together like a lock and key, and the complex structure of the male terminalia is diagnostic of genera and subgenera, and is one of the means for species identification of individual male specimens.

There are several reasons for the omission of the male terminalia in this study. Firstly, the work is intended to be a practical text for those involved in mosquito management. In all likelihood, over 95% of the material which will be seen by these people will be larvae or adult females. Secondly, examination of the terminalia is time consuming and difficult, as it requires dissection and preparation of the specimen. It is therefore unlikely that the necessary time would be available for this type of analysis in a control programme. If the reader wishes to find out about the male terminalia of individual species, they are referred to in the original descriptions of the species in question. Thirdly, for several of the W.A. species males are unknown, and for many others, although they may be well known from other parts of their range in Australia or overseas, they have not been collected from W.A. Any attempt at analysis would be very incomplete and would rely on material collected from locations very distant from W.A.

The pupae were omitted, as again, they are not described for many W.A. species. If encountered in the field, pupae can be easily reared in a small amount of water from the breeding site, and the adult identified with much greater ease and precision.

In the final analysis, it seems better to avoid possible confusion, and to concentrate on the females and larvae, the stages which are better known, easier to identify, more likely to be encountered in the field, and most important in the context of mosquito management.

Chapter 14 presents a brief review of mosquito anatomy. The taxonomic descriptions and keys use the standard terms and jargon of mosquito taxonomy and anatomy which are explained in that chapter. Chapter 15 presents the keys to the genera and explains how the keys are used. Chapters 16 through to 24 present keys and descriptions of the species in each genus in turn.

THE SPECIES CONCEPT AND THE PROBLEM OF SIBLING SPECIES

A brief outline of mosquito taxonomy was given in Chapter 1 to aid the discussion of mosquito biology. In that discussion, species were defined as consisting of interbreeding, or potentially interbreeding groups of populations, which are reproductively isolated from other such groups. This is a biologically realistic definition of the species as it focuses on the features which make species distinct (ultimately the reproductive isolation between species) and the fact that the species is an entity which continues through time, whilst the individual members do not.

With time, each species develops its own unique combination of behavioural, physiological and ecological attributes. Of these, the behavioural characteristics are perhaps the most important in maintaining the integrity of the species for it is these which determine whether individuals from two populations will reproduce when they meet in nature. Each individual uses the behaviour of another to determine whether they are suitable mates. If the behavioural signals are wrong, no mating takes place. There are other incompatibilities which may also prevent successful interbreeding even if copulation between the two species occurs (e.g. infertile eggs, abnormal development of progeny, etc.).

Whilst this definition appears concrete, the analysis of some natural situations is less clear. In some cases, species have developed biological (behavioural, ecological) distinctness sufficient to prevent interbreeding with closely related species, but this has not been accompanied by any significant morphological divergence. Thus, to the naked eye, individuals of both species appear conspecific. Such species groups are termed sibling species complexes.

Members of sibling species complexes may be separated by a number of techniques. Analyses of behaviour and genetic markers (e.g. enzyme analyses, chromosomal banding patterns) can be used to detect differences between natural populations. In many cases, member species can be forced to breed in the laboratory, and the results of these crosses often show marked disruptions to the sex ratios (normally 1:1 for males to females), and marked sterility in the progeny. Sometimes these disruptions may be seen only in one of the possible crossing experiments. That is, when dealing with two species, A and B, crosses involving female A and male B may be normal whilst the reverse cross (female B and male A) may show sterility and distorted sex ratios.

The study of important disease vectors has shown that sibling species are quite prevalent. It was recently estimated that there may be as many as five times the number of currently recognised species in the genera *Culex* and *Anopheles* because of the presence of many sibling species complexes. Whilst the presence of so many unrecognised but biologically distinct species can disrupt the neat divisions used for the identification of individual specimens, in a practical sense it is crucial that these be investigated.

Often, the members of a sibling species complex have different vector capacities, some being major vectors whilst others have little or no role in the transmission of the disease. The classic studies of the malaria vectors *Anopheles maculipennis* in southern Europe and *Anopheles gambiae* in Africa can be used to demonstrate the problem of sibling species.

Prior to the recognition of these sibling species complexes, much time, money and effort was expended in the control and attempted eradication of all populations of the then recognised 'vector'. Many anomalous and seemingly inexplicable observations were recorded. Malaria could be prevalent in one area, but absent from adjacent regions, even though the 'vector' was present. Strange changes in behaviour were noted under pressure of insecticide application in urban areas. The 'vector' would shift feeding to animals rather than man, and seek outdoor shelter for resting sites rather than within houses.

When it was finally recognised that there were several morphologically indistinguishable species included in what was originally seen as a single 'vector', most of these anomalies were resolved. The behaviour changes were due to the selective removal of one of the species, and the presence of a second (rural, zoophilic) species then became more obvious. The same reason could explain the absence of malaria in some areas in spite of large populations of the supposed vector. The dominant sibling species member in these areas was a poor vector and so transmission was minimal.

Once the presence of a sibling species complex is known, the analyses of the individual member species will show which are significant vectors. Efforts at disease control, and vector management can then be focussed on these whilst the other, inefficient vector species can be ignored, increasing the likelihood of successful disease control and reducing the overall costs of management programmes.

In W.A., three sibling species complexes have been recognised. It is possible that other taxa may also include sibling species complexes.

An annulipes s.l. was shown by Chris Green (as part of a Doctoral thesis at the University of W.A. - unpublished) to consist of at least six members Australia wide (species A to F), and three of these (A, B, D) are found in W.A. The species were originally separated on the basis of polytene chromosome banding patterns. This was later confirmed by force mating of the different species in the laboratory and observing the progeny.

An annulipes species A is confined to the wetter parts of the south west corner of the State. Species B occurs in the more arid regions of north and inland W.A. Species D is a tropical species largely confined to the Kimberley Region, though morphologically similar specimens have appeared in association with species B in collections from some localities in the Pilbara. A possible fourth species, species E, has been recognised as a unique chromosome combination on a few occasions from the Geraldton area, but no adult or larval specimens have been preserved.

An farauti s.l. in Australia has been shown to consist of at least three species (species No.1, 2 and 3). Species No.1 occurs in the malarious areas of New Guinea and the adjacent islands, and is the major vector of malaria. All three species occur in Queensland. The Northern Territory is known to have both species No.1 and 3. The form found in W.A. has yet to be analysed to determine to which of the three member species it belongs. It should be noted that the distributions of the three member species are based on limited sampling of the mosquito populations in all areas, and further analyses will undoubtedly extend the range of all species.

Cx annulirostris and *Cx palpalis* form a species pair which can be distinguished with difficulty. There are significant morphological overlaps between the populations of the two species in any given area, and whilst the typical members may be distinguished, intermediates cannot be placed in either taxon with certainty. [Note: *Cx palpalis* species is only known from the Kimberley Region, and is generally much less common then *Cx annulirostris*.]

In general, where sibling species are known, the atlas refers to each as a distinct species, even where no consistent morphological traits are available for ready separation of the species.

The problem of sibling species complexes has been raised here to ensure that the reader is aware of the potential problems in dealing with these species. The only significant problem currently recognised in W.A. is that of the *Cx annulirostris/palpalis* species pair in the Kimberly Region, and generally, the important vector species *(Cx annulirostris)* is nearly always dominant. The vector status of *Cx palpalis* species is uncertain.

PART II : A CHECKLIST OF THE MOSQUITOES OF WESTERN AUSTRALIA

Ninety species of mosquito are known from W.A. at present. Many of these have been collected on only one, or very few occasions.

Not all the different life stages are known for each species on the checklist. The larvae are unknown for thirteen *Aedes* species. Males are unknown for several of the *Aedes* as well and some species have been collected only as larvae. These, or at least some of them, will turn out to be the larval stages of species which are currently only known from adults. Whilst we can make an educated guess as to which adult the undescribed larva can be attributed, this must be confirmed by breeding through the larva to link it directly to an adult.

Seventeen of the species have not been formally described even though they have been recognised as being distinct. Such species are those with a coded prefix which stands for the taxonomist who first recognised them as distinct.

THE MOSQUITOES OF WESTERN AUSTRALIA

1. *Aedeomyia (Aedeomyia) catasticta*
2. *Aedes (Aedimorphus) alboscutellatus*
3. *Aedes (Chaetocruiomyia) calabyi**
4. *Aedes (Chaetocruiomyia) elchoensis*
5. *Aedes (Finlaya) alboannulatus*
6. *Aedes (Finlaya) britteni*
7. *Aedes (Finlaya) notoscriptus*
8. *Aedes (Finlaya) occidentalis*
9. *Aedes (Finlaya) pecuniosus*

10. *Aedes (Halaedes) ashworthi*
11. *Aedes (Macleaya) stoneorum**
12. *Aedes (Macleaya) tremulus*
13. *Aedes (Macleaya)* E.N.M.'s sp. ?#70**
14. *Aedes (Macleaya)* E.N.M.'s sp. #125**
15. *Aedes (Macleaya)* E.N.M.'s sp. #126**
16. *Aedes (Macleaya)* E.N.M.'s sp. #147**
17. *Aedes (Mucidus) alternans*
18. *Aedes (Neomelaniconion) lineatopennis*
19. *Aedes (Ochlerotatus) cacozelus***
20. *Aedes (Ochlerotatus) camptorhynchus*
21. *Aedes (Ochlerotatus) clelandi*
22. *Aedes (Ochlerotatus) eidsvoldensis*
23. *Aedes (Ochlerotatus) hesperonotius***
24. *Aedes (Ochlerotatus) hodgkini*
25. *Aedes (Ochlerotatus) mackintoshi*
26. *Aedes (Ochlerotatus) nigrithorax*
27. *Aedes (Ochlerotatus) normanensis*
28. *Aedes (Ochlerotatus) pseudonormanensis*
29. *Aedes (Ochlerotatus) purpureifemur***
30. *Aedes (Ochlerotatus) ratcliffei*
31. *Aedes (Ochlerotatus) sagax*
32. *Aedes (Ochlerotatus) sapiens**
33. *Aedes (Ochlerotatus) stricklandi*
34. *Aedes (Ochlerotatus) turneri**
35. *Aedes (Ochlerotatus) vigilax*
36. *Aedes (Ochlerotatus) vittiger*
37. *Aedes (Ochlerotatus)* E.N.M.'s sp. #71
38. *Aedes (Ochlerotatus)* E.N.M.'s sp. #85*
39. *Aedes (Ochlerotatus)* E.N.M.'s sp. #159**
40. *Aedes (Ochlerotatus)* E.N.M.'s sp. "Koorda"
41. *Aedes (Ochlerotatus)* E.N.M.'s sp. in the stricklandi section.***
42. *Aedes (Ochlerotatus)* P.F.S.L.'s Bunbury species.***
43. *Aedes (Pseudoskusea) bancroftianus*
44. *Aedes (Stegomyia) aegypti*****
45. *Aedes (Stegomyia) katherinensis*
46. *Aedes (Verrallina) funereus*
47. *Aedes (Verrallina) reesi*
48. *Aedes (Subgen. Nov.) daliensis*
49. *Aedes (Subgen. Nov.)* E.N.M.'s sp. #160*

50. *Anopheles (Anopheles) atratipes*
51. *Anopheles (Anopheles) bancroftii*
52. *Anopheles (Anopheles) powelli*
53. *Anopheles (Cellia) amictus*
    Anopheles (Cellia) annulipes (s.l.)
54. *Anopheles (Cellia) annulipes* C.A.G.'s sp.A
55. *Anopheles (Cellia) annulipes* C.A.G.'s sp.B
56. *Anopheles (Cellia) annulipes* C.A.G.'s sp.D
57. *Anopheles (Cellia) farauti (s.l.)*
58. *Anopheles (Cellia) hilli*
59. *Anopheles (Cellia) meraukensis*
60. *Anopheles (Cellia) novaguinensis*

61. *Coquillettidia (Coquillettidia)* 'Ben Lomond' sp*
62. *Coquillettidia (Coquillettidia) xanthogaster*

63. *Culex (Culex) annulirostris*
64. *Culex (Culex) australicus*
65. *Culex (Culex) bitaeniorhynchus*
66. *Culex (Culex) crinicauda*
67. *Culex (Culex) globocoxitus*
68. *Culex (Culex) molestus*
69. *Culex (Culex) palpalis*
70. *Culex (Culex) quinquefasciatus*
71. *Culex (Culex) sitiens*
72. *Culex (Culex) squamosus*
73. *Culex (Culex) starckeae*
74. *Culex (Culex) vicinus*
75. *Culex (Culex)* E.N.M.'s sp. #92
76. *Culex (Culiciomyia) pullus*
77. *Culex (Lophoceraomyia) cubiculi*
78. *Culex (Lophoceraomyia) cylindricus*
79. *Culex (Lophoceraomyia) fraudatrix*
80. *Culex (Lophoceraomyia) hilli*
81. *Culex (Lophoceraomyia)* E.N.M.'s sp. #154
82. *Culex (Lophoceraomyia)* E.N.M.'s sp. #167
83. *Culex (Lutzia) halifaxii*
84. *Culex (Neoculex) latus*

85. *Culiseta (Culicella) atra*

86. *Mansonia (Mansonoides) uniformis*

87. *Tripteroides (Polylepidomyia) atripes*
88. *Tripteroides (Polylepidomyia) punctolateralis*
89. *Tripteroides (Tripteroides) magnesianus*

90. *Uranotaenia (Uranotaenia) albescens*

* : Known only as females and males; larvae unknown.
** : Known only as adult females; males and larvae unknown.
*** : Known only as larvae; adults not known. These may represent species currently known only from adults.
**** : Apparently not active in W.A. at present.
***** : Recorded as larvae, prepared for chromosomal analyses, no specimens available.

E.N.M. : Dr.E.N. Marks of the Queensland Institute for Medical Research.
C.A.G. : C.A. Green.
P.F.S.L. : P.F.S. Liehne.

CHAPTER 14: MOSQUITO ANATOMY

The identification of mosquitoes depends on the recognition of anatomical features in both the larvae and adults. This chapter presents a brief review of the anatomy of both stages, with illustrations to show the significant features. It is not an exhaustive analysis of mosquito anatomy, but simply presents a guide to those features which are commonly used for identification of specimens. Features which are generally not used for descriptions or identification are ignored to reduce confusion. (For more detailed information on mosquito anatomy refer to R.E. Harbach and K.L. Knight (1980) 'A Taxonomists Glossary of Mosquito Anatomy' - Plexus Publ. Inc.)

A decision had to be made regarding the terminology to use for keys and descriptions of the mosquitoes. Several anatomical terms have common usage in some parts of the world but are less commonly used elsewhere. Harbach and Knight is the first serious attempt to standardise nomenclature for all mosquito anatomy. The problem arises in that this atlas is for non-taxonomists. It was decided to retain the terms widely used in the Australia literature to ensure continuity and consistency with all the major Australian texts on mosquitoes published over the past 50 years.

Viewing the structures of mosquitoes requires some magnification. Most adult structures can be seen at magnifications of between x10 and x80. Larval structure, particularly the fine head hairs or the detailed structure of the comb scales may require higher magnifications (x100 to x200) for accurate assessment. As such, different microscopes may be needed for identification of adults and larvae. Identification of larvae can be difficult, and if insufficient magnification is used, misidentification is possible. Whilst stronger lenses and eye pieces may be used to boost the power of a binocular microscope, the loss in definition of the image generally makes identification difficult.

THE EXTERNAL MORPHOLOGY OF THE LARVAL STAGE

Mosquitoes go through a series of four larval stages (instars) before pupation and emergence. All the four larval stages vary in appearance. It is generally only the fourth instar larva which has sufficient size and detailed characters to ensure identification to species level. The following discussion presents the structure of the fourth instar larva.

All mosquito species share the same basic structure. This extends even to such fine features as the small hairs on the various larval segments. The relationships between the hairs on one segment and another have been analysed, and have been shown to be homologous. There is a standard numbering system used to define each hair. The hairs are numbered from 0 to 15, generally starting on the dorsal mid-line and extending around the segment to the ventral mid-line. The same sequence of hairs is seen on both sides of the body. This system is used for both Culicine and Anopheline larvae.

A generalised diagram of a Culicine larva is presented in Figure 14.1. Figure 14.2 presents a similar illustration of an Anopheline larva. Figure 14.3 illustrates the various hair types seen in larval mosquitoes. The shape, form and relative distribution of the hairs can be important in separating species.

The basic setae are simple hairs, which can be thickened into spiniform setae. The multiple setae can be branched, forked, pectinate, plumose (feather-like), fan-shaped or dendritic, depending on the degree and type of branching. Some setae are highly specialised. Palmate setae are used in Anophelines to hang off the water surface by the action of surface tension. Stellate tufts are seen in the genera *Tripteroides* and *Aedeomyia*, and appear to be related to attachment to substrate or vegetation within the larval habitat.

a) The larval head

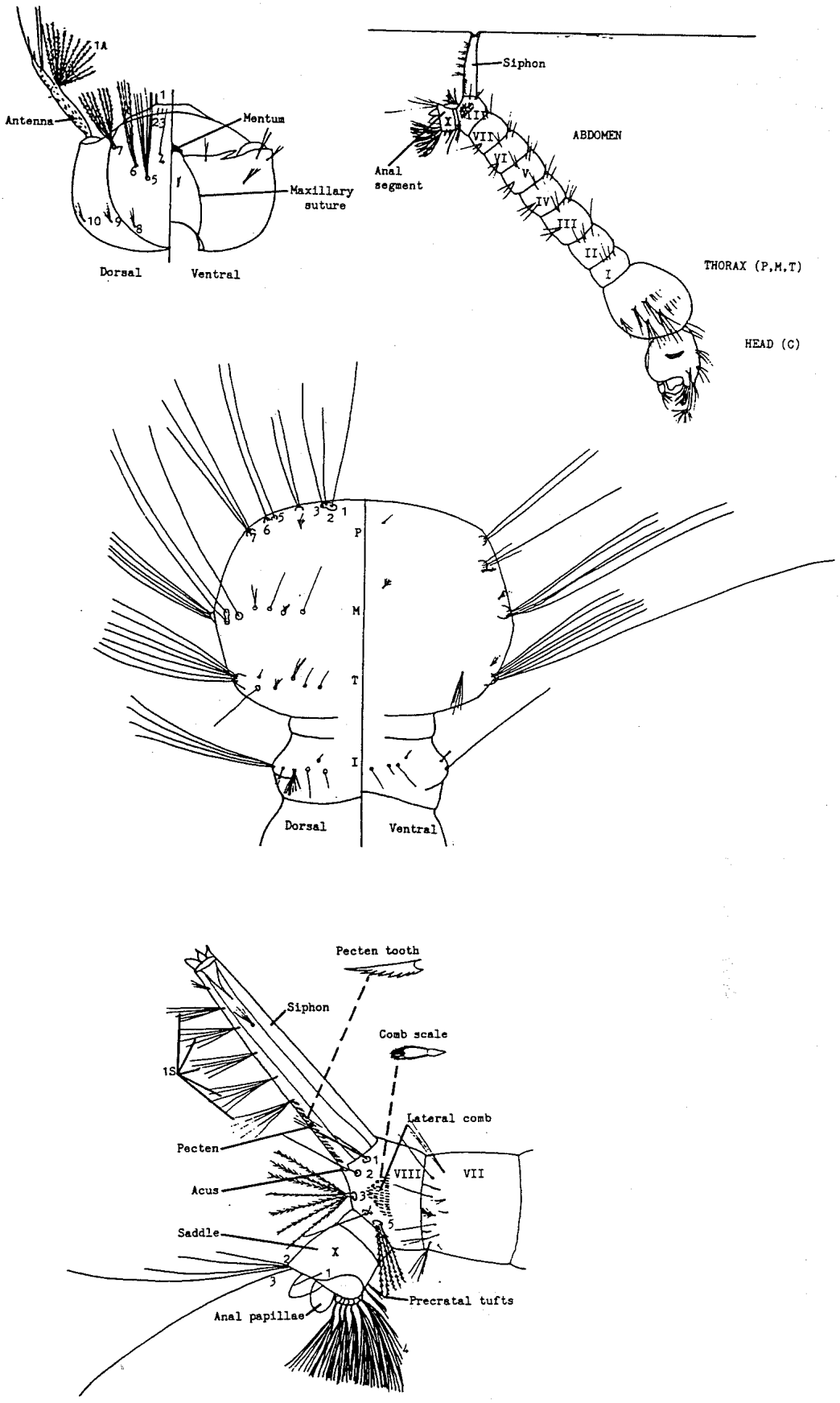
The head capsule consists of two chitinised plates, the dorsal clypeus and the lateral epicranial plates, holding the eyes and the antennae. Often the overall head shape (the ratio of length to width) can be used as an indication of species or genus. The length of the antenna relative to the head, and the relative widths of head and thorax can be diagnostic in some groups. The antenna usually has a tuft of hairs at about the mid-point termed the antennal tuft (seta 1-A).

The ten head (cephalic) setae which can be seen from above are numbered 1-C to 10-C. In Culicines, 1-C (the clypeal spines), and the structure and relative positions of hairs 4-C to 7-C are most often used for identification of species (see Figure 14.1). In Anophelines, the structure and position of 2-C and 3-C are also diagnostic (Figure 14.2).

The most obvious feature of the larval head is the mouthbrush. This dense group of hairs is used to create a current which draws food particles into the mouth. In some species, these are modified for predation and appear as a few, strongly thickened, toothed bristles (see *Ae alternans* and *Cx halifaxii).*

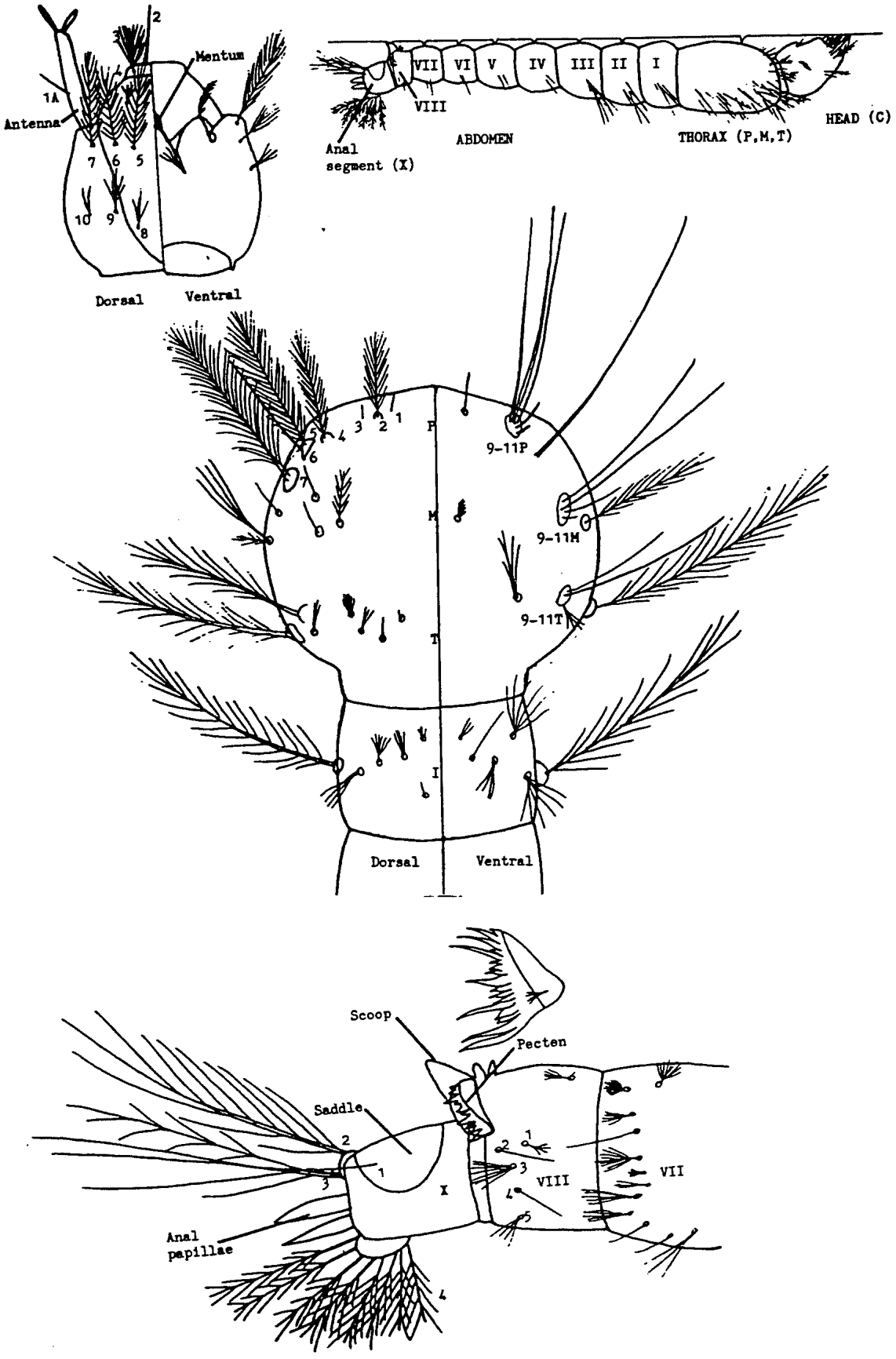
On the underside of the head are the mouthparts. Of these, the dark triangular shaped mentum is the only feature used to separate species. The overall shape and the number of teeth on each side of the mentum are characters used in species descriptions.

FIGURE 14.1 : ANATOMICAL FEATURES OF THE CULICINE LARVAE



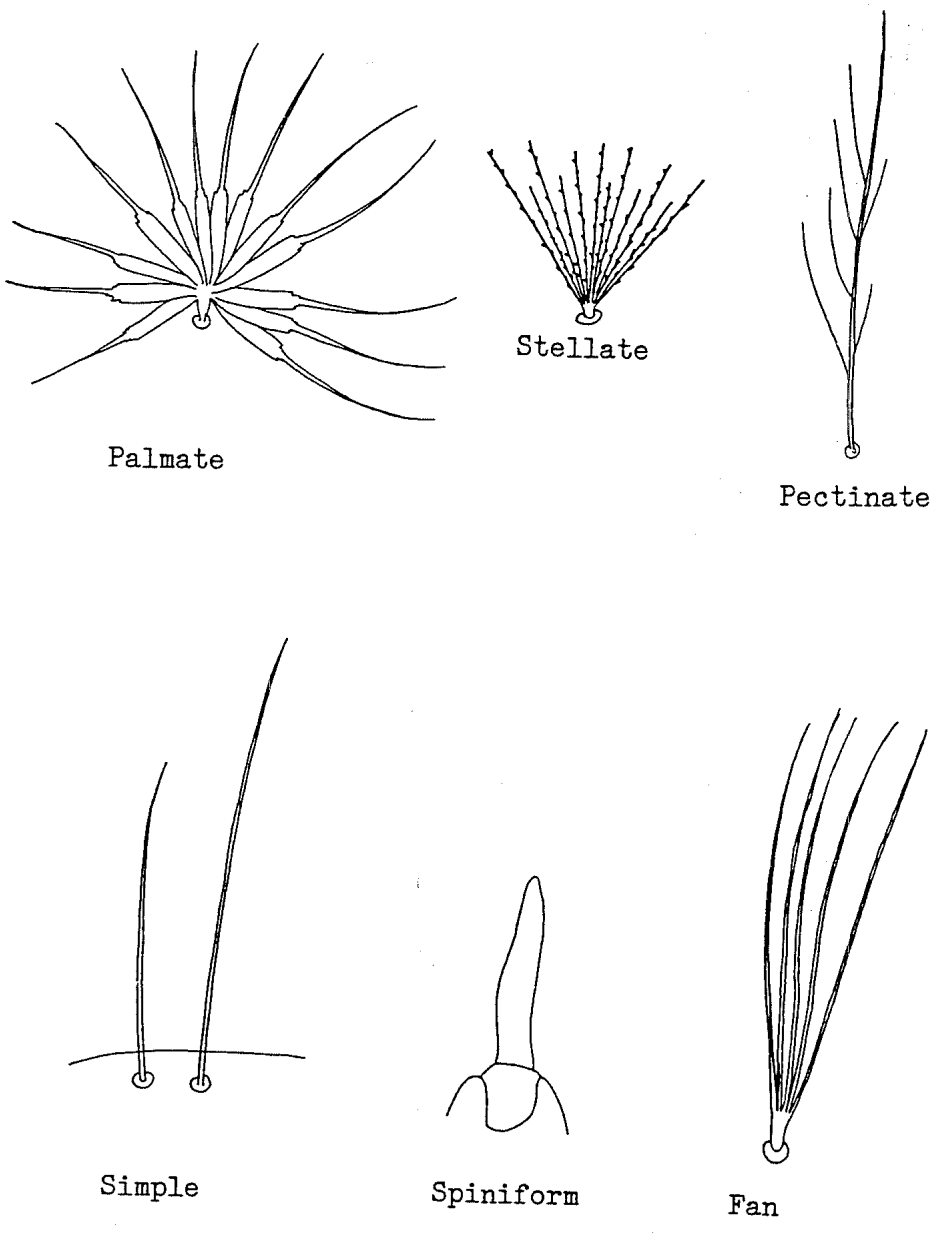
M: Mesothorax; P: Prothorax; T: Metathorax.

FIGURE 14.2 : ANATOMICAL FEATURES OF THE ANOPHELINE LARVAE



M: Mesothorax; P: Prothorax; T: Metathorax.

FIGURE 14.3 : STRUCTURE AND FORM OF LARVAL SETAE



b) The larval thorax

The thorax consists of three fused segments, which can still be recognised by the three distinct lines of setae on the thorax. The three segments are termed (from the anterior end) the pro- (P), meso- (M), and metathorax (T). In Culicines, only setae 1 to 7 of the prothorax (1-P to 7-P) are generally used to separate species. In Anophelines, the thoracic groups (setae 9-11) of all three thoracic segments are used as a diagnostic feature. The thoracic groups can be located by looking at the ventral surface of the thorax and finding the more or less lateral groups of large hairs, each group sharing a common raised base.

c) The larval abdomen

The mosquito larva has eight abdominal segments, numbered in Roman numerals from the anterior end. The diagnostic features of the abdomen are mostly on segment VIII. The pentad hairs (1-VIII to 5-VIII) and the number, distribution and form of the scales of the lateral comb (a lateral patch of scales on segment VIII) are important characteristics for identification. Attached to segment VIII are the siphon (breathing organ) and the anal segment (see below).

The Anophelines do not possess a siphon, and the features of the abdomen are fewer than in the Culicines. The shape and form of the pecten plate (this feature is homologous to the pecten on the siphon of Culicine larvae) and that of the pentad hairs can be used for identification. The spiracles at the dorsal tip of segment VIII are important for species identification. The spiracles are situated on a spiracular plate.

d) The siphon

Several characteristics of the siphon are used to separate Culicine species. The overall length and shape are important, as are the setae and pecten.

At the base of the siphon of some species is a small sclerotised hook known as the acus. The siphon index is a measure of the size and shape of the siphon and is calculated by dividing the overall length (excluding the acus and dorsal valves) by the width at the base.

There are nine siphonal setae (1-S to 9-S), the most diagnostic of which is seta 1-S, which usually forms one or more pairs of sub-ventral siphonal tufts. The number, shape and distribution of the pecten teeth (small sub-ventral teeth near the base of the siphon) are also useful diagnostic features.

In *Mansonia* and *Coquillettidia* the siphon is highly modified for piercing plant stems and these genera can be readily separated out by the structure of the siphon alone.

d) The anal segment

The anal segment in both Anophelines and Culicines has essentially similar structures. The main feature is a chitinised plate (the saddle) which covers the dorsal surface of the segment and may completely surround the segment.

The segment has four pairs of setae (1-X to 4-X). 1-X is lateral and usually found on the posterior part of the saddle. 2-X and 3-X are paired dorsal tufts, usually single or branched and positioned above the anal papillae. 4-X consists of a number of paired hairs (up to 10 pairs) below the anal papillae. The bases of these hairs often fuse into a grid structure. The hairs attached to the grid are termed cratal hairs, whilst any detached hairs anterior of the grid are termed precratal tufts.

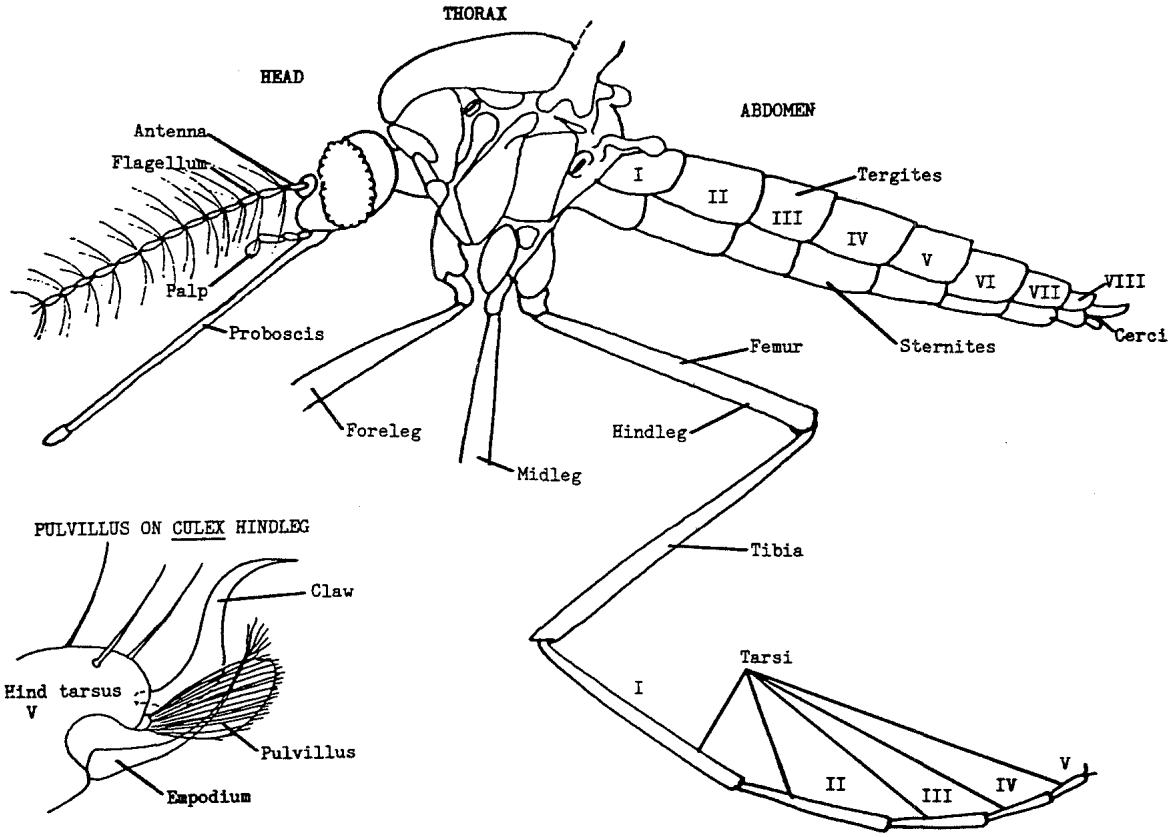
The anal papillae are the insect equivalent of kidneys and are responsible for maintaining the correct water balance within the larva. In some species the shape and length of the anal papillae relative to the saddle is indicative of the larval habitat and can be a useful feature for species identification (e.g. *Cx australicus, Cx globocoxitus* and *Cx quinquifasciatus* can be separated by looking at the anal papillae.)

THE EXTERNAL MORPHOLOGY OF THE ADULT

This section deals only with the morphology of the adult female, and as in the discussion of larval characters, presents only those features which are used in the description or identification of species. Figure 14.4 is a generalised view of an adult mosquito showing the main parts of the body.

The adult is also divided into three segments: the head, the thorax and the abdomen. Attached to the posterior thorax are one pair of wings, and a pair of vestigial wings (which act as balance organs) known as halteres. Three pairs of legs are joined to the thorax ventrally. The body is made up of a large number of chitinised plates which may be clothed in scale patches and may support bristles. The shape, colour and distribution of these scales and bristles are used to identify individual species.

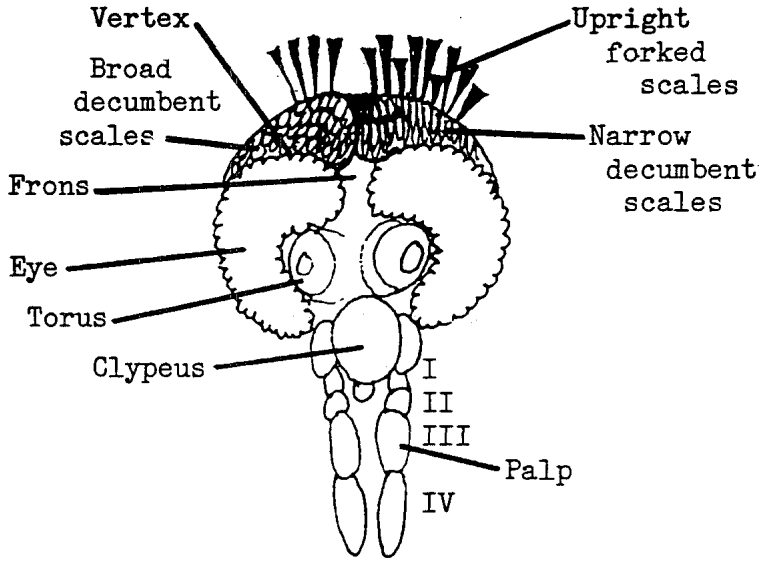
FIGURE 14.4 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - GENERAL VIEW



a) The adult head (Figure 14.5)

The adult head is composed of several elements. The lateral multifaceted eyes are perhaps the most obvious feature. The area above the eyes is the vertex, whilst the back part, next to the thorax, is the occiput (see also Figure 14.7). To the front, the actual eye border has ocular setae and often has a distinguishable row of scales. The area between the eyes is the frons. Medially below the eyes is the base of the antenna (the torus). The torus may have some small scales present medially. The antenna consists of 15 flagellar segments (the flagellum), each with a whorl of fine setae. There is marked sexual dimorphism in antennal structure in all the W.A. species. Directly below the torus is the clypeus. The clypeus is of little diagnostic significance.

FIGURE 14.5 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - THE HEAD



Below the clypeus are the proboscis (also termed the labium), and the paired sensory palps. The palps have four segments, and the scaling and length of the palp relative to the proboscis can be diagnostic. The proboscis consists of an outer sheath covered in scales which encloses the elongate mouth parts. The length of the proboscis relative to the forefemur and the distribution of scaling can be diagnostic features.

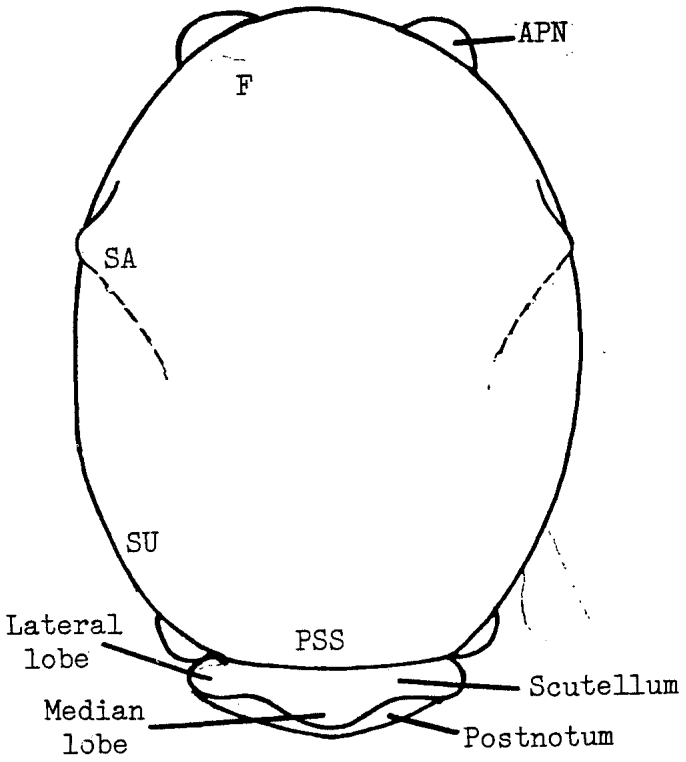
The mosquito head is clothed in scales. The scales which lie appressed to the surface of the head are termed decumbent scales and may be broad or narrow. There are, in addition, some scales on the dorsal surface of the head which stand vertically from the surface, and which are usually forked (the upright forked scales). The colour and distribution of these scales is used for identification. The distribution is presented relative to the anatomical features of the head.

b) The adult thorax

The thorax must be viewed from above and from the side. The dorsal surface of the thorax is the scutum (S), and this is joined posteriorly by the trilobed scutellum (Sc) [Figure 14.6]. The broad plate which extends from the scutellum to the abdomen is called the postnotum (P). The colouring and distribution of scales are described relative to the features of the scutum. There is a slight ridge above the mesothoracic spiracle which is termed the scutal angle (SA). Just forward of this is an area called the fossa (F). The area above the wing root is the supraalar region (SU) and that medially before the scutellum is the prescutellar space (PSS). The prescutellar space is often bare, but is bounded by marked scaling.

The scutum and scutellum form part of the mesothorax along with most of the lateral sclerites and membranous areas. The prothorax is represented by the raised anterior pronotum (APN) and the broad posterior pronotum (PPN) which lies anterior to the anterior (mesothoracic) spiracle (AS) [Figure 14.7]. Also included in the prothorax is a small membranous area directly anterior to the spiracle - the spiracular area (SP). Bristles or scales on this small area are diagnostic of *Tripteroides* and *Culiseta*. The propleuron (PPL), a small raised boss above the coxa of the foreleg on the anterior edge of the thorax, is also part of the prothorax.

FIGURE 14.6 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - THE DORSAL THORAX



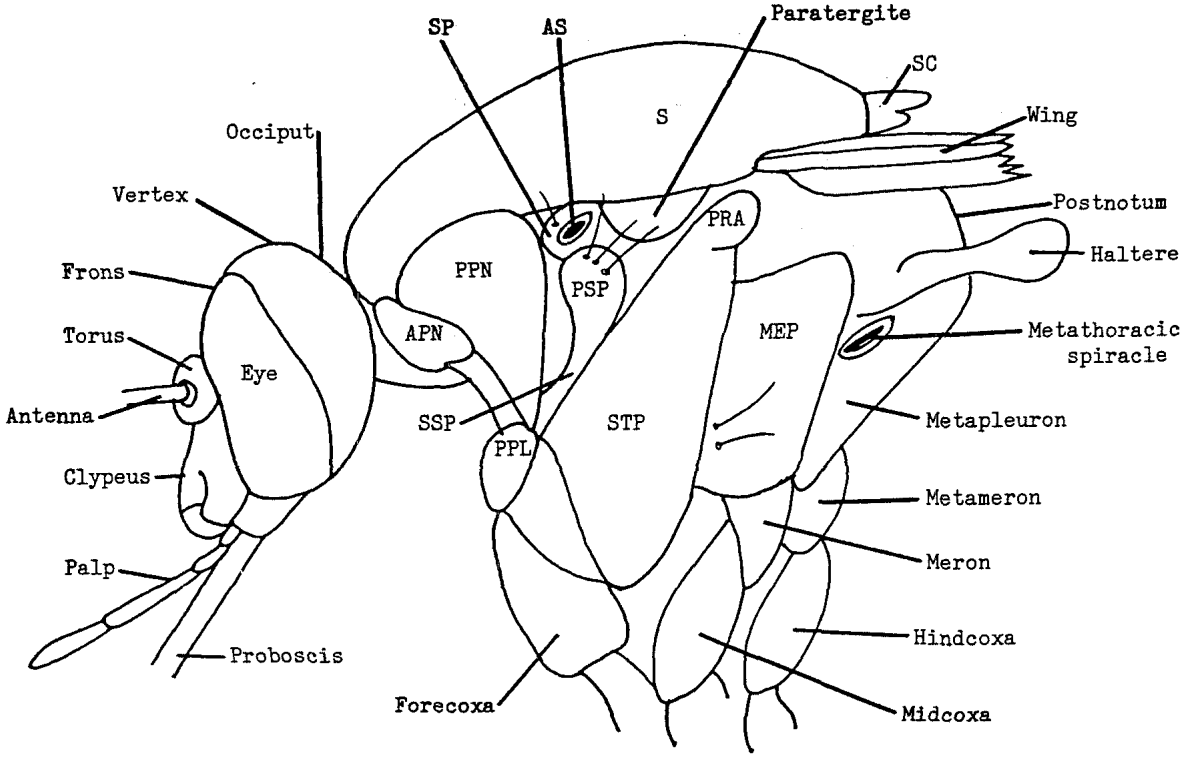
APN: Anterior pronotum; F: Fossa; PSS: Prescutellar space; SA: Scutal angle; SU: Supraalar region.

The mesothoracic sclerites include the postspiracular area (PSP) immediately below and behind the spiracle. This sclerite is continuous with the subspiracular area (SSP) which lies directly below the spiracle. To the rear of these is a large plate known as the sternopleuron (STP). The dorsal tip of the STP forms a raised boss known as the prealar area (PRA). A small area lying just below the scutum between the mesothoracic spiracle and the PRA is the paratergite. The large rectangular sclerite posterior of the STP is called the mesepimeron (MEP). Below the MEP is the meron, and posterior to this, the metameron.

The metathorax consists of the postnotum and the metapleuron. The metathoracic spiracle lies just anterior of the base of the haltere.

The dorsal and lateral aspects of the thorax are clothed both in bristles and scales. Bristles are present on most of the segments, but the most significant are the spiracular bristles on the spiracular area (SP), those on the post spiracular area (PSP) and the lower mesepimeral bristles (MEP) [Figure 14.7].

FIGURE 14.7 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - THE LATERAL THORAX



APN: anterior pronotum; AS: anterior (mesothoracic) spiracle; MEP: mesepimeron; PPL: propleuron; PPN: posterior pronotum; PRA: prealar area; PSP: postspiracular area; S: scutum; SC: scutellum; SP: spiracular area; SSP: supspiracular area; STP: sternopleuron.

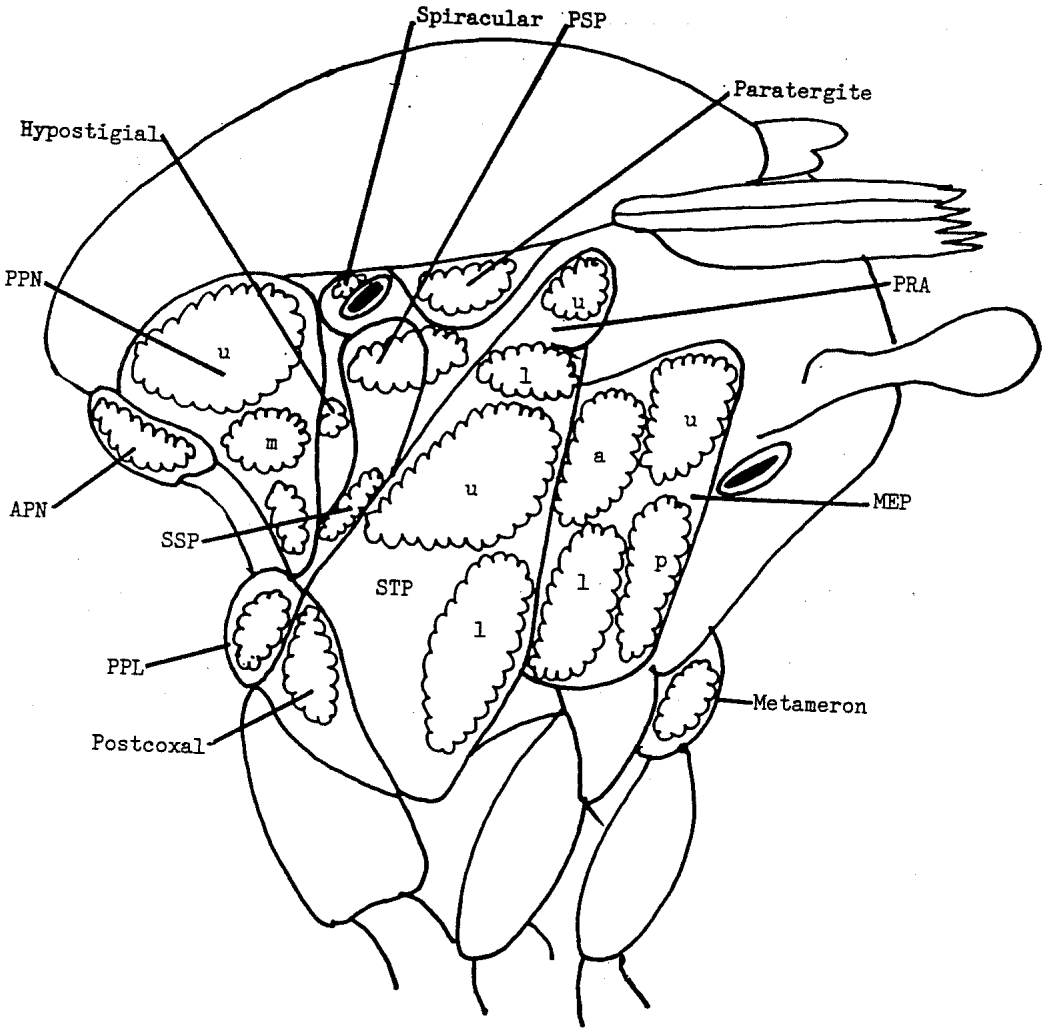
The distribution of scaling is described in relation to the relative position on the sclerite. Figure 14.8 is a view of the lateral thorax showing the main scaling patches. The patches are termed as being upper (u), medial (m), lower (l), anterior (a) and posterior (p). There is sometimes a small scale patch on the membranous area between the PSP and the PPN which is called the hypostigial patch, and sometimes some scales are on the postcoxal membrane behind the forecoxa.

c) The adult abdomen

The abdomen consists of eight segments numbered I-VIII from the anterior (thorax) end (see Figure 14.4). Each segment has a dorsal plate (tergite) and a ventral plate (sternite) attached by an expandable membrane. In some species, segment VIII is reduced and withdrawn into segment VII. The genetalia are at the end of the abdomen and can be seen as paired cerci extending beyond segment VIII in some species.

Both the tergites and sternites are covered in dense scaling in most species. The colour variations in scaling, described in relation to the position on each segment, are often of diagnostic significance (particularly in the genera *Aedes* and *Culex).*

FIGURE 14.8 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - THORACIC SCALING



APN: anterior pronotum; MEP: mesepimeron; PPL: propleuron; PPN: posterior pronotum; PRA: prealar area; PSP: postspiracular area; SSP: supspiracular area; STP: sternopleuron; u: upper; l: lower; a: anterior; p: posterior.

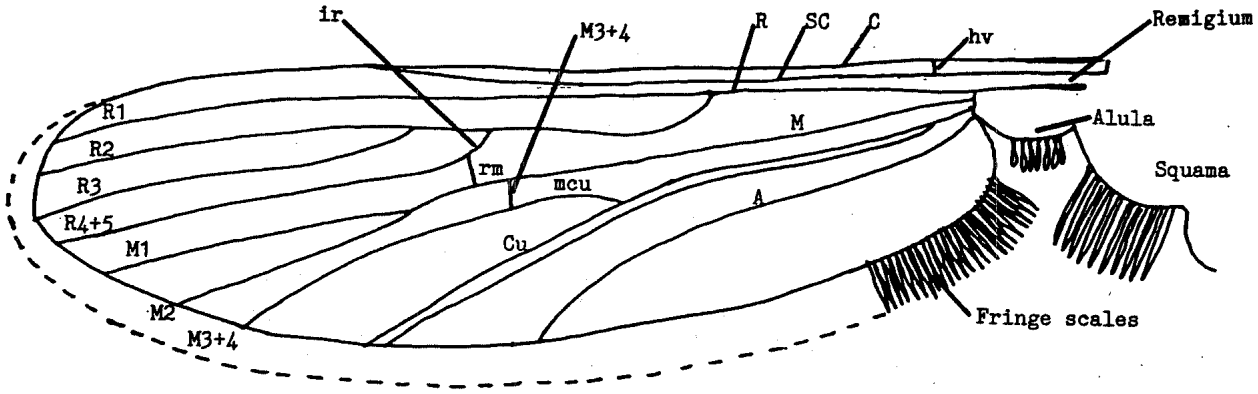
d) The wing (Figure 14.9)

The mosquito wing is clothed in scales along the wing veins and along the posterior edge. The shape, colour and distribution of the scales can be diagnostic.

The wing veins have a standard nomenclature. The primary veins are those which run from the wing root to the posterior edge of the wing and are named from the leading edge being, in order, the costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu) and anal (A). The radius, media and cubitus veins are often forked and each fork is numbered according to the order in which it reaches the posterior margin of the wing. There are, in addition, a number of small cross veins joining the primary wing veins, named with respect to the veins they join. The relative positions of the forks, cross veins and terminations of the veins can all be used to distinguish species or genera.

There is in some species a small patch of bristles on the veins at the base of the wing. Remigial bristles lie on the dorsal surface of the remigium (the common base of veins R, M, Cu and A. Occasionally, small bristles are seen on the ventral surface of the base of the subcosta (subcostal bristles).

FIGURE 14.9 : ANATOMICAL FEATURES OF THE ADULT MOSQUITO - THE WING



A: anal vein; C: costal vein; Cu: cubitus; hv: humeral cross vein; M: media; R: radius; ir: inter-radial cross vein; rm: radio-median cross vein; Sc: subcostal vein.

e) The legs

The first segment of the leg is the coxa which is the articulated joint attaching the leg to the thorax. The next segments are, in order, the femur, tibia and the five tarsal segments (Figure 14.4). Scaling and relative lengths of the various segments are often diagnostic.

The last tarsal segment usually has paired claws. The shape and form of these may be diagnostic. In *Culex* species, tarsal claws are small and partially obscured by a feathery structure called the pulvillus (Figure 14.4).

CHAPTER 15: INTRODUCTION TO THE KEYS AND KEYS TO THE GENERA

INTRODUCTION TO THE KEYS

Individual specimens are identified through the use of dichotomous keys. In such keys, a choice between two alternatives is presented at each division. The specimen should be checked thoroughly to determine which of the two possibilities is correct. This branch of the key is then followed to the next pair of options, and the process is repeated. The form of the key is akin to a branch, beginning near the trunk. The identification process is like following along a branch, ignoring the wrong forks, until the correct outer twig is reached.

The keys presented in this chapter are for identification down to genus. After arriving at a genus turn to the appropriate chapter and check your specimen against the description of that genus. If the description matches, continue to further identify your specimen using the subgenera and species keys presented in that chapter. (Note: the keys also list species where only one species in the particular genus is known from W.A.). Misidentifications are always a problem, particularly when identifications are first attempted. Perseverance and practice will allow recognition of the common species, and give increased confidence with identification of specimens of less common species.

It should be remembered that many of the 90 species listed as being recorded in W.A. are very restricted in distribution. There are generally only a relatively small group of species found in any given locality. With local knowledge, it will be possible to choose between the locally common species with very little effort.

As mentioned in the Introduction, it is wise to have specimens in your reference collection for which identifications have been confirmed by a recognised taxonomist or medical entomologist. This enables you to check current identifications against previously confirmed specimens. For details of how to prepare and maintain a reference collection, see Appendix 1.

THE PROBLEM OF VARIATION WITHIN A SPECIES

When attempting to identify an individual mosquito specimen, it should always be remembered that the specimen is only one individual taken from a population. To those inexperienced in mosquito identification, there is often some confusion when dealing with the variation observed within a particular species.

The human race is a good example to illustrate the type of variation which can be expected in a single species. The types of variation seen within one human population (size, shape, skin colour, hair colour and distribution, sexual dimorphism and age differences) make all individuals uniquely recognisable. If geographical races are considered, even more striking differences are observed. At the same time, all are still clearly recognisable as humans.

The same quality of variation is seen in mosquitoes, though mosquitoes are smaller, simpler organisms, and in most cases do not have the same global distribution. The size of the mosquito is the product of innate genetic predeterminants and the effects of the environment on the final expression of these. Such factors as temperature, nutrient levels and larval density all affect the size of the emerging adults. Even within a single habitat there can be significant variations in the size and relative proportions of individuals within the one species. Factors in the habitat can affect the colour of the emerging adults. For example, some individuals breeding in waters with dark algae have a characteristically greenish colour. Such variation must be considered when identifying an individual specimen.

Individuals from widely separated populations may show marked differences, sometimes to the extent that if the two extremes were encountered within one geographical area, they may be mistakenly identified as distinct species. Careful analysis of the population revealing intermediates between the observed extremes may show that the specimens are conspecific.

Identification can be a particular problem when dealing with aged individuals, or individuals damaged by poor handling during collection. Aging results in the loss of scales from many parts of the body, occasionally obliterating the characteristic scale patterns and sometimes diagnostic features. The identification of these specimens can be difficult. With some local experience, it is possible to identify damaged or old specimens with some certainty, but in other circumstances, this may not be possible. For this reason, it is always important to treat any collections with care so as to avoid damaging the insects. Once dead, the insects dry quickly, becoming brittle and susceptible to severe damage during handling.

When dealing with a difficult specimen, work through the key and try to determine its identity. If the characters for any couplet in the key are obscured or lost, follow both branches and check the possible identifications. Comparisons of the descriptions at both conclusions to the key should allow identification. Check against other better preserved specimens in the collection and see if it is the same as one already

identified. If an identification cannot be made, the problem species should be checked by a medical entomologist. It is worth repeating here that medical entomologists, whilst usually prepared to help, are generally very busy and should not be burdened with unnecessary queries.

KEYS TO MOSQUITO GENERA IN WESTERN AUSTRALIA
ADULT FEMALES

1.	– Palps about equal in length with proboscis	ANOPHELES
	– Palps usually very short, at most about 0.67 length of proboscis	2
2.	– Squama of wing bare; postnotum bare; wing vein 1A reaching wing margin at most slightly beyond junction of *M-Cu* and *Cu1;* microtrichae small and inconspicuous	URANOTAENIA *Ur (Ura) albescens*
	– Squama of wing fringed in part at least; or postnotum with bristles; or vein 1A reaching wing margin well beyond the junction of *M-Cu* and *Cu1;* microtrichae distinct	3
3.	– Spiracular area with 1 or more bristles or scales	4
	– Spiracular area bare	5
4.	– Bristles present dorsally on stem vein of wing (remigium) and usually also ventrally on base of subcosta; prealar bristles relatively numerous	CULISETA *Cs (Cuc) atra*
	– Stem vein and ventral surface of subcosta without bristles; at most 1-2 prealar bristles	TRIPTEROIDES
5.	– All antennal segments short and thick, basal segment with prominent scale tuft; mid and hind femora with apical tufts of suberect scales	AEDEOMYIA *Ad (Ady) catasticta*
	– Antennal segments otherwise; no apical tufts of suberect scales on femora	6
6.	– Postspiracular bristles present, or fore tarsal claws toothed, or both	7
	– Postspiracular bristles absent; all tarsal claws simple	8
7.	– Upper surface of wing with all or most scales very broad, asymmetrical; all tarsal claws simple; decumbent scales of vertex narrow	MANSONIA *Ma (Mnd) uniformis*
	– Without this combination of characters	AEDES
8.	– Pulvilli present on all claws; hind tarsal claws very small and inconspicuous	CULEX
	– Pulvilli absent	COQUILLETTIDIA

KEYS TO MOSQUITO GENERA IN WESTERN AUSTRALIA
4TH INSTAR LARVAE

1.	– Siphon absent; seta 1 palmate on most abdominal segments	ANOPHELES
	– Siphon present; Abdominal seta 1 never palmate	2
2.	– Ventral brush with a single pair of setae (sometimes with 1-2 supplementary hairs in some individuals); Antenna short, without articulated apical segment; siphon with 2 or more subdorsal setae as well as subventral setae	TRIPTEROIDES
	– Without this combination of characters	3
3.	– Siphon modified for piercing plant tissues, with a sclerotized saw-tooth process at tip	4
	– Siphon not modified; or if so, without saw-toothed process	5
4.	– Antenna with very long flexible flagellar segment	COQUILLETTIDIA
	– Antenna with short rigid flagellar segment	MANSONIA *Ma (Mnd) uniformis*
5.	– Antenna broad and flattened; some thoracic setae very long, others stellate; tip of siphon with paired hooks and branched setae	AEDEOMYIA *Ad (Ady) catasticta*
	– Antenna, thoracic setae and siphon otherwise	6

6. – Siphon with subventral setae more numerous, or if with a single pair, then these arise at 0.2 or less of the distance from the base to apex 7
   – Siphon with single pair of subventral setae arising at not less than 0.25 of the distance from base to apex, usually more 8
7. – Siphon with subventral setae more numerous, occasionally forming midventral row; never with separate pair arising at base ..... CULEX
   – Siphon with single pair of subventral setae arising near base ..... CULISETA
   Cs (Cuc) atra
8. – Maxillary suture absent or incomplete; head setae 5-C or 6-C or both often flattened, barbed, spine-like; comb often arising from large sclerotized plate..... URANOTAENIA
   Ur (Ura) albescens
   – Maxillary suture well developed; head hairs 5-C and 6-C sometimes single and barbed, never spine-like; comb plate if present smaller ..... AEDES

CHAPTER 16: Genus *AEDEOMYIA*

Aedeomyia catasticta is the only species of *Aedeomyia* known from W.A. This species is common in the more permanent wetlands of the Kimberley region, its range extending southwards as isolated populations in the few permanent wetlands of the Pilbara.

GENERIC CHARACTERS:

Adult: Palps in both sexes about 0.25x length proboscis. Scales on thorax large and broad. Lower mesepimeral bristles present. A few bristles present on mid-lobe of scutellum. Hind and midfemora with apical tufts of sub-erect scales, sometimes extending to tibiae. Tarsal segment IV of foreleg and midleg shorter than tarsal segment V; and hind tarsal segment I about as long as hind tibia. Pulvilli absent, claws equal in female. Rather short and rounded wing densely clothed in broad scales. Female abdominal segment VIII is short and broad, cerci short.

Larva: Head large; as broad as thorax. Antennae large, broadly flattened and hairy, with large tuft and three long apical setae and stout spine at tip. Mentum small with few teeth. Prothoracic hairs very long. Integument hairy. Segment VIII of abdomen with single row of comb teeth on plate. Siphon short, curved and tapering, hairy; pecten absent; seta 1-S at or beyond mid-point. Anal segment completely ringed by saddle, clothed in fine hairs; setae 2-X and 3-X single, strongly plumose along upper edge; 4-X strongly plumose. Anal papillae small.

KEYS: ADULT FEMALES: see key to genera (Chapter 15, page 93).
LARVAE: see key to genera (Chapter 15, page 93).

Aedeomyia catasticta Knab 1909

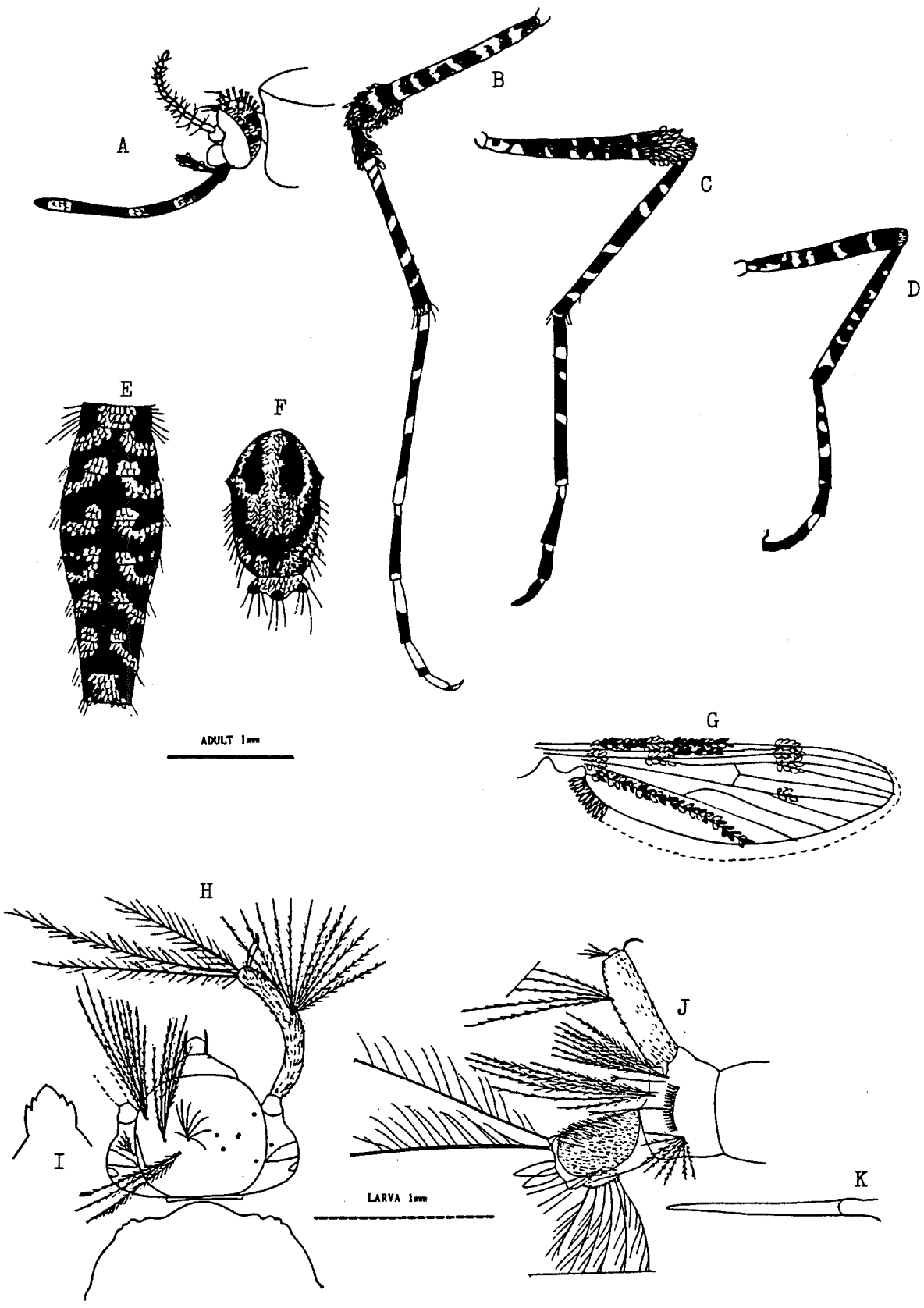
Knab, F., 1909. *Ent. News, 20:* 387.
Type locality: Samal, Bataan, Philippines.
Synonym: None

ADULT FEMALE

Head with broad flat decumbent scales pale on vertex and mesially, dark laterally; upright forked scales numerous, pale anteriorly and dark posteriorly. Torus and clypeus with broad white scales. Antenna with short globular segments. Palps about 0.16x proboscis, mottled with white scales at tip. Proboscis approximately 1.3x forefemur, dark scaled with three pale bands, apical, medial and sub-basal. Scutum densely clothed with broad white, golden and brown scales; pale and golden scales form broad mesial band with large lateral patches about midthorax; patch of long broad dark scales above wing root. Scutellum with long broad and dark scales on all lobes, a few bristles on mid-lobe. Pleura with integument brown; three lower mesepimeral bristles present; dense patches of pale scales on anterior pronotum, lower posterior pronotum, post spiracular area, upper and lower-posterior sterno-pleuron, upper mesepimeron, and prealar areas. Abdomen with tergites mainly dark scaled, with pale mid-lateral to medial basal bands, with mid-apical patches forming distinct pattern, tergite VIII mottled; sternites I-VI mottled; VII dark; VIII mottled. All coxae mottled with broad light and dark scales. Femora mottled with some pale banding; mid and hindfemora with apical patches of pale, large sub-erect scales; tibiae with narrow pale bands along entire length; hind tarsi with pale basal bands, with some pale scales on apex of preceding segment in some specimens; hind tarsus V pale, dark at tip.

LARVA

Head about 1.4x as broad as long; about 0.8x width of thorax. Antenna concolorous with head; about 1.8x length of head; seta 1-A 12 branched, pectinate, inserted about 0.75 from base. Head setae 1-C is a long, forward projecting spine; 4-C has 5-10 fine branches; 5-C has 3 large pectinate branches; 6-C has 6-8 long fine pectinate branches; 7-C has 9-11 strong pectinate branches; 8-C is single; 9-C has 3-4 short pectinate branches. Some thoracic setae very long, extending beyond head; some setae on thorax stellate. Some abdominal setae long. Abdominal segment VIII with lateral comb of 17-20 simple long spines joined basally; seta 1-VIII with 7-10 plumose branches; 3-VIII with 6 pectinate branches; 5-VIII with 6-11 pectinate branches; 2-VIII and 4-VIII single branched. Siphon is curved dorsally with large hooked setae on dorsal valves; clothed in fine hairs; acus short; siphon index is 4.7; seta 1-S single tuft of 5 long pectinate branches inserted 0.6 from base. Anal segment saddle forms complete ring; clothed in fine hairs with dorsal and posterior spines; setae 1-X with three simple branches; 2-X and 3-X both single, long, pectinate; 4-X with 6 pairs of pectinate tufts on grid; precratal tufts absent. Anal papillae long, narrow and pointed, 0.5-0.7x length of saddle.



Aedeomyia catasticta

A: Adult head (lateral); B: Hind leg; C: Mid leg; D: Fore leg; E: Abdomen (dorsal); F: Thorax (dorsal); G: Wing (only part of wing scales shown); H: Larval head (dorsal); I: Mentum; J: Abdomen (segment VIII) (lateral); K: Lateral comb scale.

BIOLOGY

Breeding sites are usually in permanent and semi-permanent fresh (and occasionally slightly brackish) water bodies such as swamps, lagoons, seepage ponds and ponded streams. Breeding is associated with the presence of filamentous algae and emergent vegetation. The larvae are often found attached to algae and may be difficult to locate. The breeding sites may be shaded, but also may be in full sunlight. The eggs of *Ad catasticta* are laid singly, beneath the water surface, attached to algal filaments.

The adult female does not bite man, though it is attracted to light and is readily captured in light or CO_2 traps. Large numbers may be captured at avian bait. Adult females are more common in tree top vegetation than near the ground. The species is generally more abundant in the dry season than in the wet, increasing populations generally coinciding with the aging of breeding habitat and growth of algae.

RELATION TO DISEASE

Ad catasticta is not known to be a vector of any significant diseases. Several arboviruses have been isolated from this species (Alfuy, Corriparta), but none are known to cause disease in man.

DISTRIBUTION

Camballin, Jul-Aug 1979, AEW. De Grey R., Jun 1978, AEW. Drysdale R., Aug 1979, AEW. Fitzroy Crossing, Aug 1953, EJB. Fortescue, Jan 1985, MEC. Kalumburu, Mar 1954, EPH; Jul 1978, PFSL/AEW; Aug 1979, AEW. Kalumburu, Carson R., Mar 1954, EPH. Kimberley Downs, May 1979, AEW. Kununurra, May 1972, PFSL; Dec 1972, PFSL; Apr 1973, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Jul 1976, PFSL; Oct 1976, PFSL; Apr-May 1977, PFSL/AEW; Nov 1977, PFSL; Jun-Jul 1978, PFSL/AEW. Lake Argyle, Dec 1972, PFSL; Nov 1977, PFSL. Lake Argyle, NE, Jul 1978, PFSL/AEW. Lake Argyle, SW, Jul 1978, PFSL/AEW. Lissadel, Jul 1978, PFSL/AEW. Lockyer Gap, Nov 1984, MEC. Louisa Downs, May 1979, AEW. Millstream, Oct 1970, DHC; Apr 1971, DHC; Oct 1978, AEW; Oct 1979, DHC; Nov 1984, MEC. Noonkanbah, Nov 1940, RTMP; Nov 1943, RTMP. Petermarer Creek, Jun 1978, AEW. Roebourne, Oct 1984, MEC. Wickham, Apr 1986, PFSL. Wittenoom, Nov 1984, MEC.

SPECIES WITH WHICH IT MAY BE CONFUSED

Aedeomyia venustipes is the only other species of *Aedeomyia* known from Australia. This species is restricted to the south east coastal parts of Australia, the most northerly record being Fraser Island in Queensland. No other species from W.A. resembles either adults or larvae of *Ad. catasticta*.

CHAPTER 17: Genus *AEDES*

The largest number of mosquito species in W.A. belong to the genus *Aedes*, and indeed over half of them fall into a single subgenus, *Ochlerotatus*.

GENERIC CHARACTERS

Adult: Palps generally short, less than 0.25x length proboscis. Upright forked scales on vertex numerous. Spiracular bristles absent, postspiracular bristles always present. Tarsal claws usually toothed, pulvilli absent. Wing membrane with distinct microtrichia.

Larva: Siphon usually short; seta 1-S a single pair of tufts, never inserted at base of siphon. Saddle rarely complete ring.

KEYS TO SUBGENERA OF *AEDES* IN WESTERN AUSTRALIA
ADULT FEMALES

(Based in part on key by Y.-M. Huang, 1968: *J. Med. Ent., 5*:169)

1.	– Wing membrane clouded on cross-vein *r-m* and on bases of *Rs* and *M3+4;* palp about 0.67 of proboscis	MUCIDUS *Ae (Muc) alternans*
	– Wing membrane not clouded or with diffuse clouding not restricted to cross vein *r-m* and bases of *Rs* and *M3+4*	2
2.	– Wings with a tuft of very long scales at base of *R* (remigium)	CHAETOCRUIOMYIA (part) *Ae (Cha) calabyi*
	– Wings without tuft	3
3.	– Head with dorsal decumbent scales largely narrow; erect scales numerous, not confined to occiput	4
	– Head with dorsal decumbent scales largely broad	10
4.	– Lower prealar area with patch of appressed scales	5
	– Lower prealar area without patch of appressed scales	7
5.	– Cerci long and slender, eighth sternite small	OCHLEROTATUS
	– Cerci short and broad, eighth sternite large, may obscure cerci	6
6.	– Lower mesepimeral bristles present; hind tarsal claws with subbasal tooth	HALAEDES *Ae (Hal) ashworthi*
	– Lower mesepimeral bristles absent; hind tarsal claws simple	FINLAYA (part)
7.	– Scutellum with broad scales on all lobes	8
	– Scutellum with narrow scales	9
8.	– Cerci long and slender; sternite VIII small with margin concave	AEDIMORPHUS *Ae (Adm) alboscutellatus*
	– Cerci short and broad; sternite VIII large, distal margin not concave	FINLAYA (part)
9.	– Cerci short	undescribed subgenus *Ae* ENM's sp. No.160
	– Cerci long	NEOMELANICONION *Ae (Neo) lineatopennis*
10.	– Head with erect scales numerous, not confined to occiput and area of upper ocular setae	11
	– Erect scales confined to occiput, or to occiput plus a row behind upper ocular setae	13
11.	– Scutellum with broad scales on midlobe, narrow and/or broad on lateral lobes; all tarsal claws simple; hind tarsal segment V all white	12
	– Without this combination of characters	FINLAYA (part)
12.	– Paratergite bare; postspiracular area with scales	CHAETOCRUIOMYIA (part) *Ae (Cha) elchoensis*
	– Scales on both paratergite and postspiracular area	MACLEAYA
13.	– Scutellum with broad scales on all lobes	14
	– Scutellum with narrow scales on all lobes	15

14. – Tarsi banded; scutellum with silvery white broad scales at least on one lobe ..... STEGOMYIA
– Tarsi not banded; scutellum with broad dark scales on all lobes ..... undescribed subgenus *Ae (subgen?) daliensis*

15. – Lower mesepimeron without hairs or bristles ..... PSEUDOSKUSEA *Ae (Psk) bancroftianus*
– Lower mesepimeron with hairs and/or fine bristles; propleuron with patch of broad white scales ..... VERRALLINA

KEYS TO SUBGENERA OF *AEDES* IN WESTERN AUSTRALIA. 4TH INSTAR LARVAE

(Based in part on key by Y.-M. Huang, 1968: *J. Med. Ent.*, 5:169)

Note: This key includes all species from W.A. except species in the subgenus *Ochlerotatus.*

1. – Pentad hairs 1-VIII and 2-VIII on common basal plate 2
– Pentad hairs 1-VIII and 2-VIII not on common basal plate 4

2. – Anal segment with seta 2-X single; siphon seta 1-S strongly developed; large larva with mouthbrushes modified for predation ..... MUCIDUS *Ae (Muc) alternans*
– Anal segment with seta 2-X branched; 1-S of siphon not strongly developed 3

3. – Lateral comb with triangular patch of 23-25 evenly fringed scales... AEDIMORPHUS *Ae (Adm) alboscutellatus*
– Lateral comb with 8 teeth in row with central spine extending beyond fringe ..... NEOMELLANICONION *Ae (Neo) lineatopennis*

4. – Ventral brush (seta 4-X) arising from sclerotized plate; mouthbrushes modified for predation ..... FINLAYA (part) *Ae (Fin) pecuniosus*
– Ventral brush (seta 4-X) arising from grid 5

5. – Anal segment with seta 4-X having more than 13 tufts (6 pairs) of branched setae 6
– Anal segment with seta 4-X having no more that 12 tufts (6 pairs) of branched setae 12

6. – Saddle completely rings anal segment ..... OCHLEROTATUS (part)
– Saddle incomplete, not meeting ventrally 7

7. – Siphonal tuft (1-S) strongly developed 8
– Siphonal tuft (1-S) not strongly developed 11

8. – Anal segment with precratal tufts present ..... OCHLEROTATUS (part)
– Precratal tufts absent 9

9. – Head with setae 5-C and 6-C single simple ..... HALAEDES *Ae (Hal) ashworthi*
– Head setae 5-C and 6-C multibranched, simple ..... [FINLAYA (part)] 10

10. – Head setae 4-C inserted anteriorly of 5-C; angle formed by 4-C, 5-C and 6-C acute ..... *Ae (Fin) alboannulatus*
– Head setae 4-C inserted adjacent to 5-C; angle formed by 4-C, 5-C and 6-C is obtuse ..... *Ae (Fin) occidentalis*

11. – Siphon with pecten teeth evenly spaced, closely set, extending little beyond midpoint of siphon; anal papillae subequal ..... FINLAYA (part) *Ae (Fin) notoscriptus*
– Siphon with pecten teeth with 1-3 posterior teeth more widely spaced than those preceding ..... VERRALLINA *Ae (Ver) funereus*

12. –	Antenna with spicules; anal segment seta 4-X with 10-12 branched setae (5-6 pairs) on distinct grid	13
–	Antennal spicules absent	15
13. –	Lateral comb scales in single row	FINLAYA (part) *Ae (Fin) britteni*
–	Lateral comb with 70+ scales in triangular patch	14
14. –	Siphon with seta 1-S well developed, at least 0.5 length of siphon	PSEUDOSKUSEA *Ae (Psk) bancroftianus*
–	Siphonal seta 1-S much shorter than 0.4 of siphon length	undescribed subgenus *Ae (subgen?) daliensis*
15. –	Comb scales in single row, most on lateral sclerotized plate	CHAETOCRUIOMYIA MACLEAYA
–	Comb scales as single row of detached scales	[STEGOMYIA] 16
16. –	Lateral comb teeth strongly pectinate	*Ae (Stg) aegypti*
–	Lateral comb teeth with basal fringe	*Ae (Stg) katherinensis*

DESCRIPTIONS OF SPECIES

Subgenus : *Aedimorphus*

SUBGENERIC CHARACTERS:

Adult: Decumbent scales on vertex narrow. Proboscis longer than forefemur; palps short, less than 0.2 of proboscis. Scutum with narrow scales. Claws of foreleg and midleg always toothed, hind claws simple or toothed. Abdominal segment VIII partially or wholly retractile; cerci variable.

Larva: Larva variable, subgeneric characters not evident.

KEYS: ADULT FEMALES: see key to subgenera of Aedes (page 98) and key to the subgenus Ochlerotatus (page 130).
LARVAE: see key to subgenera of Aedes (page 99).

Aedes (Aedimorphus) alboscutellatus (Theobald) 1905

Theobald, F.V., 1905. *Ann. Hist. Nat. Mus. Hung., 3:* 80.
Type locality: Simband, Huon Gulf, New Guinea.
Synonymy: *Aedes argentinotus* Banks, C.S., 1909. *Phillip. J. Sci.*, 4: 547. *Aedes omurensis* Yamada, S., 1921. *Annot. Zool. Jap., 10:* 73.

This species is identified in the key to subgenera of Aedes, and is also included in the keys to the subgenus Ochlerotatus as the species superficially resembles the Ochlerotatus in that the female has a pointed abdomen with abdominal sternite VIII small and retracted, cerci long, head with numerous narrow curved decumbent scales, and claws of foreleg and midleg toothed.

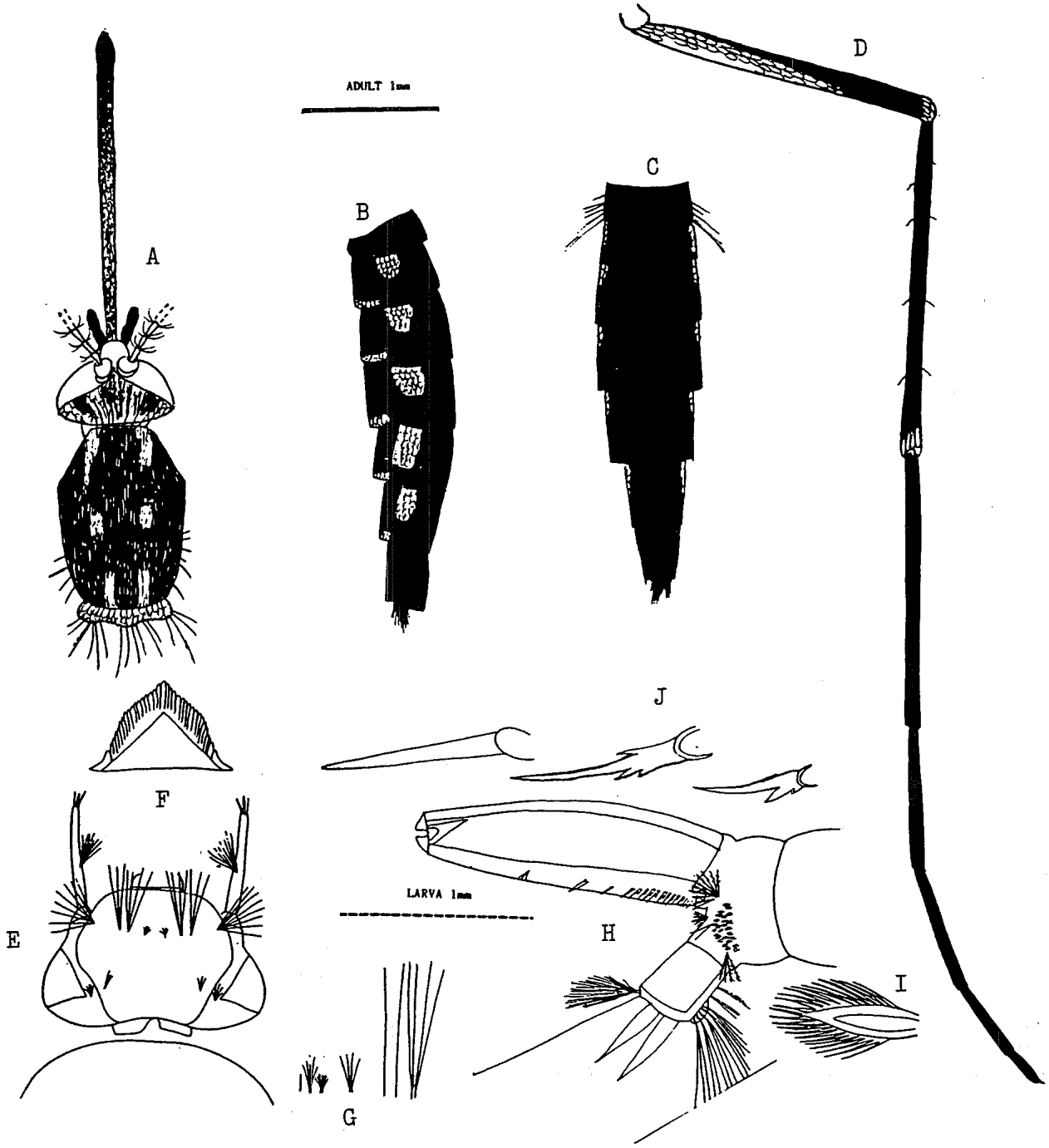
ADULT FEMALE

A moderately small species with silver/white scales on the scutellum. Head with fine narrow dark decumbent scales on the vertex, pale on occiput extending laterally to eye margin; broad dark and pale scales on sides of head; upright forked scales dark, numerous. Clypeus bare. Torus with a few broad dark scales. Palps dark scaled and short, about 0.11x length of proboscis. Proboscis black scaled, about 1.1x length forefemur. Scutal integument red/brown, clothed with small narrow dark scales, with a few small patches of pale to bronze scales on fossa and above wing root. Scutellum clothed in broad flat silver/white scales on all three lobes, in continuous band. Pleural integument brown; with scattered silver/white narrow scales on anterior pronotum and upper posterior pronotum; appressed silver white scales on propleuron, upper and posterior sternopleuron, and upper mesepimeron; 2 postspiracular bristles. Abdomen with tergites black with lateral basal white patches; sternites pale yellow, light brown apically. Forecoxa and midcoxa with patches of appressed silver/white scales. Hindfemur dark, pale ventrally on basal 0.75 with silver knee spot; tibia dark with apical silver spot; tarsi all dark. Wings dark scaled. Haltere light brown.

LARVA

Larvae not known from W.A., description based on a specimen from the Northern Territory. Antenna pale, long and thin, about 0.72x length of head; seta 1-A with 8-10 branches, inserted about 0.44 from base of antenna. Head about 0.64x as long as wide; about 0.81x width of thorax; seta 4-C with about 5 very small branches; 5-C large with 4 branches; 6-C with 3 branches; 7-C with 8 branches; 4-C to 7-C in rough line

across head. Prothoracic setae 1-P to 7-P as follows: 1-P to 4-P short with 1, 5, 6 and 5 branches respectively; 5-P and 6-P single, long; 7-P with 4 long branches. Abdominal segment VIII with lateral comb of 23-25 short fringed scales in triangular patch; setae 1-VIII with 8 pectinate branches; 2-VIII and 4-VIII bifid; 3-VIII with about 20 fine branches; 5-VIII with 5 pectinate branches. Siphon index about 3.7; siphon about 4.2x length of saddle; siphonal seta 1-S small, bifid, inserted about 0.6 from base; pecten with 12-16 teeth with basal teeth having strong denticles, apical teeth simple spines, apical 1-2 teeth separated from main row of teeth, extending to 0.37 from base. Saddle incomplete, covers dorsal 0.75 of anal segment, seta 1-X single; 2-X with about 20 branches; 3-X single; 4-X with 5 pairs of tufts on grid; 2 precratal tufts present. Anal papillae long and pointed, about equal in length to saddle.



Aedes (Aedimorphus) alboscutellatus

A: Adult head and thorax (dorsal); B: Abdomen (lateral); C: Abdomen (dorsal); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Prothoracic setae (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale; J: Pecten teeth (detail of basal, mid and apical teeth).

BIOLOGY

Ae alboscutellatus breeds in fresh transient ground pools, often associated with species of *Culex*. Near Darwin, it has been found breeding in a shaded ground pool with *Cx (Lop) sp #167* and *Ur albescens*. Elsewhere, breeding sites have been open ground pools, wheel ruts, and jungle pools.

Adults will bite man during the day and evening. Adults are taken in light traps and CO_2 baited traps, but are not attracted to avian baited traps. Although this species has a very restricted distribution in W.A., it can be a local pest elsewhere in its range.

RELATION TO DISEASE

None known.

DISTRIBUTION

Parry's Creek, Feb 1982, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is readily identified in that it has indistinct scutal ornamentation with broad white scales completely covering the scutellum.

Subgenus : *Chaetocruiomyia*

SUBGENERIC CHARACTERS

Adult: Small ornamented species, with anterior scutum generally all pale. Proboscis short. Legs short and stocky. Scutellum, vertex and pronotal lobes with broad flat scales. Wings with tuft of long stout bristles dorsally at base. Abdomen short and stout; cerci short and hidden.

Larva: Larvae of most species unknown and reliable subgeneric characters are not known.

KEYS: ADULT FEMALES: see key to subgenera of Aedes (page 98).
LARVAE: see key to subgenera of Aedes (page 99).
(Note: there are no reliable characters for the larvae of *Aedes (Chaetocruiomyia)*, and the larvae which are known cannot be distinguished readily from species of *Aedes (Macleaya)*.)

Aedes (Chaetocruiomyia) calabyi Marks 1963

Marks, E.N., 1963. *Pap. Dep. Ent. Univ. Qld., 1:* 204.
Type locality: Queen Victoria Spring, W.A.
Synonymy: none.

ADULT FEMALE

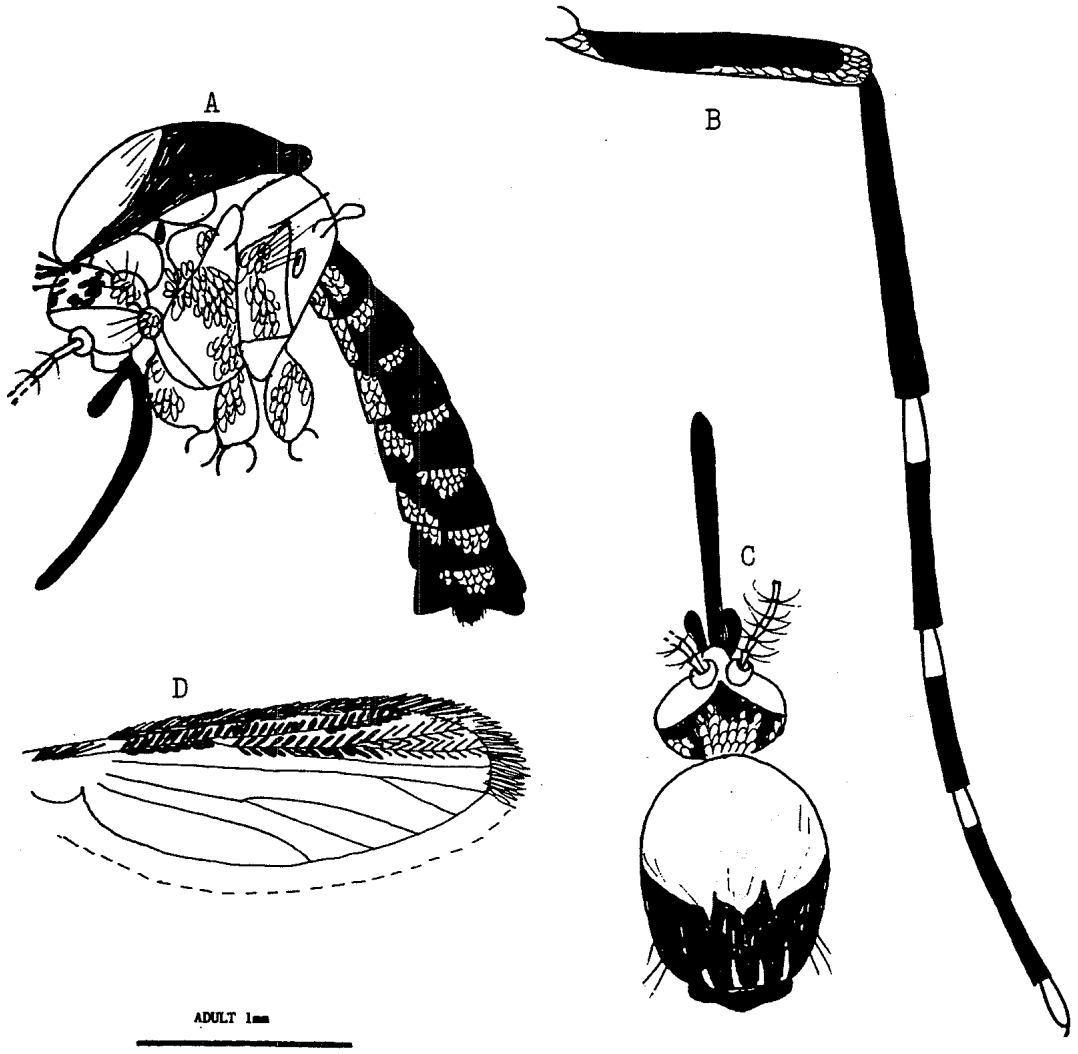
Small, dark, relatively rare species with a hunched appearance. Adults are readily identified as it is the only species from the south west with the anterior part of the scutum clothed in golden/white scales. Decumbent scales on head broad and flat with dark eye border, irregular pale patch behind; upright forked scales on occiput are pale. Torus is dark, bare. Palp dark scaled, about 0.2x length of proboscis. Proboscis dark scaled, about equal in length to forefemur. Anterior half of scutum clothed in dense, narrow golden scales, black on posterior half. Scutellum clothed with dark scales on all lobes. Anterior pronotum and posterior pronotum with broad dark scales dorsally, some pale scales ventrally; propleuron, subspiracular area, and sternopleuron with dense, appressed, broad white scales. Abdomen blunt ended; tergites dark black with lateral and medial white scale patches; sternites dark with pale medioapical patches continuing into basolateral pale patches of the next segment forming a distinct V. All coxae with appressed pale and dark broad scales. Hindfemur with pale band at base, patch of ventral pale scales extending to white knee spot; tibia dark; tarsi I-III with vivid white basal bands, IV dark, V white. Wing dark scaled with patch of elongate forked scales on base of *R*. Halteres white.

LARVA

Larva unknown.

BIOLOGY

Little is known of the biology of this species. It is associated with arid zones of southern W.A. in mallee or sclerophyll woodland areas. It bites man in the afternoon and at dusk, when conditions are favourable. Adults apparently survive through periods with little or no rainfall, becoming active and feeding when humidity rises prior to rain.



Aedes (Chaetocruiomyia) calabyi
A: Adult head, thorax and abdomen (lateral); B: Hindleg; C: Head and thorax (dorsal); E: Wing.

RELATION TO DISEASE

None known.

DISTRIBUTION

Coolgardie, 1967, ENM. Darkan, 17km SE, Jan 1953, JHC. Goongarrie, 5km S, Oct 1954, DLM. Gordon River, Jan 1972, HEP. Kalgoorlie, 1967, ENM. Kojonup, Mar 1955, DLM. Lake Grace, Mar 1955, EJB. Lake King, Mar 1955, EJB. Merredin, 50km NE, Dec 1953, DLM. Nanambinia, 8km SSW, Dec 1953, DLM. Newdegate, Mar 1955, EJB. Queen Victoria Spring, 8km S, Oct 1956, JHC.

SPECIES WITH WHICH IT MAY BE CONFUSED

There is no species in the south west of W.A. with which this species can be confused.

Aedes (Chaetocruiomyia) elchoensis Taylor 1929

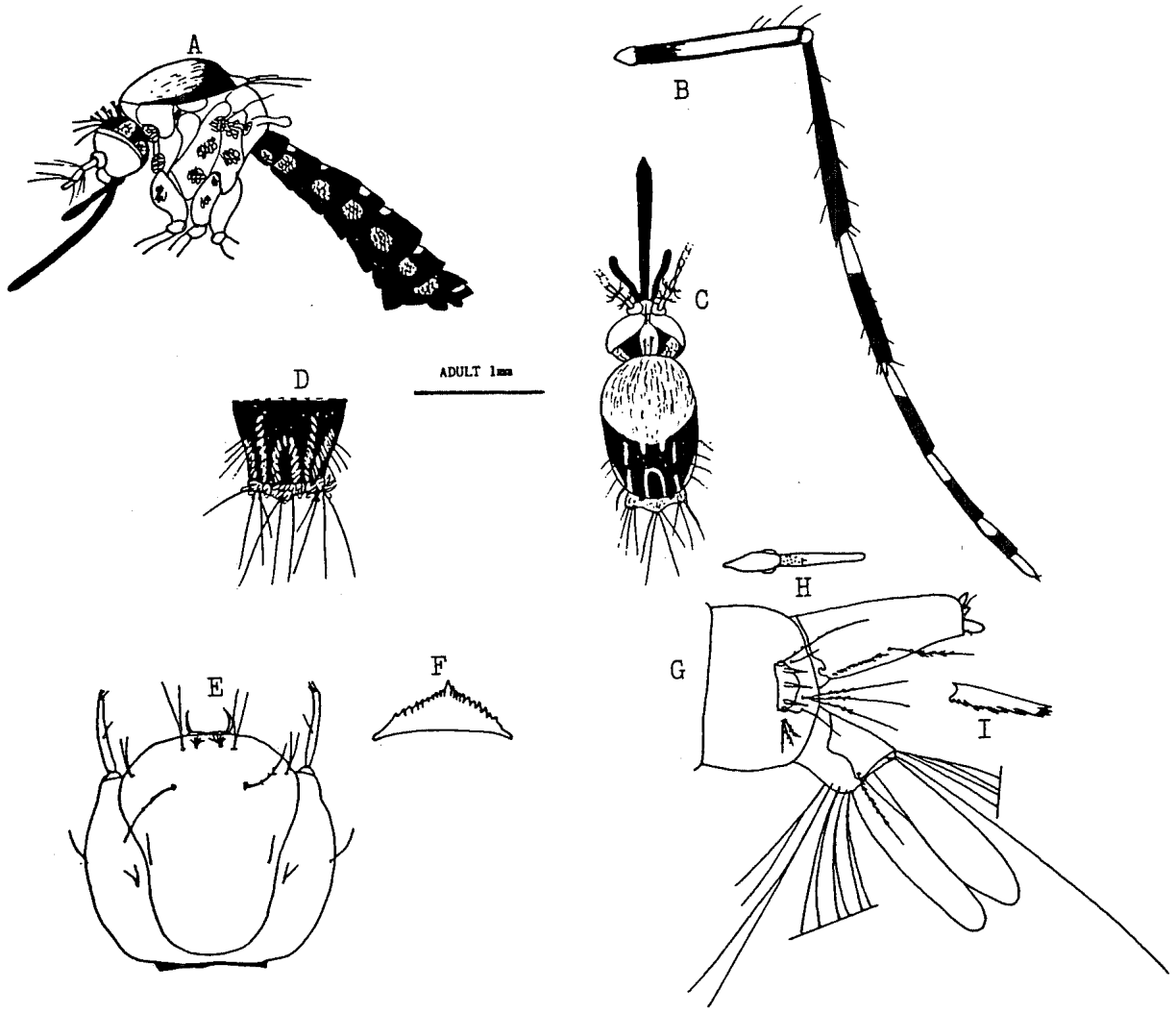
Taylor, F.W., 1929. *Bull. Ent. Res., 20:* 276.
Type locality: Elcho Island, Northern Territory.
Synonymy: None.

ADULT FEMALE

Very small, dark mosquito with the anterior half of the scutum pale scaled. Decumbent scales on head broad flat, dark with median pale stripe and some pale scales laterally; upright forked scales on vertex dark. Torus dark, bare. Palp black, about 0.4x length of proboscis. Proboscis black, about 0.88x length of forefemur. Scutum with dense narrow silver white scales on anterior half of scutum, black elsewhere with small pale patches above wing root and around prescutellar space. Scutellum with pale and dark scales on all three lobes. Pleura with silver/white scale patches on posterior pronotum, propleuron, postspiracular area, upper and posterior sternopleuron, prealar area, and anterior, posterior and upper mesepimeron; one postspiracular bristle present. Abdominal tergites black, with basal medial and lateral white scale patches; sternites largely black, with narrow pale basal bands or basal lateral patches on some segments. Coxae of all legs with some pale scales. Hindleg dark with femur having basal pale band and white knee spot and white medial stripe on apical 0.67; tibia dark; tarsi I to IV with broad basal pale bands, V all white. Wing dark scaled, without modified scales on base of *R*. Haltere light brown.

LARVA

The larva of this species was not seen, but it closely resembles that of *Aedes (Macleaya) tremulus*. The following description and the larval illustration are adapted from Marks 1964 (Proc. Linn. Soc. N.S.W., 89, 133-138). Colour pale, head light brown, siphon and saddle brown. Antenna brown about 0.33x length of head, seta 1-A inserted at about midpoint, short single. Head almost as long as broad; setae 4-C and 6-C arising near front of head, 4-C is short, 11-12 branched and inserted slightly anterior of 6-C which is 2



Aedes (Chaetocruiomyia) elchoensis

A: Adult head, thorax and abdomen (lateral); B: hindleg; C: Head and thorax (dorsal); D: Posterior scutum and scutellum (detail); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten tooth (detail).

branched; 5-C is single, frayed and directed posteriorly; 7-C is 2 branched and 8-C single; mentum with strong medial tooth, and ten strong lateral teeth. Prothoracic setae 1-7 are as follows: 1-P long, 2-3 branched; 2-P short, fine single; 3-P short, fine bifid, shorter than 2-P; 4-P short, 2-3 branched; 5-P and 6-P long, single; and 7-P with 2 long branches. Abdominal segment VIII as follows: seta 1-VIII single, strong, frayed; 2-VIII and 4-VIII single, fine; 3-VIII with 3-4 strong, frayed branches; 5-VIII strong, 3- branched; lateral comb with single row of 4 blunt spines. Siphon index about 2.2, tapering with dark basal collar and well developed acus; seta 1-S single long strong and inserted at about midpoint; pecten with 13-14 spines over basal 0.33-0.37 of siphon. Anal segment with saddle covering dorsal half, with distinct basal collar and some distinct spicules on posterior margin; seta 1-X moderately long, single frayed; 2-X with 4 long strong branches; 3-X single, long; 4-X (ventral brush) with 10 pairs of bifid setae on incomplete grid. Anal papillae rounded, about 2.66x length of saddle.

BIOLOGY

This species has been collected from open forest areas in tropical Australia. The larva was collected from a tree hole in a *Eucalyptus alba* tree, in association with *Ae (Mac) tremulus*. The adults bite man, mainly at night, and have been taken biting horses. Adults are collected quite readily in CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Drysdale R., Aug 1979, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is unique in the tropical parts of W. A., and will not easily be confused with any other species. The only species which have a similar pale thorax are *Cx (Cux) starkeae* and *Cx (Cux) vicinus*, both of which are much larger and have fawn/brown, not black, integument.

Subgenus : *Finlaya*

The subgenus Finlaya contains a large number of species which can be placed into subgroups according to natural affinities. The treatment of the subgenus here does not attempt to relate species to these natural groupings, and all species are listed alphabetically. Those wishing to discover more about the subgroups are referred to the monograph series 'The Culicidae of the Australasian Region'.

SUBGENERIC CHARACTERS

Adult: Genus with variable morphology and biology. Male palps shorter than proboscis; female palps usually 0.2-0.125 length of proboscis, rarely to 0.67. Proboscis usually longer than forefemur. No lower mesepimeral bristles. Foretarsal and midtarsal claws toothed, hindtarsal claws simple in both males and females. Female abdominal segment VIII large, not fully retractile; sternite large and prominent; cerci always short.

Larva: Head with seta 6-C in front of seta 5-C. Siphon short; seta 1-S inserted at about 0.5 of siphon. Lateral comb variable, large triangular patch or single row.

KEY TO ADULT FEMALES OF *AEDES (FINLAYA)* IN WESTERN AUSTRALIA.

1. – Proboscis with narrow pale band near midpoint; scutum dark with narrow silvery white lyre shaped pattern ..... *Ae (Fin) notoscriptus*
   – Proboscis without band; scutal scaling various, without white lyre pattern (may have broad flat silver scale patches) 2
2. – Scutal integument orange/brown, largely bare with very narrow dark scales ..... *Ae (Fin) britteni*
   – Scutal integument dark 3
3. – Tarsal segment I of midleg with basal pale band at least 0.33x length of segment; scutum with broad flat silver scales (large species) ..... *Ae (Fin) pecuniosus*
   – Tarsal segment I of midleg with basal band not more than 0.25x length of segment; scutum without silver scaling (medium sized species) 4

4. – Hind femur with preapical white band and ochreous knee spot; scutum with distinct white spots; proboscis with some mottling..... *Ae (Fin) alboannulatus*
– Hind femur without preapical pale band; scutum with bronze scale patches; proboscis dark..... *Ae (Fin) occidentalis*

KEYS: LARVAE: see key to subgenera of Aedes (page 99).

Aedes (Finlaya) alboannulatus (Macquart) 1850

Macquart, J., 1850. *Dipt. Exot.*, Suppl. 4: 10.
Type locality: Cote Orientale, Nouvelle-Hollande. [Australia].
Synonymy: None.

ADULT FEMALE

Medium to large sized species, very common in south west W.A. and readily recognised by the subapical pale ring on the hindfemur. Head with dorsal decumbent scales narrow, bronzy, with pale median patch; lateral scales broad flat, mainly dark with pale patch; upright forked scales numerous, dark. Torus with dark scales. Palp about 0.17x length of proboscis, dark with apical pale patches on segments III and IV. Proboscis dark scaled, with some mottled white scaling on mid third; about same length as forefemur. Scutum with minute bronze to black scaling, integument red/brown; white scale patches on posterior margin of fossa, above wing roots and around prescutellar space. Scutellum with narrow white scales on all lobes. Pleural integument dark; scales on anterior pronotum and upper posterior pronotum dark; broad flat pale scaling on lower posterior pronotum, propleuron, subspiracular area, postspiracular area, paratergite, upper, posterior and lower sternopleuron, prealar area, and anterior and posterior mesepimeron; three postspiracular bristles present. Abdomen with tergites dark with pale basal bands separated from lateral basal pale patches; sternites white scaled with medial and apical lateral dark scale patches. Hindfemur dark, mottled with ochre knee spot and basal and subapical pale bands; tibia mottled; tarsi I-IV with pale basal bands, V dark. Wing dark scaled. Haltere with pale stem, pale scaled above, dark laterally.

LARVA

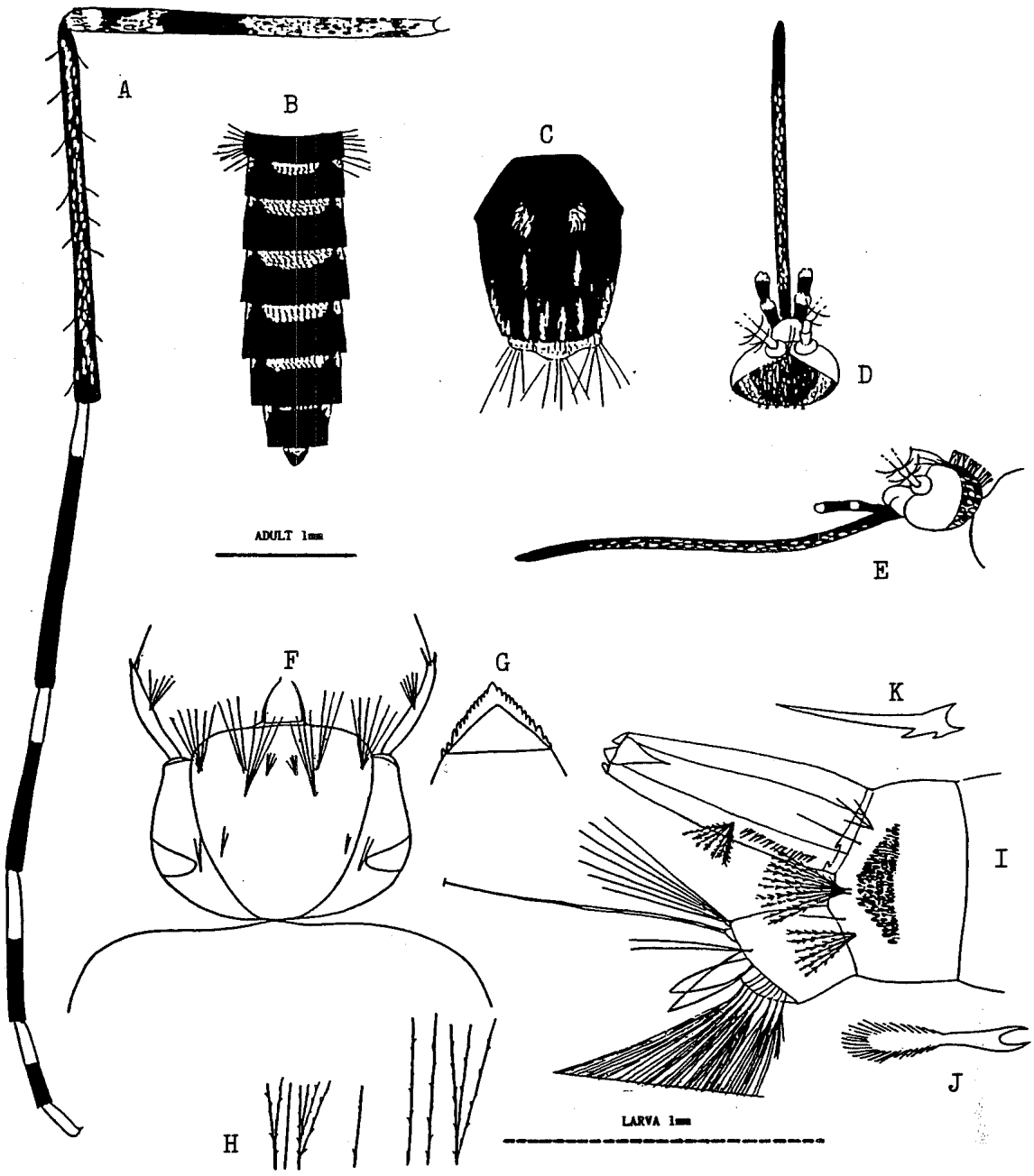
Antenna long narrow, about 0.6x length of head; seta 1-A with 3-5 branches, inserted dorsally at midpoint and reaching the tip of the antenna. Head 0.67x as long as wide, and 0.63x width of thorax; seta 1-C strong, inwardly curved; 4-C small with 4-5 branches; 5-C larger with 3-5 branches; 6-C with 2-4 strong branches; 7-C with 6-7 branches; 8-C small, with 1-2 branches; and 9-C with 2- 3 small branches; the angle formed by the sequence setae 4-, 5-, and 6-C is an acute angle. Propleural bristles as follows: 1-P bifid, moderately long; 2-P single and slightly shorter; 3-P with 4-5 branches, about 0.75x length of 2-P; 4-P single, as long as 3-P; 5-P and 6-P long, single; 7-P long, with 3 branches. Abdominal segment VIII with lateral comb with about 100 long apically fringed scales in a triangular patch; seta 1-VIII with 3 small branches; 2-VIII and 4-VIII short, single; 3-VIII with 10 long frayed branches; 5-VIII with 6 long pectinate branches. Siphon index about 2.5, tapering with well developed acus, about 2.28x length of saddle; seta 1-S single tuft with 7 plumose branches, inserted at 0.37 from base; pecten with 15 toothed spines reaching to 0.36 from base of siphon. Anal segment with saddle covering dorsal half of segment, covered in small spicules; seta 1-X bifid, fine; 2-X with 7 strong branches; 3-X long single; 4-X with 8 pairs of branched tufts on well developed grid. Anal papillae pointed, about 0.5x length of saddle.

BIOLOGY

The species breeds in temporary rain filled ground or rock pools, open or sunlit, or in forest areas. Water may be clear or clouded. The eggs of Ae *(Fin) alboannulatus* are resistant to desiccation, and are laid singly on the soil substrate of drying ground pools. Adults bite man and mammals readily at dusk, or in sheltered shaded sites during the day. Birds other than domestic fowls are also attacked. Adults are readily captured in light/CO_2 traps. *Ae alboannulatus* can be found predominantly during the months of May to October.

RELATION TO DISEASE

This species is not associated with any human disease, but may have been a mechanical vector of myxomatosis in rabbits. Recent laboratory evidence indicates that this species has low susceptibility to infection with MVEv.



Aedes (Finlaya) alboannulatus

A: Hindleg; B: Abdomen (dorsal); C: Thorax (dorsal); D: Head (dorsal); E: Head (lateral); F: Larval head (dorsal); G: Mentum; H: Prothoracic setae 1-P to 7-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); K: Pecten tooth (detail).

DISTRIBUTION

Albany, Aug 1956, EJB. Araluen, Jun 1972, PFSL; Jun 1974, PFSL. Armadale, Oct 1952, DLM, Jul 1972, PFSL. Augusta, Sep 1967; Oct 1974, PFSL. Augusta/Margaret River, May 1956, EJB. Avon River, Apr 1963, JBF. Badgingarra, Jul 1985, MEC. Bakers Hill, Jun 1968, HEP; Jun 1969, HEP. Balgar Plains, Jul 1985, MEC. Balingup, May 1956, EJB. Bedfordale, Sep 1951. Beverley, Jun 1955, EJB; Sep 1952, KRN. Beverly, 8km W, Aug 1973, PFSL. Bindoon, Sep 1973, PFSL. Boddington, Apr 1973, SJM. Boya, Jul-Aug 1967, HEP. Bridgetown, Sep 1952; May 1956, EJB. Brookton, Jun 1955, EJB; Oct 1971 HEP. Bruce Rock, Jul 1956, EJB. Bullsbrook, 4.5km N, Sep 1980, AEW. Bunbury, May 1956, EJB; Sep 1974, PFSL; Jan 1985, AEW; Mar-Dec 1985 AEW. Busselton, Sep 1952. Canning R., Apr 1963, JBF; Jan 1972, PFSL; Feb-Mar 1977, AB; Mar 1980, FWH. Canning R., Clontarf, Apr 1963, JBF. Canning R., Kent Street Weir, Apr 1963, JBF. Canning R., Kenwick, Apr 1963, JBF. Canning Vale, Jul 1972, PFSL. Capel, Aug 1940,

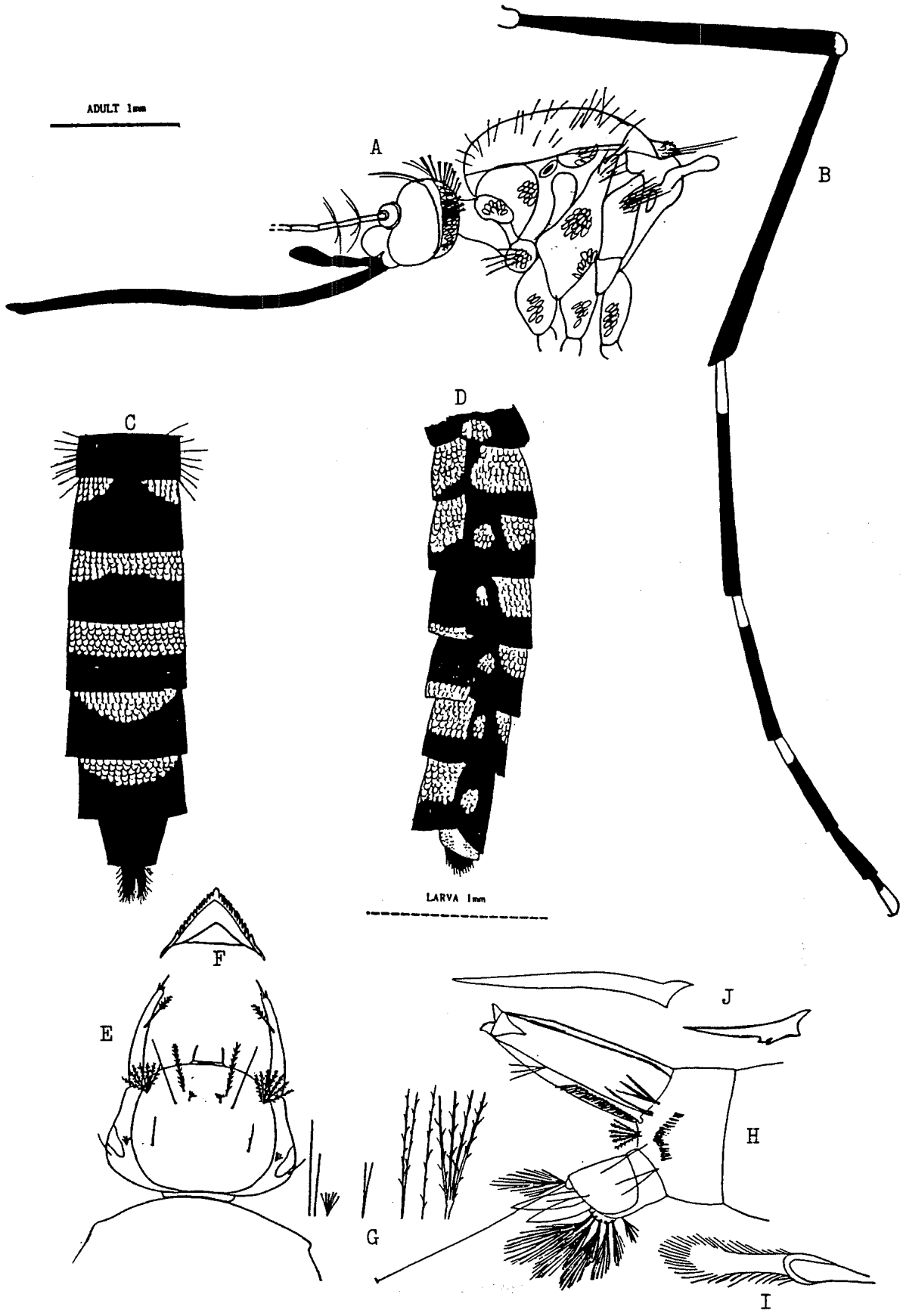
PNF. Carnamah, May 1955, EJB. Carnarvon, Feb 1984, MEC; May 1984, JWOB. Cataby Brook, Jul 1985, MEC. Cattamarra, Jul 1985, MEC. Chidlow, Aug-Sep 1973, PFSL. Chittering, Jul 1955, EJB. Cockburn, 1979, AB. Collie, May 1956, EJB. Coolanooka, Aug 1954, HIHS. Coolgardie, Aug 1956, EJB. Coomberdale, Jul 1953. Cranbrook, Aug 1956, EJB. Cunderdin, Aug 1953, DG. Dale Bridge, Jan 1953, JHC. Dale R., Jan 1952, KRN. Dale R., Beverley, Oct 1952, DLM. Dalwallinu, Jul 1955, EJB. Dandaragan, Jul 1955, EJB. Daniell, Sep 1952, DLM. Dardanup, Nov 1952, DLM; May 1956, EJB. Darkan, Nov 1952, PAH; Nov 1952, DG; Nov 1952, DLM; Jan 1953, JHC. Denmark, Aug 1956, EJB. Dongara, May 1972, CAG; Jun 1972, HEP. Donnybrook, Feb 1952, Bo; Jan 1953, JHC. Dowerin, Jul 1956, EJB. Dundas, Aug 1956, EJB. Eaton, Oct 1974, PFSL. Elleker, Oct 1974, PFSL. Esperance, Aug 1956, EJB. Forrestdale, Oct 1952, DLM; Sep 1955, DLM. Fremantle, Jun 1955, EJB. Geraldton, Jul-Aug 1985, MEC. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Gingin, 4km N, Sep 1973, PFSL. Gingin, 15km E, Sep 1973, PFSL. Glen Forrest, Aug 1976, SMP. Glencoe, Apr 1971, CAG; Jun 1971, CAG. Glengary, Jan 1952, Ma. Gnangara, Oct 1954, EPH. Gnowangerup, Jul 1956, EJB. Goomalling, Jul 1955, EJB; Aug 1968, Bu. Greenbushes, May 1956, EJB. Greenmount, Sep 1973, PFSL. Greenough R., Jun 1988, AEW. Guildford, Blakes Hill, Jul 1954. Harvey, Apr 1955, EJB; 1979, AB. Helena R., Guildford, Apr 1963, JBF. Helena R., Kalamunda, Apr 1963, JBF. Helena Valley, Jun 1954, EPH. Hill River Creek, Jul 1985, MEC. Irwin, Oct 1952, DG; May 1955, EJB. Irwin R., Aug 1952, EJB. Jandakot, Jan-Dec 1972, JCT; Jul 1972, PFSL; Mar 1974, PFSL; Mar 1975. Jandakot, Russell Swamp, Mar-Apr 1974. Jurien Bay, Jul 1985, MEC. Karberup, Oct 1952, Cr. Karratha, Feb 1984, MEC. Katanning, Oct-Nov 1952, DG. Kellerberrin, Aug 1952; Jul 1956, EJB. Kojonup, Nov 1951, Mi; Mar 1955, DLM. Koorda, Aug 1940, CFHJ; Jul 1956, EJB; Jul 1974, PFSL. Koorda, 25km S, Jul 1974, PFSL. Kununoppin/Trayning, Jul 1956, EJB. Lake Gwelup/Careniup Swamp, Nov 1982, JCT. Lake Chandala, Aug-Sep 1980, AEW; Oct 1980, PFSL. Lake Clifton, Aug 1980, AEW. Leschenault Inlet, 1986, AEW. Mandurah, May-Oct 1985, AEW. Manjimup, May 1956, EJB. Mayanup, Sep 1974, PFSL. Mayanup, 43km S, Sep 1974, PFSL. Merredin, Jul 1956, EJB. Mingenew, Aug 1954, EPH; Jul 1974, RB. Moonijim Centre, Aug 1952, DG. Moora, Nov 1953, EJB; Jun 1955, EJB. Mt Marshall, Jul 1956, EJB. Muchea, 7km N, Sep 1980, AEW. Mukinbudin, Jul 1956, EJB. Mumballup, 21km E, Sep 1974, PFSL. Murray R., May 1956, EJB; Jul 1971, CAG. Nambling, Jul 1974, PFSL. Nannup, May 1956, EJB. Narembeen, Jul 1956, EJB. Narrogin, Dec 1951; Oct 1952, Ev. Northam, Jun 1955, EJB. Northampton, May 1955, EJB. Nungarin, Jul 1956, EJB. Parrow, Jul 1985, MEC. Peaceful Bay, HEP. Peak Charles, May 1956, EPH; Nov 1963, HEP. Pemberton, Feb 1952, DLM. Perenjori, May 1955, EJB. Porongurups, Oct 1973, PFSL. Perth, HEP; Dec 1942, FNR; Nov 1943, FER; Jun 1955, EJB. Perth, Armadale/Kelmscott, Jun 1955, EJB. Perth, Clontarf, Oct 1973, PFSL; Feb 1974, PFSL; Sep 1974, PFSL. Perth, Crawley Bay, Sep 1954, EPH; Aug 1978, SMP. Perth, Darlington, Oct 1952, JHC. Perth, Floreat Park, Aug 1961. Perth, Kelmscott, Aug 1972, PFSL; Jun 1974, PFSL. Perth, Kings Park, Sep 1940, PNF; Oct 1952, DLM. Perth, Midland, Aug 1967, JB. Perth, Nedlands, Sep 1980, AEW. Perth, Peppermint Grove, Oct 1976, AEW. Perth, Roleystone, Aug 1967, HEP. Perth, Shenton Park, Sep 1977, AEW. Perth, Spearwood, Jul 1952, EPH; Jul 1954, EPH. Perth, Wembley, Aug 1961. Perth, Welshpool, Jul 1974, PFSL. Phillips R., Aug 1956, EJB. Picton, Nov 1952, DG. Plantagenet, EJB. Poppanyinning, Aug 1972, SJM. Pt.Hedland, Mar 1984, MEC. Rockingham, Jun 1955, EJB. Rottnest, Jun 1979, AEW. Rowlands, Jun 1953, CFHJ. Seabrook, Sep 1953. Serpentine/Jarrahdale, Jun 1955, EJB. Sussex, EJB. Swan R., Jun 1955, EJB. Swan R., Caversham, Apr 1963, JBF. Tachinup Creek, Oct 1974, PFSL. Toodyay, 33km NW, Sep 1973, PFSL. Tambellup, Aug 1956, EJB. Tammin, Jul 1956, EJB. The Humps, Nov 1967, HEP. Toodyay, May 1956, EJB. Upper Blackwood, May 1956, EJB. Upper Chapman, May 1955, EJB. Victoria Plains, Jul 1955, EJB. Wagin, Aug 1956, EJB. Wanneroo, Jun 1955, EJB. West Arthur, Mar 1955, EJB. Williams, Lu; Mar 1955, EJB. Wongan Hills, Aug 1954, LN. Wongan Hills/Ballidu, Jul 1955, EJB. Woodanilling, Aug 1956, EJB. Wyalkatchem, Jul 1974, PFSL. Wyalkatchem, Jul 1956, EJB; Jul 1974, PFSL. Wyalkatchem, 13km S, Jul 1974, PFSL. Yanchep, 1948. Yanchep National Park, Nov 1985, ALD. Yilgarn, Aug 1956, EJB. York, Oct 1953, JL; Jun 1955, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

Ae (Fin) alboannulatus looks superficially like *Ae (Fin) occidentalis.* The latter species is easily separated as it does not have the pre-apical pale band on the hindfemora. The larvae are more difficult to separate, and the best characters are given in the keys, though these may be poor discriminators.

Aedes (Finlaya) britteni Marks and Hodgkin 1958

Marks, E.N. and Hodgkin, E.P., 1958. *Proc. Linn. Soc. N.S.W., 83:* 33.
Type locality: Kalumburu (Drysdale River Mission), W.A.
Synonymy: None.



Aedes (Finlaya) britteni

A: Adult head and thorax (lateral); B: Hindleg; C: Abdomen (lateral); D: Abdomen (dorsal); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail of basal and apical teeth).

ADULT FEMALE

A moderate to large, highly ornamented species. Head with integument of reddish brown; narrow silver scales forming eye border and dark scaled behind; broad dark scales laterally; upright forked scales numerous, dark. Torus bare. Palp dark scaled, about 0.17x length of proboscis. Proboscis dark scaled; about 1.2x length of forefemur. Scutum with integument orange/brown; clothed with scattered narrow black scales. Scutellum densely clothed in narrow silver scales on all lobes. Pleural integument orange/brown; appressed broad silver scale patches on anterior pronotum, propleuron, posterior part of the posterior pronotum, paratergite, upper and posterior sternopleuron, and upper mesepimeron. Abdomen with tergites dark scaled with basal silver bands constricted laterally with lateral basal patches; sternites dark scaled with silvery reflections on basal half; sternite VIII enlarged and prominant. Hind leg with dark femur having a silvery knee spot; tibia dark; tarsi with pale basal bands on I-IV, V all white. Wing dark scaled.

LARVA

Antenna same colour as head; about 0.72x length of head; seta 1-A single, strong, pectinate, inserted at 0.6 from base. Head 0.74x as long as wide; about 0.65x width of thorax; setae 1-C long and thin; 4-C with 6-10 dendritic branches; 5-C single; 6-C single, strongly pectinate; 7-C with 7 pectinate branches; 8-C single; 9-C with 3-4 branches. Propleural setae as follows: 1-P single (rarely bifid) finely plumose; 2-P single and simple, shorter than 1-P; 3-P with 5-10 fine short branches. Abdominal segment VIII with lateral comb with 16 fringed scales in a line forming a shallow V shape; seta 1-VIII with 3 branches; 2-VIII and 4-VIII single; 3-VIII with 6 pectinate branches; 5-VIII bifid; all setae about equal in length. Siphon index about 2.0, slightly thicker in midline than at base; about 2.64x length saddle; seta 1-S single pair of 2-3 branched setae inserted at about 0.75 from base of siphon; pecten with 25 spines extending over basal half of siphon, toothed spines near base increasing in size toward apex with apical spines being a long curved simple spine. Anal segment with incomplete saddle; seta 1-X single; 2-X with 13 branches; 3-X single; 4-X with about 5 pairs of tufts on grid and 1-2 precratal tufts. Anal papillae long, pointed, about 1.5x length of saddle.

BIOLOGY

This species breeds in tree holes. It is not common. Little is known of the adult biology. It has not been taken biting man, but is attracted to light, being taken both in light and CO2 traps. Being a tree hole breeder, the greatest numbers of *Ae britteni* are to be found in the period following the last rains of the season, when the tree holes are filled and not flushed by further rain falls.

RELATION TO DISEASE

None known.

DISTRIBUTION

Derby, Mar 1985, AEW. Drysdale R. Mission, Mar 1954, EPH. Kalumburu, Mar 1954, ENM/EPH; Jul 1978, PFSL/AEW. Kununurra, Nov 1973, PFSL; Apr 1974, PFSL; Apr 1975, PFSL; May 1982, AEW; Jul 1982, AEW; Mar 1983, AEW; May 1983, AEW; Dec 1983, AEW; Mar 1984, AEW. Lake Argyle, Apr 1982, AEW; Jun 1982, AEW; Feb 1983, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species, once seen is not confused with any other.

Aedes (Finlaya) notoscriptus (Skuse) 1889

Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1738.
Type locality: Sydney, New South Wales, Australia.
Synonymy: none.

ADULT FEMALE

This species is very common throughout W.A., and is very variable in size from small to medium/large. The coloring of this species is also highly variable, ranging from silver/white to golden/yellow. Head with decumbent scales narrow dorsally, silver eye border and along occiput extending to point in midline, dark elsewhere; broad flat white scales laterally; upright forked scales more dense on occiput. Clypeus bare. Torus with silver/white scale patch dorsomedially. Palp dark scaled with silver/white tip, about 0.125x length of proboscis. Proboscis black with narrow pale band at 0.5-0.85 from base; about 1.3x length of forefemur. Scutum dark scaled, with a distinct lyre pattern of narrow silver/white scales, with two

submedian stripes; silver/white scale patches above wing root and around prescutellar space. Scutellum with broad flat silver/white scales on all three lobes. Pleura dark, with two silver/white transverse stripes: one running from mid posterior pronotum through postspiracular area, prealar area to the upper mesepimeron; the other from the anterior pronotum through the subspiracular area, upper sternopleuron to the lower mesepimeron; and with small white patches on the propleuron and posterior sternopleuron; three postspiracular bristles present. Abdomen with tergites dark with medial and lateral basal pale scale patches; sternites dark with basal silver patches. All coxae with silver/white scales. Hindleg with femur and tibia dark with median silver stripe along almost whole length; tarsi with pale basal bands, V white with dark scales ventrally at apex. Wing dark scaled. Haltere pale brown.

LARVA

Antenna same colour as head, about 0.43x length of head; seta 1-A single simple, inserted at about 0.67 from base. Head 0.92x as long as wide; about 0.82x width of thorax; clypeal spines stout and very strongly curved to midline; setae 4-C with 3 branches; 5-C and 6-C single; 7-C with 2-3 branches; 8-C and 9-C single. Abdominal segment VIII with lateral comb of about 20-30 fringed scales set in 2-3 rows, forming a rough triangle; seta 1-VIII with 3 branches, 2-VIII and 4-VIII single, 3-VIII and 5-VIII with 5 branches. Siphon short and thick with small acus; index about 1.4; about 1.55x length saddle; seta 1-S single pair of 3-branched tufts, inserted just above pecten at about 0.67 from base; pecten with about 20 toothed spines extending just beyond midpoint of siphon. Anal segment with incomplete saddle covering dorsal 0.75 of segment and with spines on posterior apical fringe; seta 1-X with 3 branches, 2-X with 4 branches; 3-X single, 4-X with 6 pairs of tufts on grid. Anal papillae pointed, unequal with ventral pair shorter.

BIOLOGY

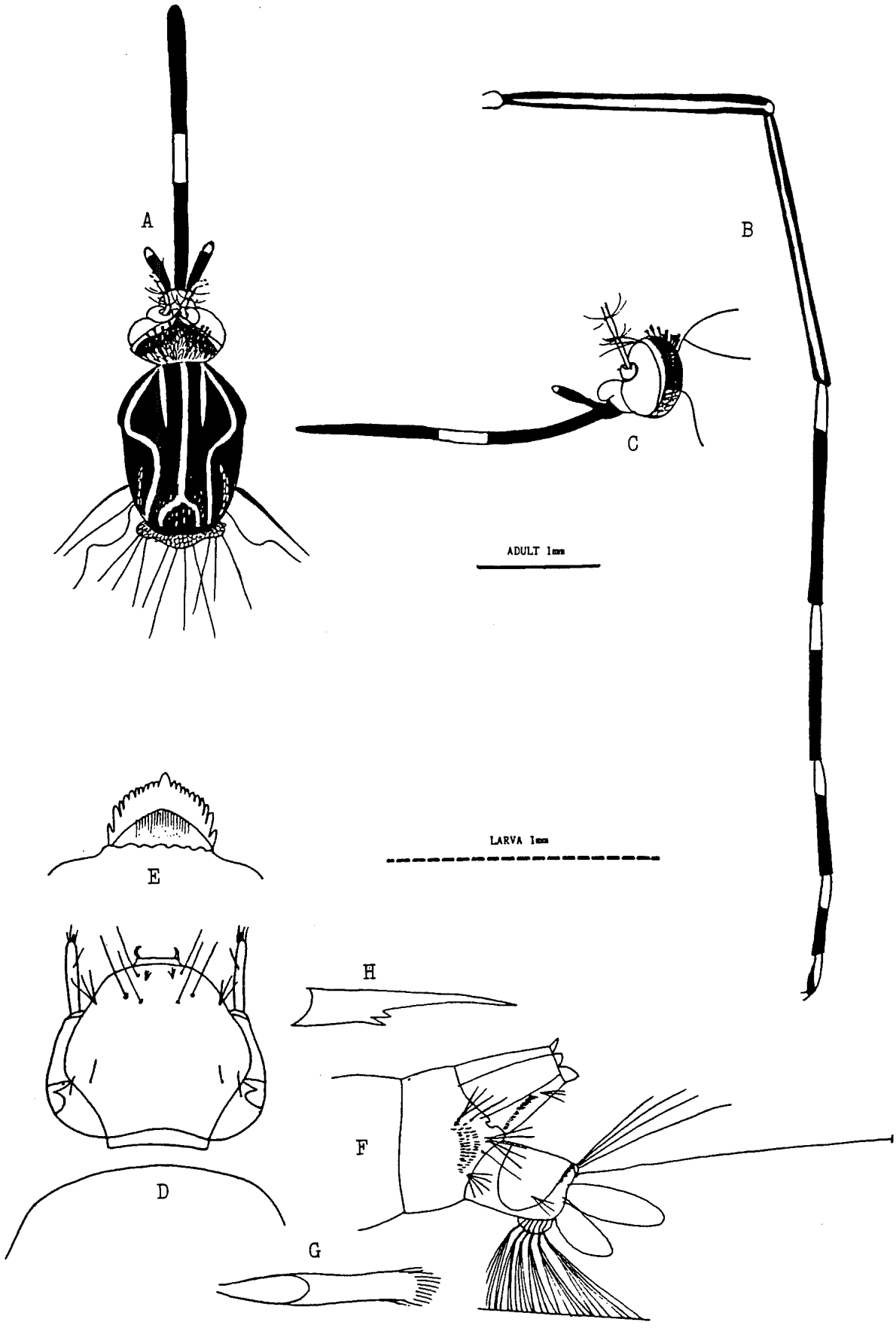
This species breeds in a variety of natural tree hole and rock hole sites, generally with some rotting vegetation, and has successfully moved into the urban habitat, colonising a number of artificial container habitats (e.g. gutters, discarded containers, pot plant bases, rainwater tanks). Collecting records show that it is a catholic species and may be found breeding in association with an immense array of other container breeding species. Occasionally, it has been identified as breeding in ground water pools. Eggs are laid singly at the waterline on the inner surface of containers, and are resistant to desiccation. The adults will bite man throughout the day, with a peak in biting at dusk. The species will utilise a variety of mammals and birds as blood meal sources. The species is readily taken in both avian and mammal baited traps, in light traps and CO2 baited traps. In the south of the State, *Ae notoscriptus* is found throughout the year, with the lowest numbers during the coldest winter months, and with a cessation of breeding in the late summer. However, the close association with artificial container sites in domestic situations results in breeding almost throughout the year in these sites. In the north, the species is found throughout the year, but with the greatest numbers in the wetter months.

RELATION TO DISEASE

This species has been investigated as a potential vector of a number of arboviruses, but has proven to be a poor vector under experimental conditions. Experimental data shows it to be a poor vector of yellow fever and dengue. It has been shown capable of carrying MVEv for a period of 10 days, but there are no records of isolation of MVEv from this species in the field. There is, however, one record of isolation of RRv from *Ae notoscriptus* collected in Darwin, and a second virus, Eubenangee virus, was isolated from a mixed pool of mosquitoes which included this species collected in Queensland. It is a good vector of the canine heart worm *Dirofilaria immitis,* and has been experimentally shown to support some strains of the filariasis worm *Wuchereria bancrofti,* but not others.

DISTRIBUTION

Brookton, Jun 1955, EJB. Broome, 1924, LEC; Mar 1984, MEC; Apr 1985, MEC. Canning R., Mar 1979, PFSL; Mar 1980, FWH. Cape Lambert, Jul 1984, MEC. Carnarvon, Feb-Mar 1984, MEC; May 1984, MEC; Jul 1984, MEC. Coolgardie, 1967, ENM. Denmark, Aug 1956, EJB. Derby, 1924, LEC; Mar 1954, EPH/EJB; Mar-Apr 1977, AEW; Feb-Mar 1984, MEC; Mar 1985, AEW. Derby, 22km E, Apr 1977, AEW. Derby, Myalls Bore, Mar 1954, EPH. Derby, Prison Boab, Mar-Apr 1977, AEW. Dundas, Aug 1956, EJB. Eucla, Oct 1954, EPH. Geraldton, Aug 1985, MEC. Glen Hill Settlement, Nov 1984, MEC. Hamlin Bay, HEP. Houtmans Abrolhos, Jan 1968, EW. Irwin, Oct 1952, DLM. Jarrahdale, May 1968, HEP. Jennacubbine, Apr 1953, DLM. Kalgoorlie, Aug 1956, EJB. Kalumburu, Jul 1978, AEW. Karratha, Feb 1984, MEC; May 1984, MEC. Kulin, Mar 1955, EJB. Kununurra, Dec 1972, PFSL; Apr 1973, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Jul 1976, AEW; Oct



Aedes (Finlaya) notoscriptus

A: Adult head and thorax (dorsal); B: Hindleg; C: Head (lateral); D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten tooth (detail).

1976, AEW; Apr 1977, AEW; Nov 1977, AEW; Jul 1978, PFSL/AEW; Apr 1980, OA; Feb 1981, OA; Feb-Mar 1982, AEW; Dec 1982, AEW; Jan 1983, AEW; Mar 1983, AEW; Jan-Mar 1984, AEW; Feb-Mar 1984, MEC; May 1984, MEC. Lake Argyle, Dec 1972, PFSL; Mar 1982, AEW; May-Jul 1982, AEW; Dec 1982, AEW; Jan-Feb 1983, AEW; Jun 1983, AEW; Feb 1984, AEW. Lake Goollelal, Jan 1982, PFSL. Lake Gwelup/Careniup Swamp, Nov 1983, JCT. Leschenault Inlet, 1986, AEW. Manjimup, May 1956, EJB. May R. crossing, Apr 1977, AEW. Meda, Apr 1977, AEW. Moora, Jun 1955, EJB. Mowanjum, Sep 1978, AEW. Mt Marshall, Jul 1956, EJB. Mt Magnet, Apr 1985, MEC. Mullewa, Apr 1985, MEC. Munkayarra Pool, Apr 1977, AEW. Northam, Jun 1955, EJB. Northampton, Apr 1985, MEC. Parry's Creek, Mar 1982, AEW; Dec 1982, AEW. Porongurups, Oct 1973, PFSL. Perth, Sep 1942, PNF; Jun 1955, EJB. Perth, Crawley Bay, Sep 1954, EPH. Perth, Midland, Oct 1953, JAB. Perth, Nedlands, Oct-Dec 1971, SJM; Jan-Mar 1972, SJM; May-Jun 1972, SJM; Sep-Nov 1972, SJM; Jan-Feb 1973, SJM; Sep 1980, AEW; Mar 1985, MEC. Perth, Peppermint Grove, Oct 1976, AEW. Perth, Subiaco, Mar 1985, MEC. Pt.Hedland, Feb-Mar 1984, MEC; May 1984, MEC. Pt.Malcolm, Israelite Bay, Nov 1954, EPH. Preston, Jun 1955, EJB. Wyalkatchem, Jul 1956, EJB. Wyndham, Apr 1953, RL; Nov 1977, AEW. Yanchep, 1948. Yeeda, Apr 1977, AEW. Yeeda, 10km N, Apr 1977, AEW. Yeeda Creek, Mar 1954, EPH/EJB. York, Jun 1955, EJB; Oct 1972, PFSL.

SPECIES WITH WHICH IT MAY BE CONFUSED

The larvae of this species, because of their characteristic swimming motion and habitat preference, are superficially like those of *Ae (Stg) aegypti*. The adults, with their lyre pattern on the scutum, also superficially resemble *Ae (Stg) aegypti*.

Aedes (Finlaya) occidentalis (Skuse) 1889

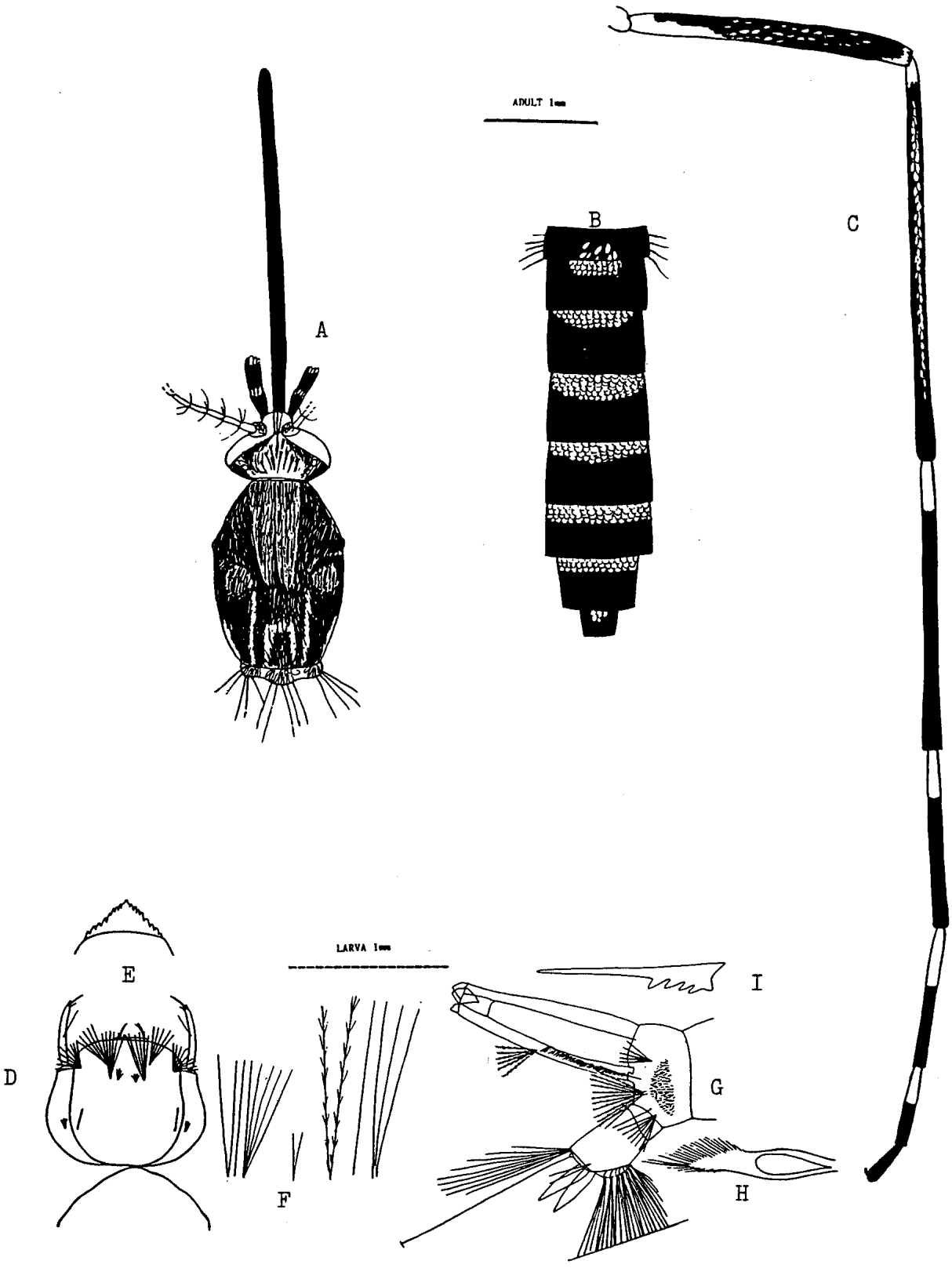
Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1729.
Type locality: King Georges Sound, W.A.
Synonymy: none.

ADULT FEMALE

A medium/large species superficially resembling *Ae (Fin) alboannulatus*. Head with narrow scales dorsally forming a pale triangle with base at occiput and apex at frons, darker scales elsewhere; broad pale and dark scales on side of head; upright forked scales numerous. Palp black scaled with pale scales at apex of all segments; about 0.2x length of proboscis. Proboscis dark scaled, about 1.25x length of forefemur. Scutum with integument dark brown; fossa with black narrow scale patches; median bronze and large round bronze scale patches at level of scutal angle; white scale patches above wing root and around prescutellar space. Scutellum with narrow curved white scales on all lobes. Pleura with integument brown; flat dark scales on upper anterior pronotum and posterior pronotum, pale below; pale broad appressed scales on postspiracular area, subspiracular area, paratergite, upper and posterior sternopleuron, and anterior and posterior mesepimeron; three postspiracular bristles present. Abdomen with tergites dark with I and II having pale median patches, III to VII with pale basal bands extended in midline and VIII dark; sternites pale with apical dark bands extended almost to base of segment in midline. All coxae with pale flat scales above, dark below. Hindleg with femur pale at base, dark above with slight mottling decreasing to apex, ochreous knee spot; tibia dark with anterior median pale stripe; tarsi I-IV dark with broad pale basal band, V dark. Wing dark scaled. haltere with pale stem, dark club.

LARVA

Antenna dark, about 0.55x length of head; seta 1-S bifid, inserted dorsally at 0.43 from base. Head 0.7x as long as wide; about 0.81x width of thorax; seta 1-C long, narrow inwardly curved; 4-C small with 4 branches; 5-C with 4-6 branches; 6-C with 3-5 branches; 7-C with 6-9 branches. Prothoracic setae as follows: 1-P bifid; 2-P single; 3-P with 5-7 branches; 4-P with 2-3 branches; 5-P with 1-2 branches; 6-P single; 7-P with 3 branches. Abdominal segment VII with lateral comb forming a large triangular patch of approximately 100 apically fringed scales; seta 1-VIII with 5 branches; 2-VIII and 4-VIII single; 3-VIII with 12 pectinate branches and 5-VIII with 7 branches. Siphon with small acus; index about 2.52; siphon about 2.88x length saddle; seta 1-S a single pair of tufts with 6 pectinate branches inserted at about 0.5 from base; pecten with 27-32 toothed spines on basal 0.5 of siphon. Anal segment with incomplete saddle covering dorsal 0.5 of segment having apical row of denticles/spines; seta 1-X bifid; 2-X with 9 branches; 3-X single; and 4-X with 7 pairs of tufts on a grid. Anal papillae pointed, about 0.67x length of saddle.



Aedes (Finlaya) occidentalis

A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten tooth (detail).

BIOLOGY

Ae (Fin) occidentalis breeds in rain filled depressions on the tops of granite outcrops in the drier portions of the south west. As such, the species is found during the winter months after rain. The distribution of *Ae (Fin) occidentalis* is generally in the more inland areas compared to it's close relative *Ae (Fin) alboannulatus*. *Ae (Fin) occidentalis* has mainly been collected as larvae and little is known of the adult biology.

RELATION TO DISEASE

None known.

DISTRIBUTION

Armadale/Kelmscott, Jun 1955, EJB. Bowgarda, Apr 1955. Bridgetown, May 1956, EJB. Bruce Rock, Jul 1956, EJB. Bushfire Rock, Aug 1967, HEP. Coolgardie, Aug 1956, EJB. Drakesbrook, Mar 1955, EJB. Dundas, Aug 1956, EJB. Esperance, Aug 1956, EJB. Gnowangerup, Jul 1956, EJB. Goomalling, Aug 1955, EJB. Halfway Rock, May 1971. Jarrahdale, Jul 1955, ARM. Kondinin, Mar 1955, EJB. Koorda, Jul 1956, EJB. Kulin, Mar 1955, EJB. Kununoppin/Trayning, Jul 1956, EJB. Merredin, Jul 1956, EJB. Moora, Jun 1955, EJB. Mt Marshall, Jul 1956, EJB. Mt Mehinup, Jun 1971, RBH. Mukinbudin, Jul 1956, EJB. Narembeen, Jul 1956, EJB. North Dandalup, Jan 1984, PFSL. Northam, Jun 1955, EJB. Nungarin, Jul 1956, EJB. Peak Charles, Nov 1968, HEP; Nov 1971, HEP. Perenjori, May 1955, EJB. Roleystone, May 1944, AW. Simpsons Rock, Apr-May 1971. South Dandalup R., Oct 1967, HEP. Tammin, Jul 1956, EJB. Wagin, Aug 1956, EJB. Wongan/Ballidu, Jul 1955, EJB. Woodanilling, Aug 1956, EJB. Wyalkatchem, Jul 1956, EJB. Yilgarn, Aug 1956, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

The species superficially resembles *Ae (Fin) alboannulatus* but the adult may be separated most easily by the absence of the preapical pale band on the hindfemur. The larvae are very difficult to separate, and the key is based on the only characters which are currently available, but these may be poor discriminators.

Aedes (Finlaya) pecuniosus Edwards 1922

Edwards, F.W., 1922. *Bull. Ent. Res., 13:* 94.
Type locality: Port Darwin, Northern Territory, S. Australia.
Synonymy: None.

(Note: A recent review by J.F. Reinert [Mosquito Systematics 20 (1988):55-68] has resurrected *Ae pecuniosus* Edwards from synonymy with *Ae purpureus*. Specimens from W.A. and the Northern Territory are all *Ae pecuniosus*. Literature records and earlier reports which refer to *Ae purpureus* from W.A. all should be treated as referring to this species. *Ae purpureus* is a Queensland species.)

ADULT FEMALE

Large dark species with characteristic silvery markings. Head with decumbent scales narrow, white; upright forked scales pale on vertex, dark behind, numerous; broad dark and silver scales on side of head. Palp dark scaled; 0.25x length proboscis. Proboscis dark scaled, 1.3x length forefemur. Scutum with black integument; scaling dark with median silver stripe continuous from apical silver border to prescutellar space; broad silver patch on fossa/posterior fossa extending as silver line to scutellum; and a silver patch above the wing root. Scutellum with broad flat silver scales on all lobes. Pleura dark with appressed silver scales on anterior pronotum, posterior pronotum, subspiracular area, paratergite, upper and posterior sternopleuron, prealar area and upper 0.75 of mesepimeron; 2-3 postspiracular bristles present. Abdomen with tergites dark with basal medial and lateral silver scale patches; sternites dark with basal silver bands on II-V, VI-VIII dark, VIII enlarged and prominant. All coxae with appressed silver scales. Hindleg with femur dark on apical half, white basally, and with small white knee spot; tibia dark; tarsi I-III with pale basal bands, IV-V dark. Wing dark scaled.

LARVA

Antenna same colour as head and about 0.35x its length; seta 1-A single, inserted dorsally about 0.65 from the base. Head about as long as broad; about 0.63x width of thorax; setae 4-C to 7-C all single; mouth brushes modified for predation. Prothoracic setae 1-P to 3-P single, 4-P bifid, 5-P to 7-P single with 7-P flattened to a brush-like spine. Abdominal segment VIII with lateral comb of 3-6 small apically denticulate spines in a single row; setae 1-VIII with 5 dendritic branches; 2-VIII and 4-VIII small and single; 3-VIII with

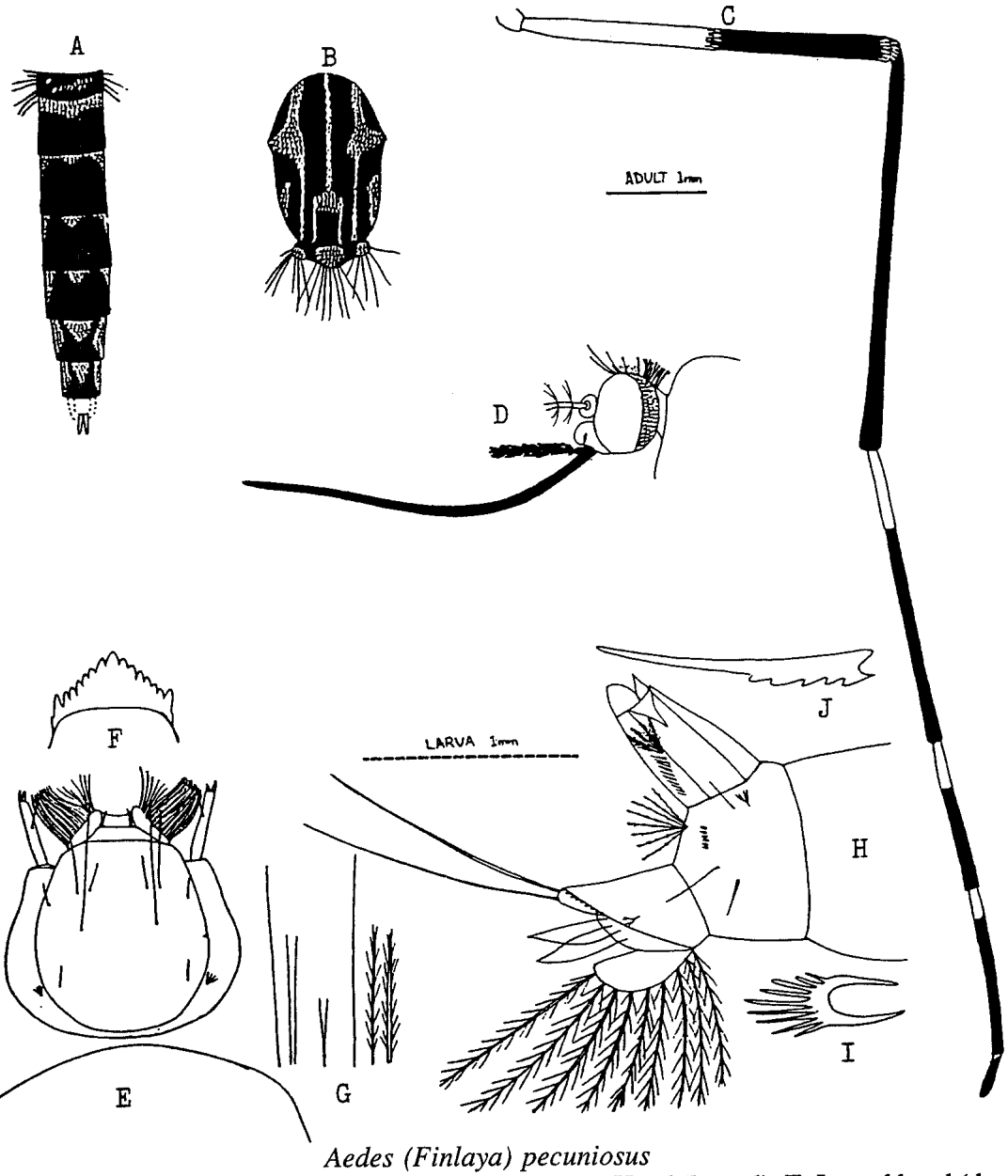
about 6-8 pectinate branches; 5-VIII a single stout spine. Siphon index about 1.34; about 0.96x length saddle, tapering; seta 1-S a single pair of tufts with 4 stout strongly plumose branches inserted at about 0.6 from base; pecten with 10 basally denticulate spines reaching to 0.41 from base of siphon. Anal segment is highly characteristic with saddle incomplete, cut away posterioventrally and extended posteriodorsally; seta 1-X with 4-5 dendritic branches; both 2-X and 3-X single; and 4-X with 9 pairs of tufts on a large sclerotised plate. Anal papillae are long and pointed, about 0.7x length of saddle.

BIOLOGY

The species breeds in rot holes in trees, particularly the boab tree, and are predatory on other species of mosquito. It has been collected in association with a range of other tree hole breeding mosquitoes: *Ae (Fin) notoscriptus, Ae (Fin) britteni, Ae (Mac) tremulus, Ae (Stg) aegypti, Tp atripes* and *Cx (Cux) quinquefasciatus*. The adults will feed off man under laboratory conditions, but rarely in the field. The adult biology is not well known. They are taken in light and CO2 baited traps. The species is most abundant in the months following the end of the wet season, but is never a dominant species in collections.

RELATION TO DISEASE

None known.



Aedes (Finlaya) pecuniosus

A: Adult abdomen (dorsal); B: Thorax (dorsal); C: Hindleg; D: Head (lateral); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten tooth (detail).

DISTRIBUTION

Derby, LEC; AHB; 1924, LEC; 1944, FHT; 1952, KLK/ENM; Aug 1978; Mar 1985 AEW. Derby, 24km E, Apr 1977, AEW. Kalumburu, Mar 1954, EPH/EJB. Kununurra, May 1982, AEW; Mar 1983, AEW; Feb-Mar 1984 AEW. Lake Argyle, Mar-May 1982, AEW; Dec 1982, AEW; Feb 1984, AEW. May R. crossing, Apr 1977, AEW. Meda, Apr 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Halaedes*

SUBGENERIC CHARACTERS

Adult: Decumbent scales on vertex narrow. Lower mesepimeral bristles present. Abdominal segment VIII of female partially retracted, cerci short and broad.

Larva: Antenna short. Lateral comb a large patch of short scales. Siphon short, index 2.0-2.5, with strongly swollen tracheae. Saddle reduced, anal papillae very small, globular.

KEYS: ADULT FEMALES: see key to subgenera of Aedes (page 98).
LARVAE: see key to subgenera of Aedes (page 99).

Aedes (Halaedes) ashworthi Edwards 1921

Edwards, F.W., 1921. *Bull. Ent. Res., 12:* 75.
Type locality: Yallingup, W.A., Australia.
Synonymy: None.

ADULT FEMALE

Medium sized species found only in southern coastal areas. Head with narrow pale decumbent scales dorsally; broad flat mottled scales on side; upright forked scales numerous, dark. Torus with some dark scales dorsally. Palp mottled; about 0.17x length of proboscis. Proboscis dark with some mottling on basal 0.2; about 1.2x length of forefemur. Scutum light with scattered white to fawn scales. Scutellum with narrow fawn scales on all lobes. Pleura with scattered broad scales on segments; light and dark scales on anterior pronotum; light scales only on posterior pronotum, prespiracular area, prealar area, upper and posterior sternopleuron, and mid to upper mesepimeron; 4 postspiracular bristles and 2 lower mesepimeral bristles. Abdomen with tergites dark with broad pale basal bands; sternites pale with darker hues toward the apex. Hindleg with femur pale on basal 0.8, dark at tip; tibia dark, slightly mottled; tarsi all dark and unbanded. Wing dark scaled. Haltere pale.

LARVA

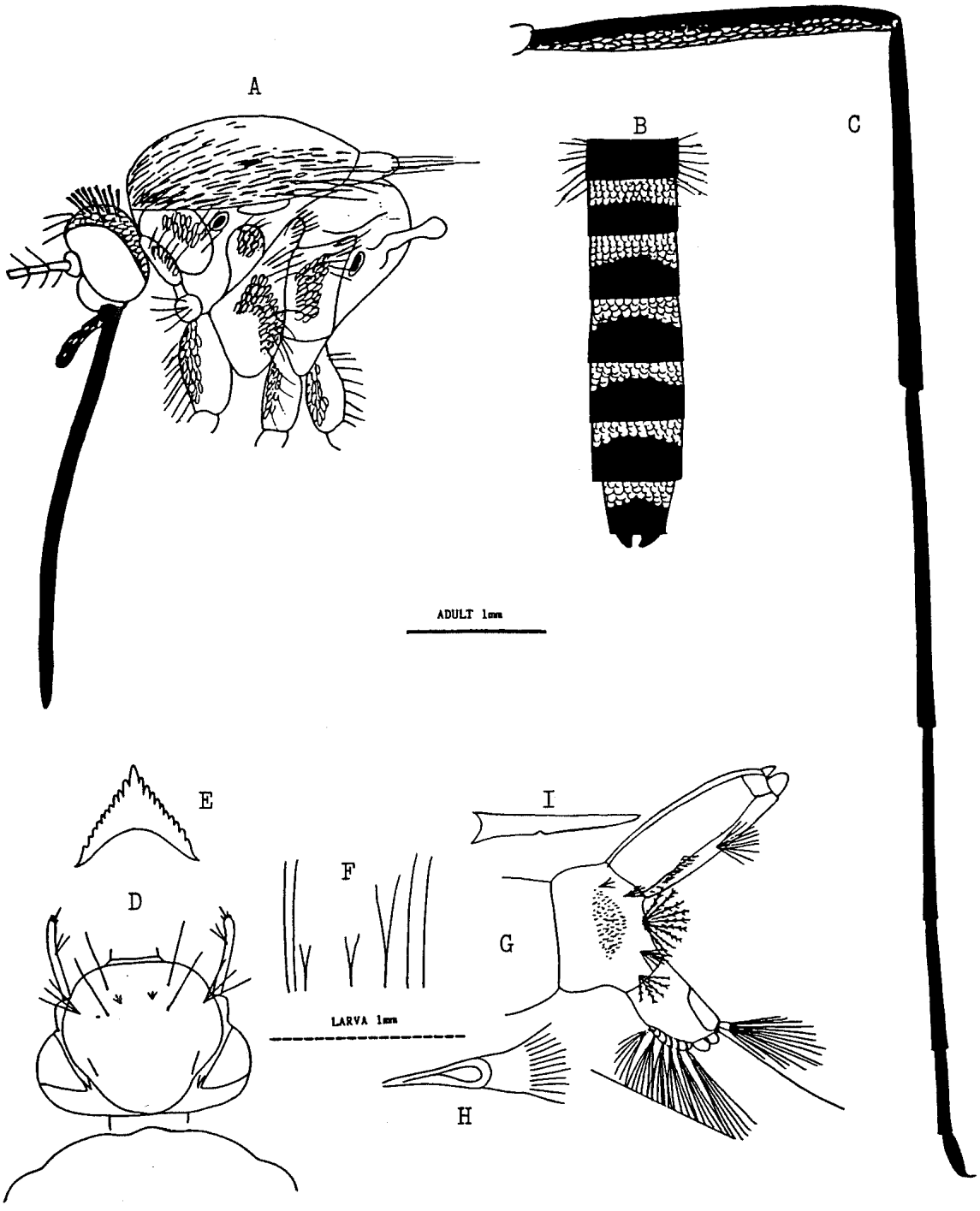
Antenna slightly lighter than head, about 0.6x length of head; seta 1-A bifid, inserted dorsally at about 0.5 from base. Head 0.64x as long as wide; about 0.5x as wide as thorax; clypeal spines long thin projecting forward; seta 4-C with 3 small branches; 5-C and 6-C single; 7-C with 3 branches; 8-C single; and 9-C bifid. Prothoracic setae as follows: 1-P and 2-P long and single; 3-P and 4-P short and bifid; 5-P long and bifid; 6-P and 7-P long and single. Abdominal segment VIII with lateral comb consisting of approximately 80-100 fringed scales in a triangular patch; seta 1-VIII with 3 small simple branches; 2-VIII with 3-4 short simple branches; 3-VIII with 7-9 pectinate branches; 4-VIII with 3-5 simple branches; and 5-VIII with 3-5 pectinate branches. Siphon with index of about 2.37; about 2.25x length of saddle; seta 1-S single pair of tufts with about 10 branches inserted at midpoint of siphon; pecten with 15 basally denticulate teeth with basal 1-2 slightly detached from main group. Anal segment with incomplete saddle covering dorsal 0.25 of segment; seta 1-X small single; 2-X with about 14 branches; 3-X long and single; 4-X with 6 pairs of tufts on grid. Anal papillae very short and globular.

BIOLOGY

The species is strictly coastal, breeding in hypersaline waters in wave filled rock holes. The adults bite man readily and may be a nuisance in some localities in the southern coastal areas. It can be found throughout the warmer months of the year.

RELATION TO DISEASE

None known.



Aedes (Halaedes) ashworthi

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic seatae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); Pecten tooth (detail).

DISTRIBUTION

Albany, Aug 1956, EJB. Augusta/Margaret River, May 1956, EJB. Cape Leeuwin, Oct 1974, PFSL. Esperance, Aug 1956, EJB. Perth, Apr 1967, HEP. Perth, Triggs Is., Feb 1972, PFSL; Sep 1976, PFSL. Rockingham, Jun 1955, EJB. Rottnest, Jan 1935, CFHJ; Nov 1954; Jun 1979, AEW; Dec 1980, PY. Sussex, EJB. Yallingup, May 1952, CFHJ.

SPECIES WITH WHICH IT MAY BE CONFUSED

Ae (Hal) ashworthi is easily distinguished by its local occurrence and unique habits.

Subgenus : *Macleaya*

The subgenus *Macleaya* needs taxonomic revision. It contains a number of undescribed species known from, at most, a few specimens. Until males and link-bred series are available, the taxonomy of this group will remain confused.

SUBGENERIC CHARACTERS

Adult: Proboscis short, little longer than forefemur. Scales on vertex broad and flat. Palp of female short, 0.25-0.33x length of proboscis. No lower mesepimeral bristles. Female abdomen stout and somewhat compressed; segment VIII laterally compressed; cerci short, broad. Legs largely dark scaled; tarsi banded, hindtarsus V usually all white.

Larva: Antenna smooth, 1-A single or bifid. Lateral comb with 3-5 strong, blunt spines on a chitinised plate. Siphon short. Saddle not complete ring. Anal papillae very long, ends rounded.

KEY TO ADULT FEMALES OF *AEDES (MACLEAYA)* IN WESTERN AUSTRALIA

(Adapted from a key by E.N. MARKS)

1. – Wing with patch of white scales at base of costa; conspicuous white knee spot on hind femur 2
   - Wing with base of costa dark; palp white at tip 3

2. – Hind tarsal segment IV with basal white band (linear white scale pattern on scutum, palps white tipped; large median white patch on tergites II- VII) ..... *Ae (Mac) stoneorum*
   – Hind tarsal segment IV all dark; palps dark at tip; anterior half of scutum mainly clothed with bright golden scales; posterior pronotum with similar scales; white median patches on terga II- VI ..... *Ae (Mac)* ENM's sp. No.126

3. – Anterior half of scutum all or mainly golden scaled (especially on fossa); (terga with median basal pale patches on II-V or I-V or with basal bands on V-VI; hind femur with white knee spot; hind tibia with narrow basal white band; basal band on hind tarsus I almost 0.25 length of segment, basal bands on hind tarsi II and III extend onto apices of preceding segment) ..... *Ae (Mac)* ENM's sp. No.125
   – Anterior half of scutum otherwise 4

4. – Lateral lobe of scutellum all or predominantly dark scaled; scutum with reduced pale scaling - a few golden scales, generally dark or with a small patch of pale scales in front of wing root, and a small amount of pale scaling around prescutellar bare area; midlobe of scutellum black scaled with a few white scales in midline; hind femur with small white knee spot; hind tibia with basal band ..... *Ae (Mac)* ENM's sp. No.70
   – Lateral lobes of scutellum not less than half pale scaled; scutum with conspicuous white and creamy scaling, white patch in front of wing root; extensive pale scaling around prescutellar bare area 5

5. – Hind femur with conspicuous white knee spot; terga with white median patches on I-V or I-VI; scutal scaling usually with linear white or light golden lyre; posterior pronotum with upper half dark scaled, lower half or more white ..... *Ae (Mac)* ENM's sp. No.147
   – Hind femur with some white scales anteriorly (very small knee spot); terga with median patched on II- V or may have complete bands on III-VI; scutal scaling variable but generally with some creamy scales, may have golden lyre in some specimens; posterior pronotum dark scaled ..... *Ae (Mac) tremulus*

KEYS: LARVAE: See key to subgenera of Aedes (page 99). (Note: no reliable characters are available for separating the few larvae of species from this subgenus which are known. Of the W.A. species, only the larva of *Ae (Mac) tremulus* is known, and this closely resembles that of *Ae (Cha) elchoensis*. Indeed, no characters are known which readily separate the subgenera Macleaya and Chaetocruiomyia.)

Aedes (Macleaya) stoneorum Marks 1977

Marks, E.N., 1977 *Proc. Ent. Soc. Wash.*, 79: 33.
Type locality: Moa (Banks) Island, North Queensland (Australia).
Synonymy: None.

ADULT FEMALE

Head clothed in broad flat scales, white eye border and on occiput, dark between, with pale scales extended in midline and on side of head; upright forked scales dark, sparse on vertex and occiput. Clypeus bare. Torus with some pale scales dorsally to midline. Palp short, about 0.14x length of proboscis; dark with white scale patches on apex of segment III and at tip. Proboscis black scaled; about 1.25x length of forefemur. Scutum with integument black; clothed in narrow black scales, with narrow curved white scales forming a distinct (but lines not continuous) lyre; white scale patches above wing root and around prescutellar space. Scutellum with discrete patches of broad white scales on all three lobes. Pleura with integument dark; curved narrow black scales on upper anterior pronotum and posterior pronotum; and narrow curved white scales on lower anterior pronotum; appressed broad white scales on propleuron, subspiracular area, upper and lower sternopleuron, anterior and upper mesepimeron and prealar area; translucent scales on postspiracular area; 2 postspiracular bristles. Abdomen with tergites dark scaled and having basal and lateral white patches on II-VII; sternites dark scaled with median basal white patches, sternite II largely pale. Coxae with pale scales dorsally. Hindleg with femur black, pale below on basal 0.67 and silver/white knee spot; tibia black with pale basal ring; tarsi black with broad basal white bands on tarsi I-IV and apical row of white scales on tarsi I and II, tarsus V all white. Wing dark scaled with small white patches on the costa and subcosta. Haltere pale with silver/white scales on club.

LARVA

Unknown.

BIOLOGY

This uncommon species is tropical, found in open woodland communities. Specimens have been taken biting man, and adults have been taken in CO_2 baited traps. In Palmerston, near Darwin, the species has been taken predominantly in the February to April period, towards the end of the wet season. The species was uncommon.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

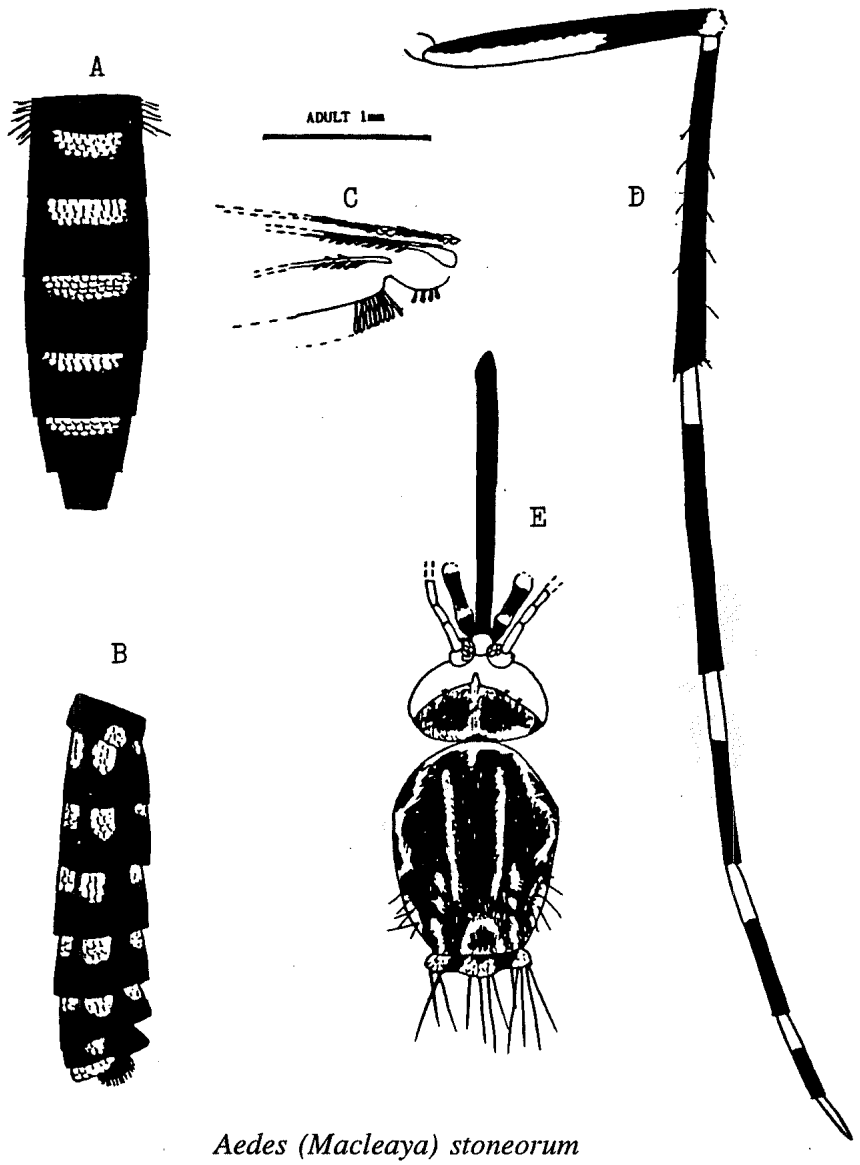
Derby, Mar 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

Superficially resembles other species belonging to the subgenus Macleaya, but is readily distinguished using the features in the key. The rough lyre on the thorax may be a source of confusion with both *Ae (Fin) notoscriptus* and *Ae (Stg) aegypti*, but the scutal markings in both these species are succinct and more sharply defined when compared to *Ae stoneorum*.

Aedes (Macleaya) tremulus (Theobald) 1903

Theobald, F.V., 1903. *Entomologist, 36:* 155.
Type locality: South Queensland, Australia.
Synonymy: *Danielsia minuta* Taylor, F.H., 1912 *Appendix II Bull. Nth. Terr. Aust., 1a:* 30.
Danielsia alboannulata Taylor, F.H., 1912 *Appendix II Bull. Nth. Terr. Aust., 1a:* 30.
Aedimorphus australis Taylor, F.H., 1914. *Proc. Linn. Soc. N.S.W., 39:* 457.
Aedimorphus australis var. *darwini* Taylor, F.H., 1914. *Proc. Linn. Soc. N.S.W., 39:* 457.
Mimetomyia doddi Taylor, F.H., 1919. *Proc. Linn. Soc. N.S.W., 43:* 831.



Aedes (Macleaya) stoneorum

A: Abdomen (dorsal); B: Abdomen (lateral); C: Wing (detail of pale scaling at base of costa); D: Hindleg; E: Head and thorax (dorsal).

ADULT FEMALE

Head clothed in broad flat scales, dark above, pale to side; with triangular patch of narrow curved white scales on occiput; upright forked scales sparse, black. Torus with translucent scales mesially. Palp black with white tip; about 0.2x length of proboscis. Proboscis black; about 1.1x length of forefemur. Scutum with dark integument, clothed in bronze, black and white scales, sometimes forming an indistinct lyre. Scutellum with narrow pale scales on all three lobes. Pleura with brown integument; narrow curved pale scales on anterior pronotum; narrow curved pale and dark scales on posterior pronotum; appressed broad white scales on propleuron, sternopleuron, mesepimeron, postspiracular area, subspiracular area, prealar area and paratergite; 1 postspiracular bristle. Abdomen with tergites dark scaled and with pale basal lateral and median white patches on II-V, VI with lateral basal patches only, VII dark and VIII pale above; sternites pale with apical lateral dark patches. All coxae with appressed pale and dark scales. Hindleg with femur black, pale below on basal 0.5-0.67, with white knee spot; tibia dark; tarsi I-III black with broad basal bands, IV dark, and V all white. Wing all dark scaled. Haltere pale.

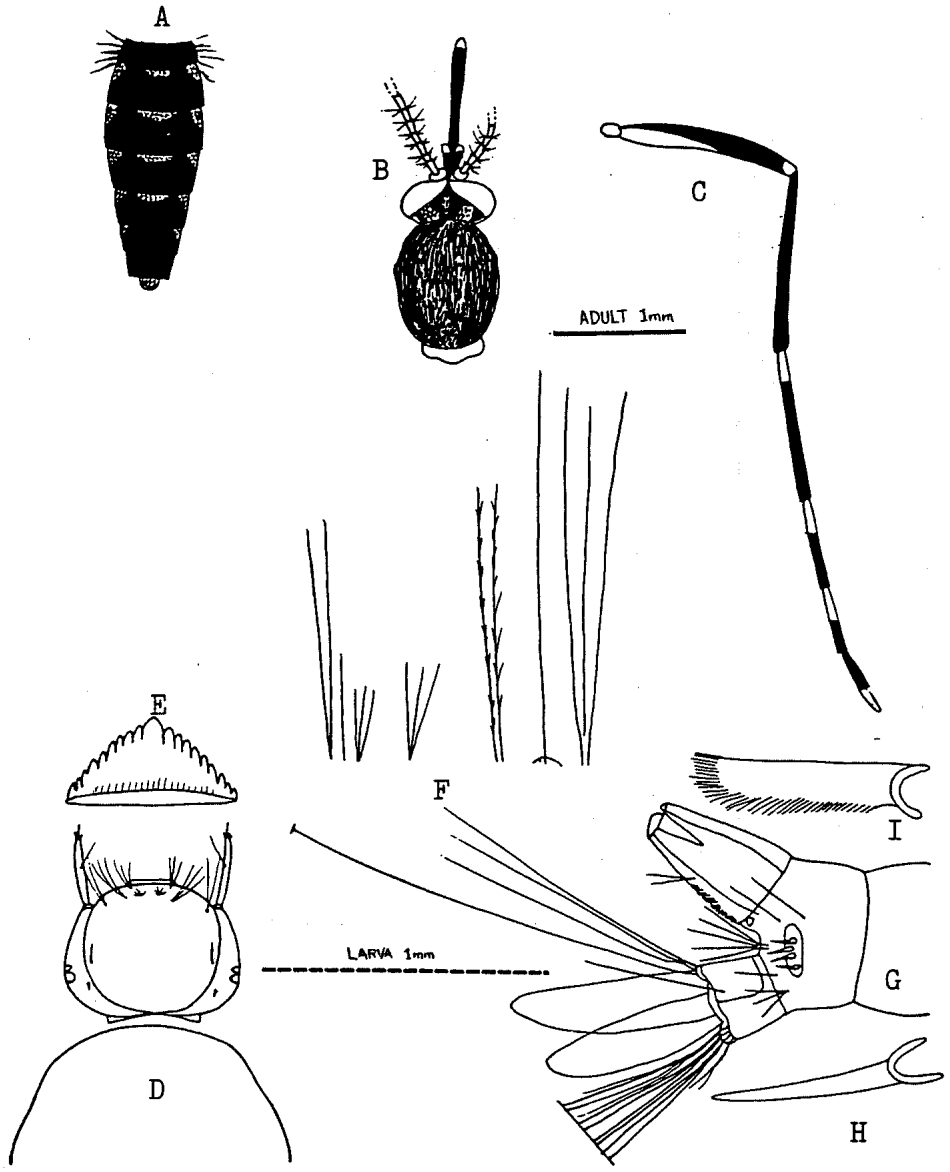
LARVA

Antenna same colour as head; about 0.45x length of head; seta 1-A single inserted dorsally at 0.43 from base. Head 0.9x as long as wide; about 0.72x width of thorax; setae 4-C short with 5-8 branches; 5-C with 1-2 branches; 6-C with 3 long backward curved branches; 7-C with 2-5 branches; 8-C single; and 9-C with 2-3

branches. Prothoracic setae: 1-P bifid; 2-P single; 3-P with 3 branches; 4-P with 3-5 branches; 5-P with 2-3 branches; 6-P single; and 7-P with 3 branches. Abdominal segment VIII with lateral comb of 4 stout blunt spines on basal sclerotised plate, one spine may be detached; seta 1-VIII, 2- VIII and 4-VIII single; 3-VIII with 5 branches; 5-VIII with 2-3 branches. Siphon index about 2.32; siphon about 2.3x length of saddle; seta 1-S single pair of unbranched hairs inserted at about 0.55 from base; pecten with about 12-18 long fringed spines extending below siphon. Anal segment with saddle covering dorsal half of segment; seta 1-X single, moderately long; 2-X with 3 long branches; 3-X single and long; 4-X with 4 pairs of tufts on weak grid. Anal papillae long, broadly rounded; about 3-4x length of saddle.

BIOLOGY

Natural breeding sites are in tree holes, but has become a semi-domestic container breeder in many parts of Australia. It has been collected breeding in dams, rainwater tanks, gutters, septic tanks, rock holes, wells, tree holes, old tyres and discarded containers, often in association with *Cx quinquefasciatus, Ae notoscriptus, Tp atripes* and *Tp punctolateralis*. The adults bite man readily and can be a serious pest in some areas, particularly at dawn and in the early morning. The adults will feed on a variety of mammals and



Aedes (Macleaya) tremulus

A: Adult abdomen (dorsal); B: Head and thorax (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scales (detail); I: Pecten tooth (detail).

birds. Adults do not appear to disperse far and both males and females are often collected in traps. The species is readily captured in ovitraps, and in light and CO_2 baited traps, and is readily taken in mammal and avian baited traps. Swarms of male *Ae tremulus* can occasionally be seen in the immediate vicinity of CO_2 baited traps which have been left out overnight. This species is uncommon in the southern parts of W.A. but is occasionally picked up in collections in the winter and autumn months. In the north, it is a common species in collections, particularly in urban areas. It is found throughout the year, but with lowest numbers in the driest months.

RELATION TO DISEASE

Kunjin virus has been isolated from *Ae tremulus* from the Ord River area of W.A., but its role as a vector is unclear. The species was considered a possible vector of myxomatosis in South Australia.

DISTRIBUTION

Ashburton R., Jun 1955, EJB. Balgo Mission, Jun 1978, AEW; Mar 1981, AEW. Banjiwarn, 7km S, Feb 1980, TFH. Beebingarra Creek, Jun 1978, AEW. Billiluna, Sturt Crossing, Mar 1981, AEW. Broome, Apr 1953, AKO; Sep 1978, AEW; Feb-Mar 1984, MEC; May 1984, MEC; May 1985, MEC. Camballin, May 1979, AEW; Jul-Aug 1979, AEW. Cape Lambert, Jun 1984, MEC. Carnarvon, Apr 1979, AEW; May 1984, JWOB; May 1984, MEC; Mar 1985, MEC; Jun 1985, MEC. Cygnet Bay, Oct 1978, AEW. Dampier, Jun 1984, MEC. De Grey Station, Jun 1978, AEW; Mar 1979, AEW. Derby, Sep 1950, EJB; Apr 1951, EJB; Sep 1951, EJB; Mar 1954, EPH; Mar 1954, EJB; Mar-Apr 1977, AEW; Oct 1978, AEW; Feb 1984, MEC; Mar 1985, AEW; Mar 1985, MEC. Derby, 40km S., Mar-Apr 1977, AEW. Derby, Myalls Bore, Mar 1954, EPH; Feb-Apr 1981, RN/JR. Drysdale River, Aug 1979, AEW. Fitzroy Crossing, May-Jun 1954, EPH; May 1986, AEW. Gascoyne River crossing, Apr 1979, AEW. Geraldton/Greenough, May 1955, EJB. Halls Creek, Jul 1953, EJB. Kalumburu, Mar 1954, EPH; Jul 1978, AEW. Karratha, Jul 1985, MEC. Kellerberrin, Jan 1956, DLM. Kimberly Downs Station, Mar 1954, EPH/EJB; May 1979, AEW. Kimberley Research Station, Feb 1953, RL; Mar 1954, EPH. Koolan Is., Sep 1984, MEC. Kununurra, May 1972, PFSL; Dec 1972, PFSL; Apr 1973, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Jul 1976, AEW; Apr-May 1977, AEW; Nov 1977, AEW; Jul 1978, PFSL/AEW; Feb-Mar 1982, AEW; May-Jul 1982, AEW; Oct-Dec 1982, AEW; Jan-Mar 1983, AEW; Jun-Jul 1983, AEW; Oct-Dec 1983, AEW; Feb 1984, MEC; Jan-Mar 1984, AEW; Jun 1984, AEW. La Grange, Oct 1978, AEW. Lake Argyle, May 1972, PFSL; Dec 1972, PFSL; Mar-May 1982, AEW; Nov-Dec 1982, AEW; Jan-Feb 1983, AEW; May 1983, AEW; Jul 1983, AEW; Oct-Nov 1983, AEW; Feb 1984, AEW. Lake Argyle, NE, Jul 1978, PFSL/AEW. Lake Grace, Mar 1955, EJB. Leonora, Jun 1956, EJB. Leschenault Inlet, 1986, AEW. Liveringa, Nov 1943. Louisa Downs, May 1979, AEW. Madura, Oct 1954, EJB. Marble Bar, Mar 1979, AEW. May R. crossing, Apr 1977, AEW. Meda, Apr 1977, AEW. Mia Mia, Apr 1980, AEW. Millstream, Jan 1975, PFSL. Minderoo, Jun 1955, EJB. Minnie R., Apr 1977, AEW. Mullewa, Apr 1985, MEC. Newman, Mar 1979, AEW; Mar 1981, PF. Newman, Gingianna Billabong, Mar 1979, AEW. Nyang, Apr 1980, AEW. Onslow, Feb 1954, EPH; Mar 1954, EPH/EJB; Jun 1955, EJB; May 1985, MEC. Ord River, Jul 1978, PFSL/AEW. Parry's Creek, Dec 1972, PFSL; Jul 1978, AEW; Feb 1982, AEW; Nov-Dec 1982, AEW; Jan 1983, AEW; Nov 1983, AEW; Jan-Feb 1984, AEW. Pt.Hedland, Jul 1973, EJB; Jun 1978, AEW; Mar 1979, AEW; Jan 1980, BB; Feb-Mar 1984, MEC; May-Jul 1984, MEC; Sep 1984, MEC. Queen Victoria Spring, 1967, ENM. Roebourne, Feb 1954, EPH/EJB; Feb 1954, MMC; May-Jun 1984, MEC. Roebourne, Harding R., Apr 1979, AEW. Strelley R., Jun 1978, AEW. Tabba Tabba Creek, Jun 1978, AEW. Tom Price, Mar 1979, AEW. Winning, Apr 1980, AEW. Wogoola, Jun 1955, EJB. Wyloo, Apr 1980, AEW. Wyndham, Nov 1977, AEW; Apr 1980, OA; Feb-Mar 1982, AEW; Jun 1982, AEW; Feb 1984, MEC. Yanrey, Jun 1955, EJB. Yeeda, Mar 1977, AEW; Apr 1977, AEW. Yeeda R. crossing, Apr 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

The adult of this species is difficult to distinguish from one of the undescribed *Ae (Mac)* ENM's sp76 (a species not as yet collected from W.A. but known from the Northern Territory. *Ae (Mac)* ENM's sp76 is distinguished most readily by the palp being dark at the tip where *ae tremulus* has the palp pale at the tip. The larvae are also not easily distinguished from *Ae (Mac)* ENM's sp76, nor from the larvae of *Ae (Cha) elchoensis*. It is best to confirm species identification with the adults, and to seek the advice of a medical entomologist to confirm identification of specimens which key to the undescribed species.

A number of undescribed species of the subgenus *Macleaya* are known from W.A. Some are widespread, but most are very rare and only a few specimens have been collected. These species are listed below:

Aedes (Macleaya) ENM's sp. No.70

ADULT FEMALE

(Not seen, the description is adapted from the Key.) Female palp white at tip. Scutum predominantly dark with a few golden scales and a small patch of pale scales above wing root and around prescutellar area. Scutellum with lateral lobe predominantly dark scaled; middle lobe black scaled with a few white scales in midline. Hindleg with base of tibia with pale band; hindtarsus I with wide white basal band. Wing sales all dark.

LARVA

Not seen, but is known from Torres Strait collections.

BIOLOGY

The species breeds in tree holes and in some domestic containers (drums). Adults do not appear to bite man.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Rare species known from the Ord Valley and Kimberleys.

Aedes (Macleaya) ENM's sp. No.125

ADULT FEMALE

(The description is adapted from the Key.) Female palp white at tip. Anterior half of scutum clothed in golden scales (especially on fossa). Abdomen with tergites dark with basal median white patches on II-V or I-V or with basal bands on V-VI. Hindfemur with white knee spot; hind tibia with narrow basal band; hindtarsi I and II with broad basal bands and narrow apical pale ring. Wing dark scaled.

LARVA

Unknown.

BIOLOGY

Only adults of this species have been collected. They have been captured in CO_2 baited traps and biting man. Nothing is known of its biology. It is a species of the arid interior.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Banjiwarn, 7.5km SE, Feb 1980, TFH. Coolgardie, 40km SE, Oct 1965, NVD.

Aedes (Macleaya) ENM's sp. No.126

ADULT FEMALE

(Not seen, the description is adapted from the Key.) Palp dark at tip. Scutum with anterior half clothed in bright golden scales. Pleura with posterior pronotum with bright golden scales. Abdomen with tergites dark with median white patches on II-VI. Hindleg with femur having white knee spot. Wing with pale scales on base of costa and subcosta.

LARVA

Unknown.

BIOLOGY

This rare species has been taken as adults in CO_2 traps and resting in a rabbit warren. Nothing is known of its biology.

RELATION TO DISEASE
None known or suspected.

DISTRIBUTION
Balgo Mission, Darbai R., Mar 1981, AEW.

Aedes (Macleaya) ENM's sp. No.147

ADULT FEMALE
(Not seen, the description is adapted from the Key.) Palp with white tip.
Scutum with conspicuous white to light golden lyre; white patches above wing root and prescutellar area. Lateral lobes of scutellum with extensive pale scaling. Pleura with posterior pronotum with upper half dark scaled, lower half pale. Abdomen with tergites dark with white median patches on I-V or I- VI. Hindfemur with conspicuous white knee spot. Wing dark scaled.

LARVA
Unknown.

BIOLOGY
This species has been collected coming to man. Nothing is known of its biology.

RELATION TO DISEASE
None known or suspected

DISTRIBUTION
Coolgardie, 40km SE, Oct 1965, NVD. Darkan, Jan 1953, JHC. Galena, Oct 1953, DLM. Higginsville, Oct 1954, DLM. Irwin, Oct 1956, DLM. Kellerberrin, Jan 1956, DLM. Merridin, 50km NE, Dec 1956, DLM. Mt Rugged, 25km N, Jul 1953, DLM. Paynes Find, Oct 1963, JHC. Pemberton, 25km E, Mar 1956, DLM. Queen Victoria Springs, Oct 1956, JHC.

Subgenus : *Mucidus*

SUBGENERIC CHARACTERS
Adult: Large, conspicuously ornamented species, particularly on legs and wings (dark areas on wing membrane over crossveins). Female palp about 0.67x length of proboscis. Scales on vertex and scutellum narrow. Hindlegs very long; claws on forelegs and midlegs toothed. Female abdomen with segment VIII small and completely retractile, cerci long and narrow.
Larva: Very large, with mouthbrushes modified for predation. Ventral brush large and extended by a complete row of precratal tufts.

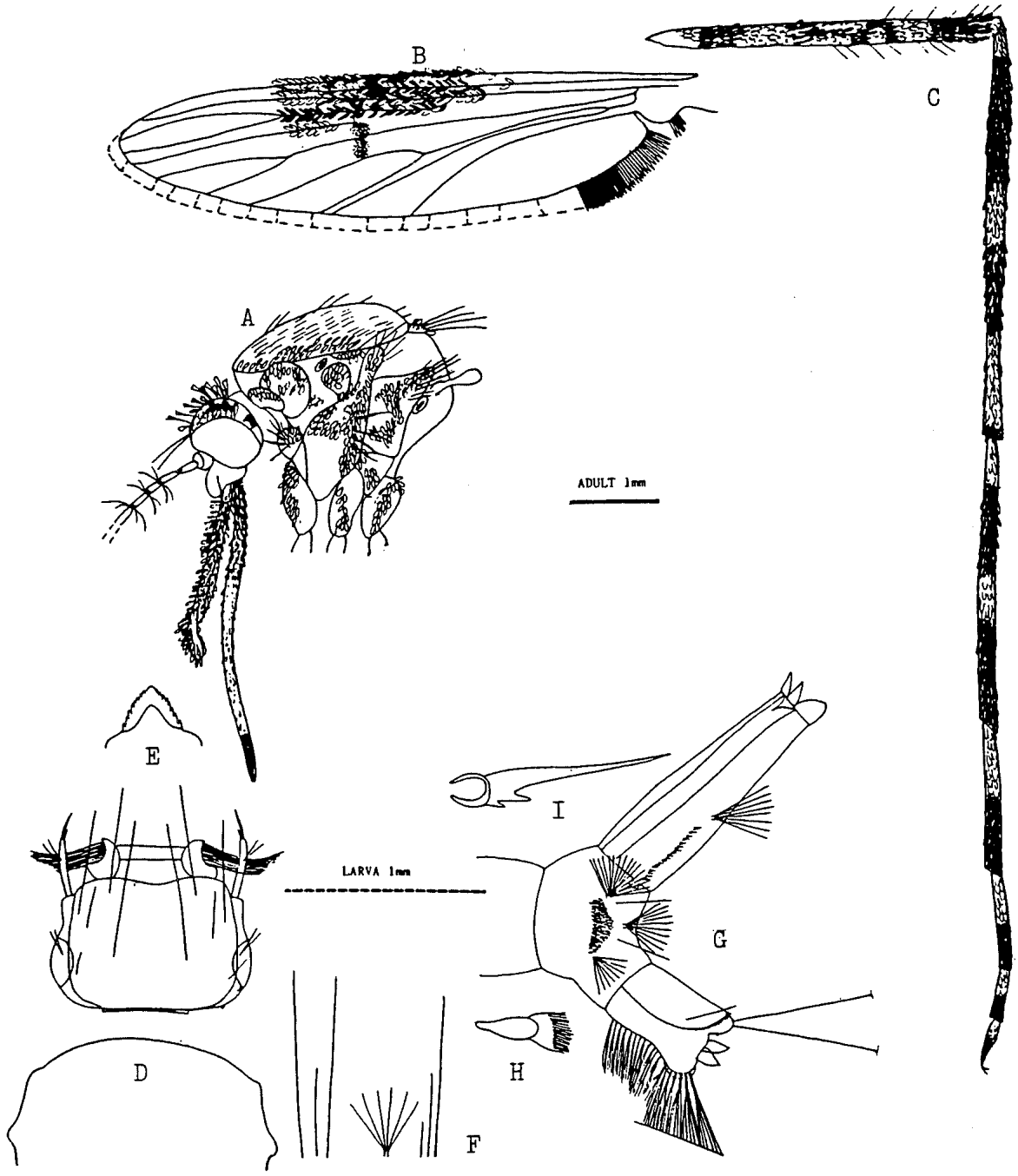
KEYS: ADULT FEMALES: see key to subgenera of Aedes (page 98).
LARVAE: see key to subgenera of Aedes (page 99).

Aedes (Mucidus) alternans Westwood 1835

Westwood, J.O., 1835 *Ann. Soc. Ent. Fr., 4:* 681.
Type locality: Nova Hollandia (i.e. Australia).
Synonymy: *Culex commovens* Walker, F., 1856. *Insecta Saunders, 1* (Diptera): 432.
Culex hispidosus Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1726.
Culex kermorganti Laveran, M.A., 1901. *C. R. Seanc. Soc. Biol., 53:* 568.

ADULT FEMALE
A very large species with distinctive shaggy appearance. Head with long narrow pale and yellow/brown scales on vertex; upright forked scales numerous on occiput. Torus pale scaled above mesially. Clypeus bare. Palp about 0.67x length of proboscis; clothed in long scales and having a mottled/banded appearance with pale, dark and brown scales. Proboscis mottled on basal 0.4 with indistinct pale band from 0.4-0.8 from base, tip dark; about same length as forefemur. Scutum clothed in admixture of long narrow pale white and brown scales with a few bronzy scales; patches of long pale scales above wing root and around prescutellar space. Scutellum with shaggy narrow pale scales on all lobes. Pleura with

integument light brown; with fairly dense covering of long pale scales on all segments except anterior sternopleuron which is bare; 4 lower mesepimeral bristles; 6 postspiracular bristles. Abdomen with tergites having a mixture of pale, golden and brown scales, pale mesial patches, apex predominantly golden, some long basolateral scale patches on tergites II and III; sternites mottled with white, golden/yellow and brown scales, basolateral white patches; segment VIII retracted; abdomen with pointed appearance. All legs banded for their entire length; hindleg with femur having three broad pale and dark bands, dark at apex; tibia with three pale and two dark bands and a narrow ring of dark scales at apex; tarsi I with basal and medial pale band, II-V with basal band only; claws equal and toothed. Wing mottled on entire surface with posterior fringe having discrete alternating pale and dark patches; pale scale patches at apex of subcosta; wing membrane with dark clouded areas around the crossvein *r-m* and on the bases of *M3+4* and *Rs*.



Aedes (Mucidus) alternans

A: Adult head and thorax (lateral); B: Wing (clouding of membrane around r-m shown, and detail of scaling shown for part of wing); C: hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten tooth (detail).

LARVA

Antenna pale at base, darker near tip; about 0.45x length of head; seta 1-A bifid, inserted dorsally at about 0.76 from base. Head has characteristic angular appearance, mouthbrushes modified for predation; head about 0.76x as long as wide and about 0.74x width of thorax; all head setae (4-C to 8-C) are single; 9-C bifid. Propleural groups as follows: 1-P to 3-P single, 4-P with 5-6 branches; 5-P to 7-P single. Abdominal segment VIII with lateral comb of about 50 fringed scales in an irregular triangular patch; seta 1-VIII with about 16 branches; 2-VIII and 4-VIII single; 3-VIII with about 10 branches; 5- VIII with about 8 branches. Siphon index about 4.44; siphon about 2.6x length of saddle; seta 1-S with single pair of tufts each with about 8 branches, inserted at about 0.38 from base of siphon; pecten with 18-21 spines with basal denticles extending to 0.3 from base of siphon. Anal segment with saddle covering dorsal half of segment and covered with prominant spicules, and with a prominant posterior fringe of small spines; seta 1-X to 3-X single; 4-X with 7 pairs of tufts on grid, preceded by about 12 precratal tufts along entire length of segment. Anal papillae short and pointed; about 0.36x length of saddle.

BIOLOGY

The species generally breeds in saline waters (tidal salt marsh pools) in the northern parts of Australia, but also can be found in fresh water ground pools. Eggs are laid singly on moist soil and can withstand desiccation. The species is often associated with *Ae vigilax* and *Cx sitiens* in brackish or saline sites, and with *Ae vittiger*, *Ae theobaldi* and *Cx annulirostris* in fresh water sites. In the southern parts of its range in W.A., it has been found breeding in association with *Ae alboannulatus* and *Cx australicus*. Larvae are predacious and cannibalistic. The adults are strong fliers and the species is reported to undertake migratory flights. Adults bite man readily during the day and at dusk, often becoming active and biting just prior to storms in arid areas. The species has been taken at mammalian or bird baits, and is often taken in low numbers in light or CO_2 baited traps. In the south, the species is rare and is generally found in the arid interior and more northerly areas. In the north, it is more common and is collected throughout the year.

RELATION TO DISEASE

None known. Specimens of this species have occasionally been screened for the presence of arboviruses, but none have been isolated to date.

DISTRIBUTION

Balgo Mission, Jun 1978, AEW; Mar 1981, AEW. Beebingarra Creek, Jun 1978, AEW. Billiluna, Mar 1981 AEW. Billiluna, Sturt Crossing, Mar 1981, AEW. Camballin, May 1979, AEW. Carnarvon, Feb-Mar 1984, MEC; May 1984, ADC; May 1984, JWOB; May-Jun 1984, MEC; Oct 1984, MEC. Coolgardie, Aug 1956, EJB. De Grey R., Jun 1978, AEW. Derby, Apr 1977, AEW; Aug 1978; Mar 1985, AEW. Karratha, Apr 1981, MW/TH; Jul 1984, MEC. Kathleen Valley, 1963, TM. Kimberley Research Station, Feb 1960, KTR; Feb 1962, KTR. Kununurra, Dec 1972, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Mar 1976, RWW; Apr-May 1977, AEW; Jul 1978, PFSL/AEW; Feb 1981, OA; Feb-Mar 1982, AEW; Dec 1982, AEW; Jan-Mar 1983, AEW; Jun 1983, AEW; Nov-Dec 1983, AEW; Jan-Mar 1984, AEW. Lake Argyle, Mar-Apr 1982, AEW; Dec 1982, AEW; Jan-Feb 1983, AEW; Feb 1984, AEW; Feb 1984, MEC. Louisa Downs, May 1979, AEW. Manberry, 20km E, Jul 1964, LEK. Newman, Mar 1979, AEW; Mar 1981, PF. Newman, Gingianna Billabong, Mar 1979, AEW. Ord River, Jul 1978, PFSL/AEW. Parry's Creek, Feb-Mar 1982, AEW; Nov-Dec 1982, AEW; Jan 1983, AEW; Nov 1983, AEW; Jan-Feb 1984, AEW. Port Hedland, Oct 1984, MEC. Strelley R., Jun 1978, AEW. Wyndham, Mar 1930, TGC; Mar 1982, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Neomelaniconion*

SUBGENERIC CHARACTERS

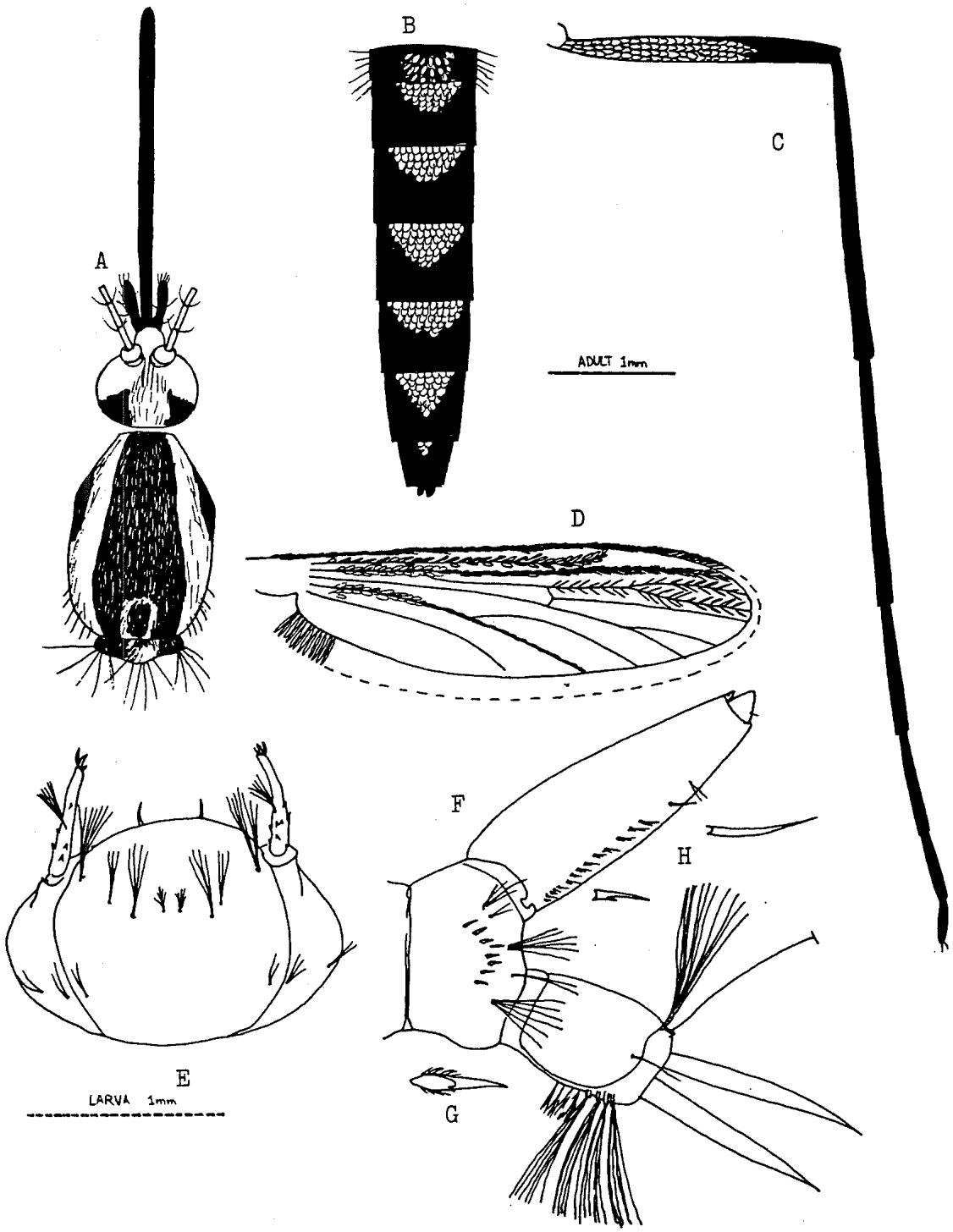
Adult: Head with narrow decumbent scales on vertex, upright forked scales numerous but not reaching front of head. Proboscis usually dark, palps short. Scutum and scutellum clothed in narrow scales. Abdominal segment VIII of female short and completely retractile, cerci long. Tarsi dark, fore and mid claws toothed. Alula and squama of wing with well developed fringe scales.

Larva: Antenna spiculate with small seta (1-A) with few branches. Lateral comb with stout spines in one or two rows. Siphon rather long; pecten extending beyond midpoint with one or more of the distal teeth more widely spaced. Precratal tufts present.

KEYS: ADULT FEMALES: see key to subgenera of *Aedes* (page 98) and key to the subgenus Ochlerotatus (page 130).
LARVAE: see key to subgenera of *Aedes* (page 99).

Aedes (Neomelaniconion) lineatopennis (Ludlow) 1905

Ludlow, C.S., 1905. *Can. Ent., 37:* 133.
Type locality: Camp Gregg, Bayambang, Pangasinan, Luzon, Philippines.
Synonymy: *Pseudohowardina linealis* Taylor, F.H., 1913, *Rep. Aust. Inst. Trop. Med.,* 1911: 57.



Aedes (Neomelaniconion) lineatopennis
A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Wing (shows detail of scaling on basal part of wing); E: Larval head (dorsal); F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten tooth (detail of basal and apical teeth).

ADULT FEMALE

A medium sized species found in the wetter parts of tropical W.A., readily distinguished by the characteristic golden scutal ornamentation. Head with narrow golden/yellow scales on vertex to occiput in midline, dark laterally, golden scales forming a triangle which flows into lateral scutal bands; upright forked scales golden, numerous. Torus and clypeus bare. Palp dark scaled; slightly less than 0.2x length of proboscis. Proboscis dark; about 1.2x length of forefemur. Scutum with dark brown integument; black curved scales medially, with broad golden bands to side, forming a distinct V with the point on the head; some golden scales around prescutellar space. Scutellum sparsely clothed in long golden scales on all lobes. Pleura with dark brown integument; anterior pronotum and posterior pronotum bare; propleuron with some broad gold/translucent scales; small patches of translucent scales on upper and posterior sternopleuron and upper mesepimeron; 5 postspiracular bristles; 1 lower mesepimeral bristle. Abdomen with tergites dark scaled, with pale median triangular patches on II-VI, VII dark, VIII small retracted, cerci dark, small pale apicolateral scale patches on tergites VI-VII; sternites all dark scaled. Coxae of all legs with some broad translucent scales. Hindleg with femur dark, pale below on basal 0.67; tibia dark; tarsi all dark. Wing dark scaled. Haltere with pale stem and black scales on club.

LARVA

(Larva not known from W.A. This description based on specimens from Queensland.) Antenna brown, spiculate, about 0.5x length of head; seta 1-A with 4 branches, inserted just below midpoint. Head about 0.85x as long as broad, about 0.9x width of thorax; seta 4-C small with 5-9 simple branches; seta 5-C with 4-7 simple branches; 6-C with 3-6 simple branches; 7-C with 8-13 simple branches. Prothoracic seta 1P short with 1-2 branches; 2-P short with 3 branches; 3-P short with 4 branches; 4-P short with 2 branches; 5-P and 6-P single, long; 7-P with 3 long branches; pleural groups with blunt basal tubercle. Abdominal segment VIII with lateral comb of 6-8 fringed spines in an irregular single row; seta 1-VIII with 5 short simple branches; 2-VIII with 1-2 short branches; 1-VIII and 2-VIII arise from small basal plate; 3-VIII with 6 branches; 4-VIII with 2 branches; 5-VIII with 6 simple branches. Siphon index about 2.8-3.3, about 2.5x length of saddle; seta 1-S a single pair of setae with 2 short branches, inserted at about 0.66 from base of siphon; siphon with small acus; pecten with about 13 spines, basal 1-3 very short, 3-10 evenly spaced and reaching to 0.45 of siphon (1-10 with basal denticles), 11-13 simple and more widely spaced reaching to 0.66 from base of siphon. Saddle incomplete, almost reaching in midline ventrally; seta 1-X short, single; 2-X multibranched; 3-X single and long; 4-X with 4 pairs of multibranched setae on grid, and 4 precratal tufts. Anal papillae very long and pointed, about 2.7x length of saddle.

BIOLOGY

Ae lineatopennis breeds in transient rain filled ground pools, usually with some vegetation. Adults bite man readily at dusk, and are known to bite a variety of mammals. They have been taken in light and CO_2 baited traps as well as in mammal baited traps. The species is restricted to tropical W.A., and is collected during and following the wet season.

RELATION TO DISEASE

None known in Australia, though there have been a couple of arboviruses isolated from this species in Asia. It should be noted that the Australian populations probably represent a distinct species from the Asian forms.

DISTRIBUTION

Derby, Mar 1985, AEW. Kununurra, Nov 1973, PFSL; Apr 1974, PFSL; Apr 1975, PFSL; Apr-May 1977, AEW; Jul 1978, PFSL/AEW; Feb-Mar 1982, AEW; May 1982, AEW; Sep 1982, AEW; Nov-Dec 1982, AEW; Jan-Mar 1983, AEW; May 1983, AEW; Dec 1983, AEW; Jan-Mar 1984, AEW. Lake Argyle, Nov 1977, AEW; Mar 1982, AEW; Dec 1982, AEW; Feb 1984, AEW. Ord River, Jul 1978, PFSL/AEW. Parry's Creek, Feb-Mar 1982, AEW; Dec 1982, AEW; Jan-Mar 1983, AEW; Jan-Feb 1984, AEW. Wyndham, Feb-Mar 1982, AEW; May 1982, AEW; Mar 1984, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Ochlerotatus*

Ochlerotatus is a large subgenus represented by 24 species, 6 of which are undescribed (though 2 of these are larvae which are probably those of species currently known only from adults). As for *Finlaya*, the members of the subgenus form natural affinity groups within it. However, the treatment of the species here does not reflect the natural groupings, but rather lists the species alphabetically. In addition, the subgenera *Aedimorphus* and *Neomelaniconion* which superficially resemble *Ochlerotatus* are included in the key to adults.

SUBGENERIC CHARACTERS

Adult: *Aedes* with varied ornamentation. Scales on vertex of head always narrow. Narrow scales on scutellum and pronotal lobes. Proboscis slender, longer than forefemur. Lower mesepimeral bristles present. Claws on forelegs and midlegs toothed. Abdominal segment VIII of female small and completely retractile, cerci long and narrow.

Larva: Antenna more or less spiculate, seta 1-A branched, inserted about midpoint. Head hair 5-C inserted behind 6-C. Siphon generally with index greater than 2; pecten rarely with apical teeth detached. Lateral comb teeth in triangular patch, but sometimes reduced and forming, more or less, a single row. Anal segment with ventral brush (seta 4-X) always well developed, often with precratal tufts.

KEY TO ADULT FEMALES OF *AEDES (OCHLEROTATUS)* IN WESTERN AUSTRALIA

(Adapted from a key by E.N. MARKS)

1. – Scutum creamy white scaled with four strikingly contrasted black longitudinal stripes ..... *Ae (Och) vittiger*
   – Scutum otherwise 2
2. – Tarsi of all legs with distinct basal white bands; bands on hind tarsi II-III at least 0.125 length segment 3
   – Tarsi unbanded, or reduced and never 0.125 length of segment 12
3. – Wing scales entirely dark, or with pale scales restricted to very base of wing, i.e. the costa, subcosta and radius 1, and not extending beyond humeral cross vein 4
   – Wing with at least some pale scales elsewhere 7
4. – Hind tarsal bands extending to apices of preceding segments 5
   – Hind tarsal bands basal only 6
5. – White bands over femoro-tibial and tibio-tarsal joints of hind legs; femora slightly mottled; wings with a few pale scales at base of costa and radius ..... *Ae (Och)* ENM's "Koorda" sp.
   – No bands over joint of segments; mid and hind femora unmottled; wings all dark ..... *Ae (Och) clelandi* (part)
6. – Anterior surface of hind femur, tibia and tarsus I extensively mottled (hind tarsal bands 0.167- 0.25 on II, 0.2-0.25 on III, 0.125-0.33 on IV; V dark or with band to 0.3) ..... *Ae (Och) camptorhynchus*
   – Hind tarsal segment I unmottled, femur and tibia with or without slight mottling; tergites with basal bands; hind tarsi with basal bands 0.125-0.167 on II-IV ..... *Ae (Och)* ENM's sp. No.159 (part)
7. – Wings with numerous broad white scales on all veins (some 3-4x as long as broad); pale basal bands on tergites broad and produced to triangle. ..... *Ae (Och) eidsvoldensis*
   – Wing scales normal in size and shape 8
8. – Lateral patches on tergites narrower at base than at mid segment; proboscis pale ventrally on basal 0.67; scutal integument dark ..... *Ae (Och) vigilax*
   – Lateral patches on tergites broadest at base 9
9. – Wing with very inconspicuous pale mottling; hind tibia and tarsus I unmottled; hind tarsal banding 0.125-0.167 on II-IV; scutal integument dark; proboscis pale ventrally on mid 0.3 ..... *Ae (Och)* ENM's sp. No.159 (part)
   – Wing with conspicuous mottling, moderate to extensive 10
10. – Scutal scaling dark; proboscis dark or slightly mottled (scutal integument black; hind tibia mottled; sternites dark or mottled mesially) ..... *Ae (Och) normanensis*
    – Scutal scaling predominantly golden or creamy, often with dark patches on fossa but not mesially 11

11. – Wing very extensively mottled, costa almost entirely white below humeral cross vein; sternites pale with inconspicuous apicolateral dark patches; hind tibia and tarsus I mottled; most upright forked scales of head pale; proboscis pale ventrally almost to apex ..... *Ae (Och)* ENM's sp. No.71

– Wing with moderate mottling, costa dark basal of humeral cross vein; sternites dark or mottled apically; hind tarsus I unmottled; upright forked scales of head mainly dark; Proboscis dark ventrally on apical 0.35; scutal integument varies from reddish to dark brown; anterior hind tibia mottled or not ..... *Ae (Och) pseudonormanensis* (part)

12. – Wing dark scaled, or with pale scales restricted to very base of wing, i.e. the costa, subcosta and radius 1 13
– Wing extensively mottled, or with at least some pale scales elsewhere 24
13. – Scutum with broad lateral margin of pale scales contrasting with darker scales mesially 14
– Scutal scaling otherwise 18
14. – Femora unmottled; scutal margins bright yellow, continuous on to head (northern species) ..... *Ae (Neo) lineatopennis*
– Fore and mid femora mottled 15
15. – Wings with at least some pale scales on base of costa and radius; scutal integument black; small hypostigial scale patch (fossa entirely white) *Ae (Och) nigrithorax*
– Wings entirely dark scaled; scutal integument reddish to dark brown; hypostigial scales absent 16
16. – Tergites II-IV with broad creamy median stripe ..... *Ae (Och) ratcliffei*
– Tergites otherwise 17
17. – Tarsal segments II-III of fore and mid legs with basal white patches and bands or patches on hind leg ..... *Ae (Och) mackintoshi*
– Tarsal segments II-III without basal bands or patches ..... *Ae (Och) hodgkini*
18. – Fore and mid femora distinctly mottled 19
– All femora unmottled 21
19. – Wing all dark scaled; femoral mottling not conspicuous; basal posterior white patches on at least hind tarsi I-II; scutal scaling mixed dark and golden, without pattern ..... *Ae (Och) hesperonotius* (part)

– Wing with some pale scales on base of costa and radius; mottling of femora conspicuous 20
20. – Scutal scaling dark bronze, with whitish scales above wing root, around prescutellar space and on scutellum, integument black ..... *Ae (Och) sagax*
– Scutal scales mainly golden brown, with deep creamy or pale golden scales above wing root, around prescutellar space and on scutellum, integument reddish to dark brown ..... *Ae (Och)* ENM's sp. No.85

21. – Shining white patches at apex of hind femur and tibia; scutellum with broad white scales ..... *Ae (Adm) alboscutellatus*

– Not with this combination of characters 22
22. – Hind femur pale anteriorly on basal 0.5-0.67, pale to apex posteriorly; hind tarsi with distinct basal patches ..... *Ae (Och) clelandi* (part)

– Hind femur entirely dark anteriorly, or with a few basal pale scales 23
23. – Tergites with apical as well as basal lateral patches; hind femur entirely dark anteriorly; scutal integument reddish brown; sternites dark; tarsi all dark ..... *Ae (Och) purpureifemur*

	– Tergites with basal lateral patches only; hind femur with some pale scales anteriorly at base; scutal integument dark brown; sternites pale; hind tarsi with some pale scales at base of I-II	*Ae (Och) hesperonotius* (part)
24.	– Tergites with both apical and basal lateral white patches	25
	– Tergites with basal lateral pale patches only and with basal white bands or median patches	26
25.	– Pleural scaling dense, forming broad white band contrasting strongly with reddish brown scaling and integument above; hypostigial scaling present	*Ae (Och) stricklandi*
	– Pleural scaling sparse, sub and post spiracular areas with scale patches, no hypostigial scales; tergites mottled	*Ae (Och) turneri*
26.	– Tergites with median basal elongate triangles or complete stripes, usually arising from basal bands; sternites white; hypostigial scale patch present	*Ae (Och) sapiens*
	– Tergites with basal bands or patches not produced mesially; no hypostigial scale patch	27
27.	– Tibiae mottled; tarsi unbanded; tergites with paired submedian basal white patches, usually rounded and narrowly joined	*Ae (Och) cacozelus*
	– Tibiae unmottled; hind tarsi with narrow basal bands	28
28.	– Wing with inconspicuous mottling; scutal integument dark, scaling predominantly dark; sternites dark apically	*Ae (Och)* ENM's sp. No.159 (part)
	– Wing with conspicuous mottling; scutal integument reddish brown, scaling golden; sternites mottled apically	*Ae (Och) pseudonormanensis* (part)

KEY TO 4TH INSTAR LARVAE OF *AEDES (OCHLEROTATUS)* IN WESTERN AUSTRALIA

1.	– Head with seta 5-C single, rarely bifid on one side	2
	– Head seta 5-C with 2 or more branches	9
2.	– Lateral comb in triangular or irregular patch; siphon seta 1-S less than 0.5x length siphon	3
	– Lateral comb teeth in single row	5
3.	– Saddle covers dorsal 0.88 of anal segment; 2 precratal tufts present	*Ae (Och) vigilax*
	– Saddle covers only dorsal 0.5 of anal segment; 2-3 precratal tufts	4
4.	– Head with seta 7-C single, about 0.75x length antenna	*Ae (Och) pseudonormanensis*
	– Head with seta 7-C 3 branched; about 0.67x length antenna	*Ae (Och)* ENM's sp. No.71
5.	– Pecten with 1-3 detached spines above insert of siphon seta 1-S	6
	– Pecten without detached spines	8
6.	– Saddle completely ringing anal segment; anal papillae about 2x length saddle; siphonal seta 1-S with 1-2 branches	*Ae (Och) vittiger*
	– Saddle not complete; anal papillae at most only slightly longer than saddle; siphonal seta 1-S multibranched	7
7.	– Abdominal setae 1-VIII 4-8 branched, 3-VIII 7-14 branched; siphon index 2.3-2.8 (av.=2.6); pecten with 20-25 spines (less in some specimens), usually only 1 detached tooth above seta 1-S; anal segment with seta 2-X with 9-12 branches	*Ae (Och) sagax* *Ae (Och)* ENM's sp. No.85
	– Abdominal seta 1-VIII 3-6 branched, 3-VIII 6-11 branched; siphon index 2.8-3.6 (av.=3.0); pecten with 19-28 spines, 1-2 detached spines above 1-S; seta 2-X of anal segment with 7-9 branches	*Ae (Och) nigrithorax*

8. –	Lateral comb of 6 long, strong, tapering spines, about 0.3x length saddle, each with short lateral fringe of fine denticles and arising from a distinct, dark sclerotized base; anal segment with seta 2-X 18-22 branched ..	*Ae (Och)* ENM's sp. nr. stricklandi
–	Lateral comb with row of 4-5 long, strong, tapering spines, about 0.33x length saddle, without basal fringe of denticles, but arising from a distinct, dark sclerotized base; anal segment with seta 2-X 10-15 branched	*Ae (Och) stricklandi*
9. –	Head with seta 6-C single	10
–	Head seta 6-C multibranched	13
10. –	Anal segment without precratal tufts; anal papillae short, less than 0.5 length saddle	11
–	Precratal tufts present	12
11. –	Lateral comb with 22-25 fringed scales in triangular patch	*Ae (Och) clelandi*
–	Lateral comb with 8-13 stout spines in irregular row	*Ae (Och)* PFSL's sp. A
12. –	Abdominal seta 4-VIII single; anal papillae about 2x length saddle; 24-29 pecten spines over basal 0.67 of siphon	*Ae (Och)* ENM's 'Koorda' sp.
–	Abdominal seta 4-VIII 2-3 branched; anal papillae 2.5-3x length saddle	*Ae (Och) normanensis*
13. –	Anal papillae short, globular; lateral comb scales coarsely fringed, without central spine	*Ae (Och) camptorhynchus*
–	Anal papillae distinctly pointed	14
14. –	Siphon with dorsal valve hairs modified as strongly curved hooks ..	*Ae (Och) eidsvoldensis*
–	Siphon without modified dorsal valve hairs	15
15. –	Lateral comb of 5-6 large pointed spines with slender base (sometimes inconspicuously fringed basally) in irregular row	*Ae (Och) mackintoshi*
–	Lateral comb with 15+ scales in triangular patch	16
16. –	Lateral comb with 19-24 slender pointed spines, finely fringed on basal 0.33	*Ae (Och) hodgkini*
–	Lateral comb of 33-60 short, broad scales in 4-6 rows, scales with even apical fringe of coarse denticles, finely fringed laterally	*Ae (Och) ratcliffei*

Aedes (Ochlerotatus) cacozelus Marks 1963

Marks, E.N., 1963 *J. Ent. Soc. Qld., 2:* 45.
Type locality: Darkan (110 miles SSE of Perth), W.A.
Synonymy: None.

ADULT FEMALE

(Not seen for this manual, the description here is taken from Marks, E.N., 1963 *J. Ent. Soc. Qld., 2:* 45.) Head with dark integument; decumbent scales narrow dark, white on vertex and nape of neck; broad white and black scales on side of head; upright forked scales numerous, dark. Torus dark with numerous black and white scales. Clypeus dark. Palp black scaled; about 0.2x length of proboscis. Proboscis black scaled, almost 1.5x length of forefemur. Scutum with integument dark; scaling dark with pale scale patches on anterior margin, above wing root and around prescutellar space. Scutellum with pale narrow scales on all lobes; midlobe with some black. Pleura with anterior pronotum and posterior pronotum with dark scales above, pale below; broad white scales on propleuron, subspiracular area, anterior and upper sternopleuron, postspiracular area, paratergite, and prealar area; 9-12 postspiracular bristles; 3 lower mesepimeral bristles. Abdomen with tergites largely dark, tergite I white scaled mesially and along apical border, II-V with narrow basal pale band separated from elongated lateral pale patches which may reach almost to apical margin of segment, band indented in midline, sometimes broken, VI-VII with indefinite white scaling at base; sternites white with irregular, discontinuous median dark line, and apical lateral dark patches; cerci long, dark. Coxae with light scaling. Hindleg with femur having white knee spot, mottled with pale scaling on basal 0.75; tibia mottled; tarsi with segment I mottled, II with a few pale scales, III-V dark. Wing with extensive mottling on cubitus, costa dark except at base, radial veins R2 and R3 dark. Haltere with pale stem and white scaling on knob.

LARVA

Not known.

BIOLOGY

No information available.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Darkan, Oct 1952, DG. Piawaning, 7km W, Sep 1956, DLM.

SPECIES WITH WHICH IT MAY BE CONFUSED

The species superficially resembles *Ae stricklandi*. This is a rare species - if you should identify a specimen as *Ae cacozelus*, refer it to a medical entomologist for confirmation.

Aedes (Ochlerotatus) camptorhynchus (Thomson) 1869

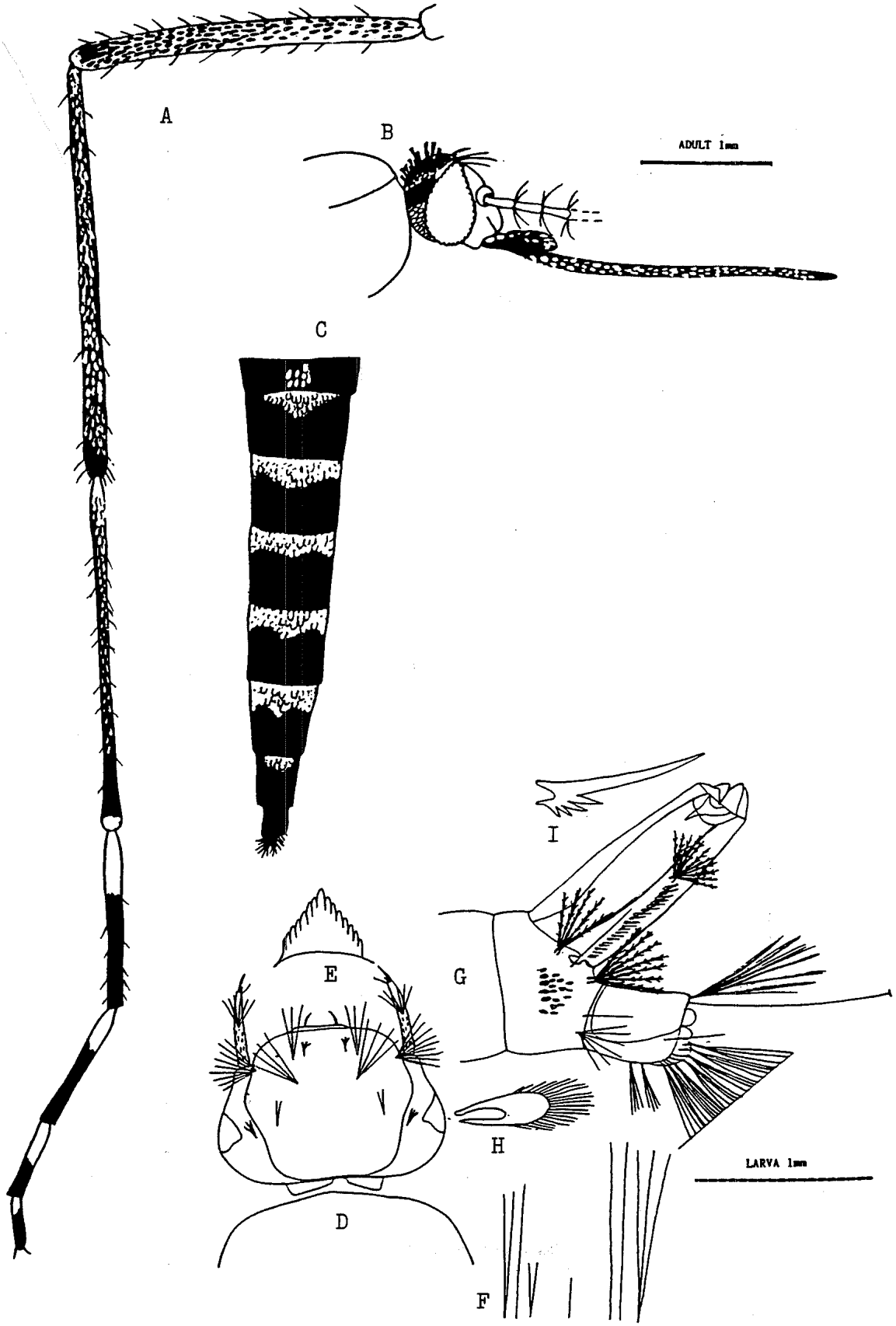
Thomson, C.G., 1869. *Kong Sven Freg. Eugenies Resa, Dipt. :* 443.
Type locality: Sydney, New South Wales, Australia.
Synonymy: *Culex labeculosus* Coquillett, D.W., 1905. *Ent. News, 16:* 116.
Culicelsa westralis Strickland, E.H., 1911 *Entomologist, 44:* 130.
Culicada inornata Strickland, E.H., 1911 *Entomologist, 44:* 201.
Culicada nigra Taylor, F.H., 1914. *Trans. Ent. Soc. Lond.,* 1914 : 688.
Culicada annulipes Taylor, F.H., 1914. *Trans. Ent. Soc. Lond.,* 1914 : 693.
Culicada victoriensis Taylor, F.H., 1914. *Proc. Linn. Soc. N.S.W., 39:* 460.

ADULT FEMALE

A moderate to large species, very common in the wetter parts of the south. Head with narrow white scales on vertex, brown laterally with broad white and dark scales on side of head; upright forked scales numerous, both dark and light. Torus with pale and dark scales. Clypeus bare. Palp dark, sparsely mottled in middle, pale at tip; about 0.17x length of proboscis. Proboscis dark at base and tip, mottled on middle 0.75; about 1.4x length of forefemur. Scutum with integument dark brown; clothed in narrow bronzy scales with small discrete patches of white scales on anterior promontory, median fossa, above wing root and around prescutellar space. Scutellum with narrow curved white scales on all lobes. Pleura with anterior pronotum and posterior pronotum having broad dark scales above, pale below; dense white scaling covering propleuron, subspiracular area, postspiracular area, upper and posterior sternopleuron, prealar area, and anterior and upper mesepimeron; 3 postspiracular bristles; 1 lower mesepimeral bristle. Abdomen with tergites dark scaled, with pale basal lateral and median patches on II-VII, VI-VII with some pale apical median white scaling; sternites white with basal median dark patches. Coxae pale scaled, some dark on coxa I. Hindleg with femur mottled, pale at base, darker at apex; tibia mottled, dark on apical 0.17; tarsi dark with basal bands, I with narrow basal band, II-IV basal band broader, V with narrow basal band. Wing dark scaled. Haltere with pale stem, dark knob, some pale scales on knob.

LARVA

Antenna darker than head, about 0.5x its length; seta 1-A with 5-6 branches inserted at 0.67 from the base; distinct spicules on basal 0.5 of antenna. Head 0.7x as long as wide; about 0.8x width of thorax; setae 4-C and 5-C with 4 branches; 6-C with 3 branches; 7-C with 9 branches, 8-C with 1-2 branches; and 9-C with 1-3 branches. Propleural groups: 1-P bifid; 2-P single; 3-P with 2 branches; 4-P to 6-P single; 7-P with 3 branches. Abdominal segment VII with lateral comb having 16-18 blunt ended fringed scales in a rough triangle; seta 1-VIII with 5 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 7-9 pectinate branches; 5-VIII with 5-6 simple branches. Siphon with marked acus; siphon index about 2.55; about 2.38x length of saddle; seta 1-S single pair of pectinate tufts with about 11 branches inserted at 0.56 from base; pecten with 18-23 spines, basally denticulate, extending to about midpoint of siphon. Anal segment with incomplete saddle covering dorsal 0.67 of segment; setae 1-X and 3-X single; 2-X with 8 branches; 4-X with 7-9 pairs of tufts on grid and 1-2 precratal tufts. Anal papillae short, globular; about 0.22x length saddle.



Aedes (Ochlerotatus) camptorhynchus

A: Adult hindleg; B: Head (lateral); C: Abdomen (dorsal); D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

BIOLOGY

This species breeds in coastal brackish water and essentially replaces *Ae vigilax* in the southern parts of W.A. It can also be found breeding in salt affected waters in inland areas, and in temporary fresh ground water sites. The species disperses over quite long distances and is able to successfully colonise fresh water habitats where no saline or brackish water is available. The species can be found throughout the year, but predominantly during the period March to December, with the greatest numbers in June to August. The species is a major pest, biting during the day and evening. It is often taken in light and CO_2 baited traps. It has also been taken in avian baited traps.

RELATION TO DISEASE

Ae camptorhynchus has been shown to be capable of supporting replication of both MVEv and RRv in the laboratory. It is unlikely that it has a role in the dissemination of MVEv in W.A., but circumstantial evidence strongly suggests a role for this species in the transmission of RRv. For example, the commencement of RRv transmission in southern W.A. coincides with high numbers of *Ae camptorhynchus,* well before the populations of the well known vectors of RRv *(Ae vigilax* and *Cx annulirostris)* reach significant levels. Indeed, the recent isolation of RRv from field caught *Ae camptorhynchus* in Victoria further suggests that this species may have a significant role in RRv transmission in southern Australia.

DISTRIBUTION

Albany, Aug 1956, EJB. Augusta, Oct 1974, PFSL. Avon River, Apr 1963, JBF. Bejoording, Jan 1951, CFHJ; Mar 1951. Beverley, Sep 1952, KN; Aug 1973, PFSL. Beverley, Myal Pool, Oct 1952, KN. Bolgart, Aug 1952, DG. Borden, Aug 1952, JB. Boyanup, Jun 1967, HEP. Brookton, Jun 1955, EJB. Bruce Rock, Jul 1956, EJB. Bunbury, May 1956, EJB; Jan-Dec 1985, AEW. Busselton, Sep 1952. Canning R., Apr 1963, JBF; Apr 1975, RH; Apr 1975, PFSL; Feb 1977, AB; Mar 1977, AB; Mar 1980, FWH. Canning R., Clontarf, Apr 1963, JBF. Canning R., Kent St. Weir, Apr 1963, JBF; Oct 1973, PFSL; Feb 1974, PFSL. Canning R., Manning, Jun 1979, AEW. Carbanup, Nov 1952, Ev. Carbellup, Feb 1952, Karrel. Carnamah, May 1955, EJB. Carnarvon, May 1984, JWOB; Jun 1980, AHCS. Cranbrook, Aug 1956, EJB. Cunderdin, Aug 1951, CFHJ. Denmark, Aug 1956, EJB. Dowerin, Jul 1956, EJB. Eaton, Sep 1974, PFSL. Esperance, Nov 1954, EPH; Aug 1956, EJB. Fitzgerald R., Dec 1970, KTR; Oct 1975. Fremantle, Jun 1955, EJB. Geraldton, Jul-Aug 1985, MEC. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Gnowangerup, Mar 1952, JAK; Jul 1956, EJB. Goomalling, May 1951, CFHJ; Jul 1951; Aug 1951, CFHJ; Jul 1955, EJB. Gordon R., HEP. Grass Valley, Sep 1953, JL. Hopetoun, May 1988, AEW. Irwin R., Aug 1954; Nov 1954, EPH. Jandakot, Oct 1974, PFSL. Jandakot, Russell Swamp, Apr 1974. Jerramungup, Oct 1974, PFSL; May 1988, AEW. Jurien Bay, Jul 1985, MEC. Karbonup, Oct 1952, Karel. Katanning, Aug 1956, EJB. Kellerberrin, Jul 1956, EJB. Kojonup, Nov 1951, Miles. Kybenup Centre, Oct 1952, Ka. Kybellup, Sep 1951, Cr; Oct 1952, Ka; Jan 1953, Ha. Lake Chandala, Aug 1980, AEW. Lake Clifton, Aug 1980, AEW. Lake Gwelup/Careniup Swamp, Nov 1982, JCT. Leschenault Inlet, 1986, AEW. Mandurah, Feb 1971, HEP; Apr 1971, CFHJ; Mar-Dec 1985, AEW. Manjimup, May 1956, EJB. Meckering, 1953, WJL. Moora, Jul 1953; Jun 1955, EJB. Moore R., Sep 1951, Cr. Morawa, May 1955, EJB. Murchison R., Apr 1985, MEC. Muresk, Jan 1953. Narrogin, Mar 1955, EJB. North Quellington, Oct 1953, BJL; Oct 1953, JL. Northam, 11km S., Sep 1973, PFSL. Northampton, May 1955, EJB. Peaceful Bay, HEP. Perth, HEP; Dec 1942, Ni; Nov 1943, FER; Jan 1948, CFHJ; Jul 1959, WRO; Sep 1963, TMR. Perth, Attadale, May 1953, EJB. Perth, Belmont, Jun 1955, EJB. Perth, Clontarf, Oct 1973, PFSL; Feb 1974, PFSL. Perth, Darlington, Jun 1954. Perth, Kings Park, Jul-Aug 1953, DLM; Sep 1965, LEK; Aug 1967, HEP. Perth, Maylands, Oct 1974, PFSL. Perth, Mt Lawley, May 1972, EA. Perth, Nedlands, Mar 1953, EPH; Oct-Dec 1971, SJM; Jan 1972, SJM; Mar 1972, SJM; Jun 1972, SJM; Sep-Nov 1972, SJM. Perth, Peppermint Grove, Oct 1976, AEW. Perth, Shenton Park, Aug 1953, DLM; Sep 1977, AEW. Perth, Wembley, Oct 1961, AD. Phillips R., Aug 1956, EJB. Picton, Nov 1952, DG. Plantagenet, EJB. Rockingham, Jun 1955, EJB. Rottnest, Jun 1979, AEW. Sandy Gully, Oct 1952, DG. Seabrook, Sep 1953, JL. Serpentine Falls, Feb 1951, CFHJ. Sussex, EJB. Swan River, Bennett's Brook, Apr 1963, JBF. Swan River, Crawley Bay, Aug 1978, SMP. Swan River, Pelican Point, Feb 1970, PNFF; Jun 1974, PFSL. Tambellup, Aug 1956, EJB. Wagin, Aug 1956, EJB. West Arthur, Mar 1955, EJB. Wongan Hills, Jun 1952, VK; Aug 1954, LN. Woodanilling, Aug 1956, EJB. Woodmans Point, Aug 1963, JBM. York, Oct 1953, JL; Jun 1955, EJB; Oct 1972, PFSL. York, 16km S, Aug 1973, PFSL. Yunderup, Sep 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

Once familiar with this species, it is not readily confused with other species, with the possible exception of *Ae sagax*.

Aedes (Ochlerotatus) clelandi (Taylor) 1914

Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond.*, 1913 : 690.
Type locality: Flinders I., Bass Strait (near Tasmania), Australia.
Synonymy: None.

ADULT FEMALE

A moderately sized species which is common in some areas of the south west. Head with pale yellow/white scales dorsally, pale fawn broad scales on side; upright forked scales numerous. Torus with dark scales dorsally. Clypeus bare. Palp dark; about 0.14x length of proboscis. Proboscis dark scaled, about 1.25x length of forefemur. Scutum with red/brown integument; scaling a mixture of narrow, curved bronze and some pale scales, pale around prescutellar space. Scutellum with discontinuous sparse narrow pale scaling on all lobes. Pleura with narrow dark scales on anterior pronotum and posterior pronotum; narrow pale scales on propleuron, subspiracular area, and postspiracular area; broad pale scale patches on upper and posterior sternopleuron, anterior and posterior mesepimeron and prealar area; 7 postspiracular bristles. Abdomen with tergites dark with white basal lateral triangular patches extended to midline on segments III-VI forming a narrow basal band; segment VIII narrow and withdrawn; sternites pale; cerci dark. Hindleg with femur dark above, pale below on basal 0.67; tibia dark; tarsi dark with very small white basal patches on tarsi II and III. Wing dark scaled. Haltere with pale stem; knob fawn to dark.

LARVA

Antenna dark, about 0.44x length of head; seta 1-A with 1-2 branches, inserted 0.53 from base; antenna with basal spicules. Head 0.75x as long as wide; about 0.85x width of thorax; seta 4-C with 3-4 branches; 5-C bifid; 6-C single; 7-C with 7 branches; 8-C and 9-C are bifid. Propleural groups: 1-P to 6-P all single; 7-P with 2-3 branches. Abdominal segment VIII with lateral comb having 22-25 fringed scales in triangular patch; seta 1-VIII with 5 branches; 2-VIII and 4-VIII single; 3-VIII with 8 pectinate branches; and 5- VIII with 5 pectinate branches. Siphon with small acus; siphon index about 2.1; about 2.05x length of saddle; seta 1-S a single pair of setae with 5 branches inserted at 0.56 from base; pecten with 23-25 toothed spines extending to midpoint of siphon. Anal segment with saddle forming a complete ring; seta 1-X single; 2-X with 8 branches; 3-X single; 4-X with about 7 pairs of tufts on grid; 1-2 precratal tufts. Anal papillae short, pointed; about 0.63x length of saddle.

BIOLOGY

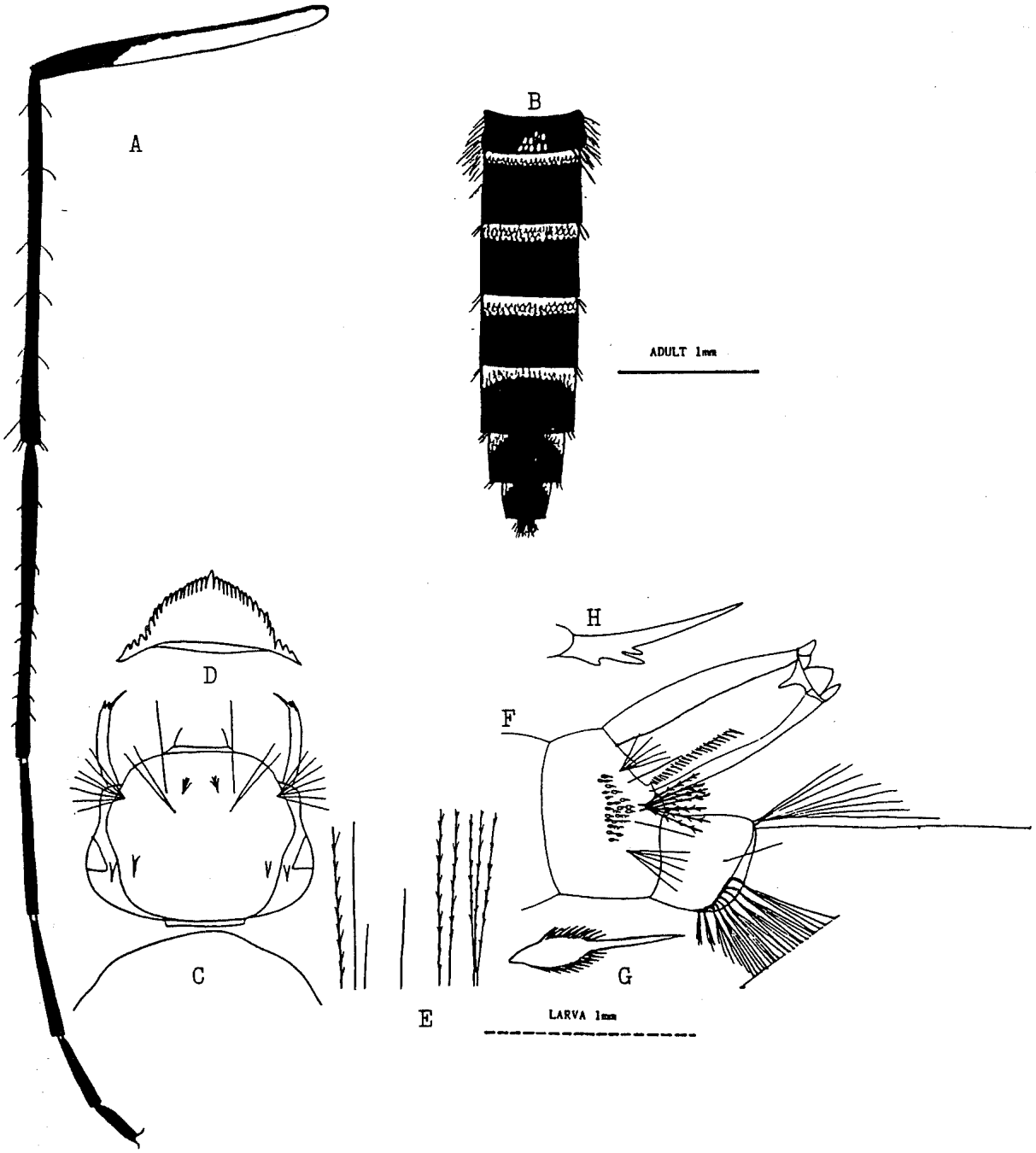
Larvae are found in open fresh clear water devoid of vegetation to pools with grass and algae, and flooded rabbit burrows. Adults are day biting, and will attack man. They are taken in CO_2 baited traps. Adults are generally found in April to October.

RELATION TO DISEASE

No known relation to human disease, and regarded as an unlikely vector of myxomatosis.

DISTRIBUTION

Albany, Aug 1956, EJB. Albany, Emu Park, DLM. Augusta, Oct 1974, PFSL. Bullsbrook, DLM; Sep 1980, AEW; Oct 1980, PFSL. Bunbury, Apr-Nov 1985, AEW. Canning R., Aug 1955, DLM. Cattamarra, Jul 1985, MEC. Chittering, Jul 1955, EJB. Dale R., DLM. Darkan, DLM; Nov 1952, DG. Denmark, Aug 1956, EJB. Eaton, Sep 1974, PFSL. Forrestdale, DLM. Gingin, Jul 1955, EJB. Gnangara, Aug 1955, DLM. Karagullen, EJB. Lake Chandala, Aug-Oct 1980, AEW. Lancelin, EJB. Leschenault Inlet, 1986, AEW. Mandurah, Apr-Oct 1985, AEW. Manjimup, May 1956, EJB. Moonijin Centre, Aug 1982, DG. Muchea, Sep 1980, AEW. Muchea, 7km N, Sep 1980, AEW. Narrogin, Dec 1951, DG. Perth, Armadale/Kelmscott, Jun 1955, EJB. Perth, Kewdale, FNR. Serpentine/Jarrahdale, Jun 1955, EJB. Swan R., Jun 1955, EJB. Williams, Dec 1951, Lu.



Aedes (Ochlerotatus) clelandi

A: Adult hindleg; B: Abdomen (dorsal); C: Larval head (dorsal); D: Mentum; E: Prothoracic setae 1-P to 7-P (shoulder hairs); F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

SPECIES WITH WHICH IT MAY BE CONFUSED

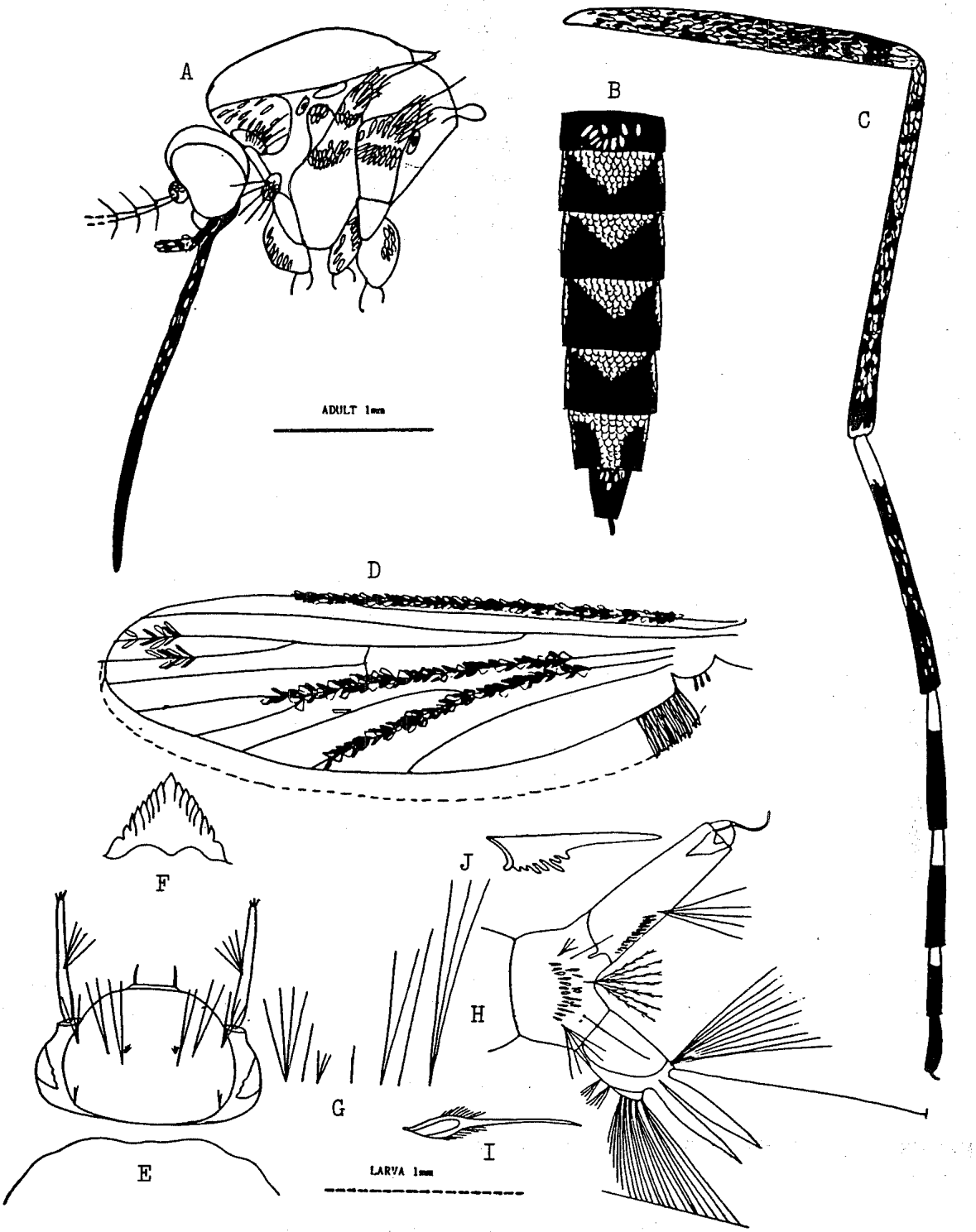
None.

Aedes (Ochlerotatus) eidsvoldensis Mackerras 1927

Mackerras, I.M., 1927. *Proc. Linn. Soc. N.S.W., 52:* 295.
Type locality: Eidsvold, Queensland.
Synonymy: None.

ADULT FEMALE

A medium to large species generally found in the warmer, arid regions of the State. Head with narrow golden decumbent scales medially on vertex; broad pale and dark scales on sides; upright forked scales numerous. Torus with broad pale scaling dorsally. Palp dark with small white patches at apex of segments III and IV; about 0.125x length of proboscis. Proboscis dark, slightly mottled near base, pale below on basal 0.67; slightly longer than forefemur. Scutum with admixture of bronzy and golden scaling; pale above wing



Aedes (Ochlerotatus) eidsvoldensis

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

root and around prescutellar space. Scutellum with narrow pale scales on all lobes. Pleura with upper portion densely covered in broad shaggy yellowish scales. Abdomen with tergites dark, pale basal median triangular patches and lateral basal patches; sternites mottled. Hindleg with femur and tibia mottled, femur with small ochre knee spot; tarsi I to IV with narrow basal bands, V dark. Wings extensively mottled with pale and dark scales on all veins.

LARVA

Antenna slightly darker at tip; about 0.77x length of head; seta 1-A with 5 branches, inserted at 0.53 from base; antenna spiculate near base. Head 0.58x as long as wide; about 0.8x width of thorax; clypeal spines are sharp, stout, forward projecting spines; seta 4-C with 4 branches; 5-C and 6-C bifid; 7-C with 2-3 branches. Prothoracic setae: 1-P with 3-4 branches; 2-P single; 3-P with 3 branches; 4-P single; 5-P bifid; 6-P single; 7-P with 3 branches. Abdominal segment VIII with lateral comb of about 20 fringed scales in irregular triangular patch; seta 1-VIII with 3-4 short branches; 2-VIII and 4- VIII single; 3-VIII with 7 pectinate branches; 5-VIII with 3-5 branches. Siphon slightly tapering with small acus; siphon index about 3.16; siphon about 2.1x length of saddle; seta 1-S a single pair of setae with 5 branches inserted at 0.4 from base; pecten with about 14 broad denticulate spines to 0.32 from base of siphon; valve hairs at apex of siphon modified to strong hooks. Anal segment with saddle covering dorsal 0.75 of segment; seta 1-X single; 2-X with 10-12 branches; 3-X single; 4-X with 6 pairs of tufts on grid; 1-2 precratal tufts. Anal papillae long and pointed; about 1.4x length of saddle.

BIOLOGY

Larvae are found in ground pools of various sorts. Adults will bite man readily, and will take blood meals from a variety of mammals and birds. Adults are taken in light traps, animal baited traps, and in CO_2 baited traps. The species can be a pest in some arid areas when first rains following a dry spell occur.

RELATION TO DISEASE

This species may be capable of supporting replication of MVEv, but little is known of its vector potential.

DISTRIBUTION

Carnarvon, Jul 1964, LEK; May 1984, JWOB; Feb-Mar 1984, MEC*; Jun 1984, MEC*. Balgo Mission, Jun 1978, AEW; Mar 1981, AEW. Cherrabun, May 1979, AEW. Exmouth, Mar 1985, MEC. Karratha, Feb 1984, MEC*. Millstream, Apr 1971, DHC. Newman, Mar 1979, AEW; Mar 1981, PF. Port Hedland, Jun 1984, MEC; Oct 1984, MEC. Whim Creek, Jun 1984, MEC. (*: as *Ae theobaldi* – not confirmed by a recognised medical entomologist.)

SPECIES WITH WHICH IT MAY BE CONFUSED

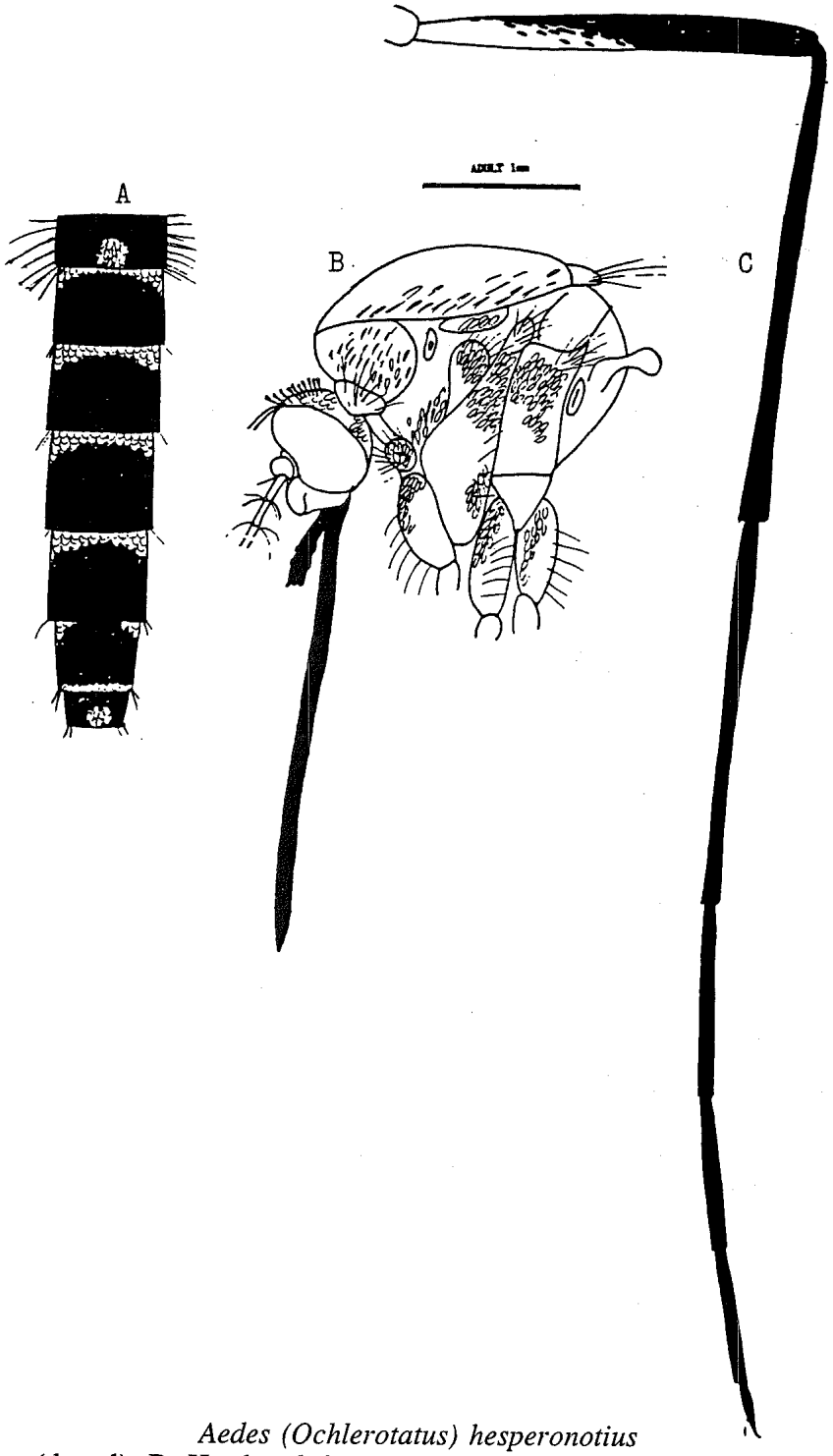
This species was originally described as a subspecies of *Ae theobaldi* (which is not known from W.A. at present), and closely resembles that species. In addition, the taxon *Ae eidsvoldensis* may contain more than one species, but more collections, particularly of males and linkbred series will be needed to resolve this.

Aedes (Ochlerotatus) hesperonotius Marks 1959

Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 131.
Type locality: 2 miles east of Bullsbrook, W.A.
Synonymy: None.

ADULT FEMALE

Head with narrow golden scaling on occiput and frons, some dark on vertex; broad flat yellowish scales on side; upright forked scales dark, numerous. Torus with a few narrow pale scales. Clypeus bare. Palps short, black; about 0.18x length of proboscis. Proboscis black; about 1.33x length of forefemur. Scutum with integument dark brown; scaling a sparse mixture of narrow bronze and black scales, paler scales above wing root and around prescutellar space. Scutellum with long narrow pale scales on all lobes. Pleura with brown integument; narrow pale scales on anterior pronotum; posterior pronotum with narrow pale scales below, dark above; dense, appressed pale scales on propleuron, subspiracular area, postspiracular area, upper and posterior sternopleuron, prealar area and anterior and upper mesepimeron; 5-7 postspiracular bristles. Abdomen with largely dark scaling with pale basal bands, extended laterally and sometimes broken in midline; sternites pale with dark median and apicolateral patches on posterior segments. Coxae with broad pale scales. Hindleg with femur dark, pale below on basal 0.5-0.67 anteriorly, pale to apex posteriorly; tibia dark; tarsi all dark. Wing dark scaled. Haltere palish stem, knob dark scaled.



Aedes (Ochlerotatus) hesperonotius
A: Adult abdomen (dorsal); B: Head and thorax (lateral); C: Hindleg.

LARVA

Not known.

BIOLOGY

Little is known of the biology of this species. Only adult females have been taken. The species appears to have only one generation each year, with adults appearing for a brief period in September/October. The adults have been taken in CO_2 baited traps. There is an undescribed larva taken in the same localities as adults which may be the larva of this species. Confirmation of any relationship must await the link breeding of larvae and adults. The larva is described briefly later in the manual, and reference is made to Ae *hesperonotius* in the discussion.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Bullsbrook, 3.5km NE, Aug 1953, DLM. Bullsbrook, 5km N, Aug 1954, DLM. Bunbury, Aug-Nov 1985, MEC. Dale River, 17km SW Beverly, Oct 1952, DLM. Leschenault Inlet, 1986, MEC. Mandurah, Sep-Oct 1985, MEC.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species resembles *Ae clelandi*, but can be separated most easily by the dark thoracic integument (*Ae clelandi* has a reddish thoracic integument).

Aedes (Ochlerotatus) hodgkini Marks 1959

Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 112.
Type locality: Woodanilling, north of Albany, W.A.
Synonymy: none.

ADULT FEMALE

Moderate sized species, restricted to the south west, fairly rare. Head with decumbent scales narrow and pale mesially, darker laterally with broad pale scales on side; upright forked scales numerous, not confined to occiput. Palp dark scaled; about 0.2x length of proboscis. Proboscis dark scaled; about 1.2x length of forefemur. Scutum with integument red/brown; broad irregular lateral stripe of yellow/white scaling with bronzy scaling between; paired submedian and dorsocentral pale stripes; some pale scales around prescutellar space. Scutellum with long narrow pale scales on all lobes. Pleura with brown integument; narrow pale scales on anterior and posterior pronotum; broad band of appressed pale scales running from propleuron, through subspiracular area, upper sternopleuron, prealar area, to upper mesepimeron; small patch of white scales on lower sternopleuron; 4 postspiracular bristles. Abdomen with tergites dark with pale basal bands extending into medial triangles on II-VI and with basolateral pale patches extending almost to apex; sternites pale with basal median and apicolateral dark patches. Coxae densely clothed in broad pale and dark scales. Hindleg with femur dark, with pale stripe on basal 0.67 and small white knee spot; tibia dark; tarsi unbanded. Wing dark scaled. Haltere pale brown.

LARVA

Antenna dark; about 0.5x length of head; seta 1-A with 6 branches, inserted at about 0.5 from base; antenna spiculate near base. Head 0.68x as long as wide; about 0.77x width of thorax; seta 4-C with 4 dendritic branches; 5-C with 3-4 branches; 6-C with 2-3 branches; 7-C with 6 branches; 8-C single; 9-C bifid. Abdominal segment VIII with lateral comb of about 21 stout spines in a triangular patch; setae 1-VIII and 5-VIII with 5 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 8 pectinate branches. Siphon with small acus, slightly tapering; siphon index about 2.53; siphon about 2.2x length of saddle; seta 1-S a single pair of setae with 4 pectinate branches inserted at 0.53 from base; pecten with 21-25 teeth with fine basal denticles, extending to 0.48 from base. Anal segment with saddle incomplete, covers dorsal 0.67 of segment; seta 1-X single and long; 2-X with 7-9 branches; 3-X single; 4-X with 7 pairs of tufts on grid; 1 precratal tuft. Anal papillae short, pointed; about 0.28x length of saddle.

BIOLOGY

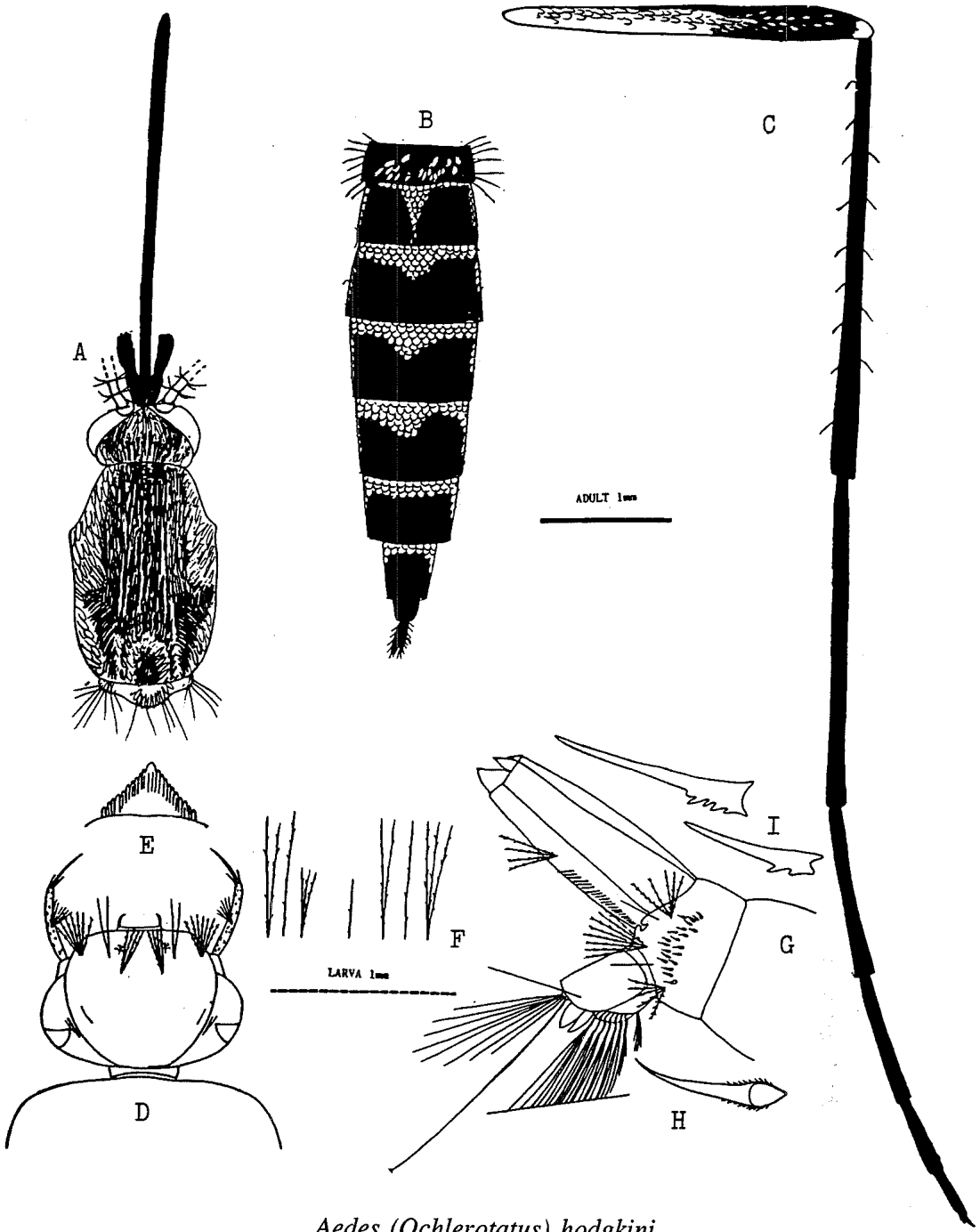
Larvae are found in fresh, clear grassy pools. This species is uncommon, and little is known of the adult biology. The species appears to have a restricted seasonal distribution, suggesting that it has only one generation per year.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Katanning, Oct 1952, GD. Manjimup, Oct 1931, Ma. Tambellup, Aug 1956, EJB. Woodanilling, Aug 1956, EJB.



Aedes (Ochlerotatus) hodgkini

A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail of basal and apical teeth).

SPECIES WITH WHICH IT MAY BE CONFUSED

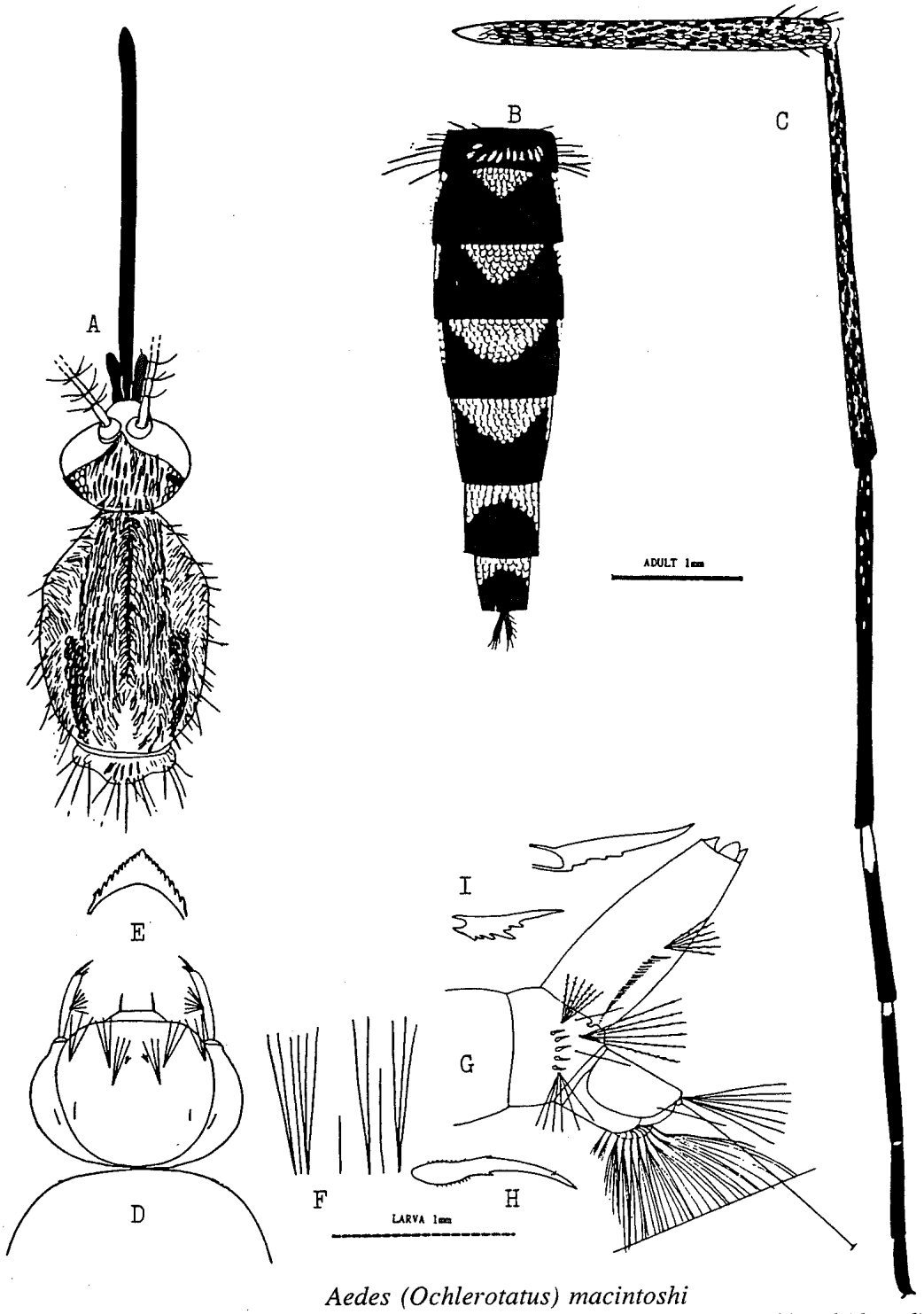
This species forms a part of a grouping of three species with similar thoracic patterning: *Ae hodgkini, Ae mackintoshi* and *Ae ratcliffei*. The characters in the key separate these species readily.

Aedes (Ochlerotatus) macintoshi Marks 1959

Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 117.
Type locality: Albany, W.A., Australia.
Synonymy: None.

ADULT FEMALE

This is a moderately large but uncommon species found in the south west of the State. Head with narrow pale decumbent scales mesially, a few dark behind the eye margin; upright forked scales pale, numerous. Torus with pale scales above, dark medially. Palp dark scaled; about 0.15x length of proboscis. Proboscis dark scaled; about 1.2x length of forefemur. Scutum with reddish brown integument; scaling with bronze medially, broad pale lateral bands; some golden scales on medial half of fossa and in narrow submedian lines and around prescutellar space. Scutellum with narrow pale scales on all lobes. Pleura with scattered pale scales on anterior pronotum and posterior pronotum; appressed broad pale scaling on



Aedes (Ochlerotatus) macintoshi

A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail of basal and apical teeth).

propleuron, subspiracular area, prealar area, upper sternopleuron and anterior mesepimeron; small patch of pale scales on posterior sternopleuron and postspiracular area; 6 postspiracular bristles. Abdomen with tergites dark scaled, with rounded median basal pale patches and lateral basal pale patches, broadest at base and reaching almost to apex of segment; sternites pale scaled with some basomedian and apicolateral dark patches. Coxae with patches of broad appressed pale scales. Hindleg with femur mottled, pale on basal 0.5 below; tibia mottled; tarsus I mottled, tarsi II-III with narrow pale basal band or patch.

LARVA

Antenna dark, about 0.46x length of head; seta 1-A with 6 branches, inserted at 0.45 from base; antenna with strong spicules. Head 0.7x as long as wide; about 0.8x width of thorax; setae 4-C, 5-C and 6-C all with 3 branches; 7-C with 6-7 branches; 8-C and 9-C single. Propleural groups as follows: 1-P bifid; 2-P single; 3-P with 2-3 branches; 4-P and 5-P bifid; 6-P single; 7-P with 2-3 branches. Abdominal segment VIII with lateral comb of 5 stout spines in row; setae 1-VIII and 3-VIII with 6 pectinate branches; 2-VIII and 4-VIII single; 5-VIII with 6 simple branches. Siphon finely spiculate and with acus; siphon index about 2.67; siphon about 2.4x length of saddle; seta 1-S a single pair of setae with 6 pectinate branches inserted at midpoint of siphon; pecten with 28-32 denticulate spines extending to 0.46 from base. Anal segment with saddle covering dorsal half of segment, covered in fine spicules; seta 1-X single; 2-X with 7 branches; 3-X single; 4-X with 8 pairs of tufts on grid and 2 precratal tufts. Anal papillae short, pointed, subequal; about 0.3x length of saddle.

BIOLOGY

Larvae are found in fresh, clear, open waters with shallow reeds and grass. The species is uncommon and little is known of the adult biology.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Albany, Aug 1956, EJB. Brookton, Jun 1955, EJB. Cranbrook, Aug 1956, EJB. Gingin, 1955, EJB. Lancelin, Sep 1956, MCU. Muchea, Jun 1956, EJB. Northam, Jun 1955, EJB. Perth, Kings Park, Jul 1953, DLM; Sep 1953, FNR; Oct 1953, DLM/FNR. Perth, Welshpool, Jul 1973, PFSL; Jul 1974, PFSL. Toodyay, Jun 1955, EJB. Woodanilling, Aug 1956, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species forms a part of a grouping of three species with similar thoracic patterning : *Ae hodgkini*, *Ae mackintoshi* and *Ae ratcliffei*. The characters used in the key separate these species readily.

Aedes (Ochlerotatus) nigrithorax (Macquart) 1847

Macquart, J., 1847. *Dipt. Exot.*, Suppl. 2: 9, 25.
Type locality: Tasmania, Australia.
Synonymy: *Aedes macleayanus* Mackerras, I.M., 1927. *Proc. Linn. Soc. N.S.W., 52:* 291.

Ae nigrithorax is included in the keys as a single female collected by N.V. Dobrotworsky near Pemberton was confirmed by Dr E.N. Marks as conforming to the description of this species. In addition, a series of specimens were collected by Tony Wright near Ravensthorpe which key to *Ae nigrithorax*. I have not seen any of these specimens. The following descriptions are taken from material from Victoria and New South Wales. Any specimen which keys out to *Ae nigrithorax* should be referred to a medical entomologist for confirmation.

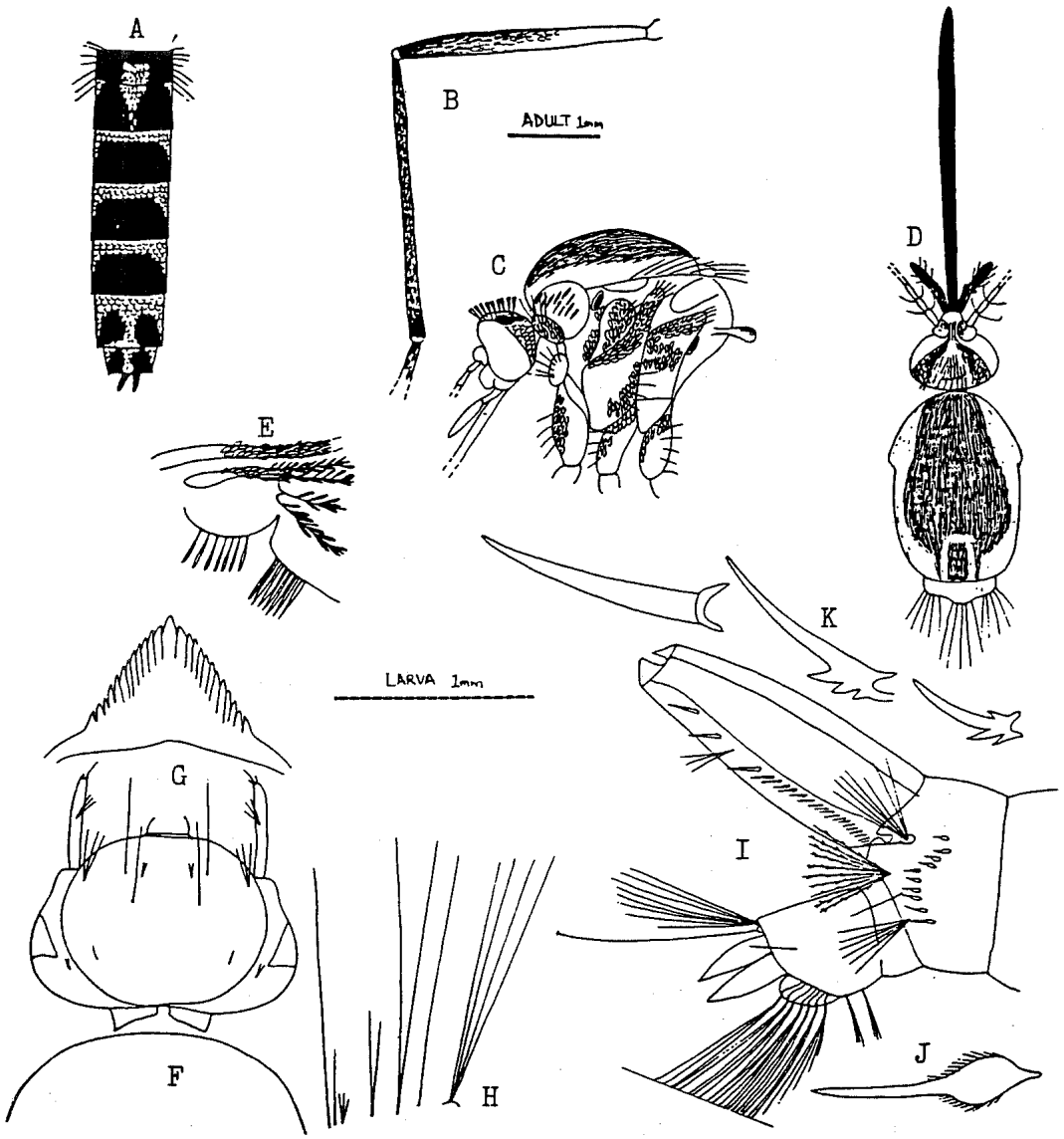
ADULT FEMALE

Ae nigrithorax is a medium sized species with dense scaling on the lateral thorax, and broad pale lateral margins to the scutum. Head with decumbent scales narrow on vertex, white medially to yellow laterally; broad flat white scales on side of head; pale upright forked scales numerous. Clypeus bare. Torus with small white scales. Palp about 0.2x length of proboscis, dark with a few pale scales at apex of palp segment III. Proboscis dark scaled, about 1.5x length of forefemur. Scutum with black integument, clothed with narrow bronze scales medially with broad lateral margin of narrow white and golden scales, white scaling around prescutellar space. Scutellum with long narrow white scales on all three lobes. Pleura with integument dark

brown; anterior pronotum and posterior pronotum with long narrow scales, bronze/golden above and pale below (shaggy in appearance); very dense appressed white scales on propleuron, hypostigial patch, postspiracular area, subspiracular area, upper and posterior sternopleuron, anterior, upper and lower mesepimeron, prealar area and paratergite; 4 lower mesepimeral bristles; 7 postspiracular bristles. Abdomen with tergites brown scaled with narrow creamy yellow basal bands and broad lateral basal patches; tergite I with median apical patch contiguous with basal median patch on tergite II; tergites VI and VII with pale basal band extended in midline to apex of segment, and with some apical pale scales; sternites white scaled. Hindfemora pale almost to apex; tibia mottled; tarsi unbanded, but hind tarsus I mottled on basal half. Wing dark scaled, with a few pale scales at the very base of costa and radius. Haltere with pale brown stem; club with pale white and brown scales.

LARVA

Antenna dark brown, slightly less than 0.5x length of head; seta 1-A with 3 branches, arising at 0.4 from base. Head about 0.6x as long as broad, about 0.83x as wide as thorax; seta 4-C with 1-2 branches; 5-C and 6-C single, long; 7-C with 3-4 branches; 8-C single and 9-C with 2 branches. Propleural setae 1-P single long; 2-P single, short; 3-P with 2-3 short branches; 4-P with 2 short branches; 5-P with 2 long branches; 6-P



Aedes (Ochlerotatus) nigrithorax

A: Adult abdomen (dorsal); B: Hindfemur and tibia; C: Head and thorax (lateral); D: Head and thorax (dorsal); E: Wing (detail of pale scales on base of costa and radius); F: Larval head (dorsal); G: Mentum; H: Prothoracic setae 1-P to 7-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); K: Pecten teeth (detail of basal, mid and apical teeth).

single, long; 7-P with 4 long branches. Abdominal segment VIII with lateral comb of 10-11 spines with narrow basal fringe in a single row; seta 1-VIII with 5-7 branches; 2-VIII and 4-VIII single; 3-VIII with 10-12 branches; 5-VIII with 5-8 branches. Siphon index about 2.75 or more; siphon about 2.4x length of saddle; seta 1-S with 3-4 branches inserted at around 0.6 from base; pecten with 20-25 spines on basal 0.8 of siphon, basal teeth as toothed spines, apical as simple spines, last 1-2 teeth more widely spaced and apical of seta 1-S. Anal segment with saddle covering dorsal 0.87 of segment; seta 1-X single; 2-X with 9-10 branches; 3-X single, long; 4-X with 7 pairs if tufts on grid; 1-2 precratal tufts. Anal papillae long and pointed, about 0.7x length of saddle.

BIOLOGY

Ae nigrithorax breeds in open, sunlit shallow pools with decaying leaves, occasionally in deeper pools and swamps. The species breeds in pools filled by winter rains and generally has one generation per year. However, late rains may allow a second generation in some years. Adults appear in September but may extend to October. Adults are day biting but are not greatly attracted to man. However, they may be a pest near to breeding areas.

RELATION TO DISEASE

No information available.

DISTRIBUTION

Pemberton, 1965, NVD. Ravensthorpe, May 1988, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

Ae nigrithorax adults are fairly easily distinguished by the scutal markings. The larva is not distinguishable from that of *Ae sagax.*

Aedes (Ochlerotatus) normanensis (Taylor) 1915

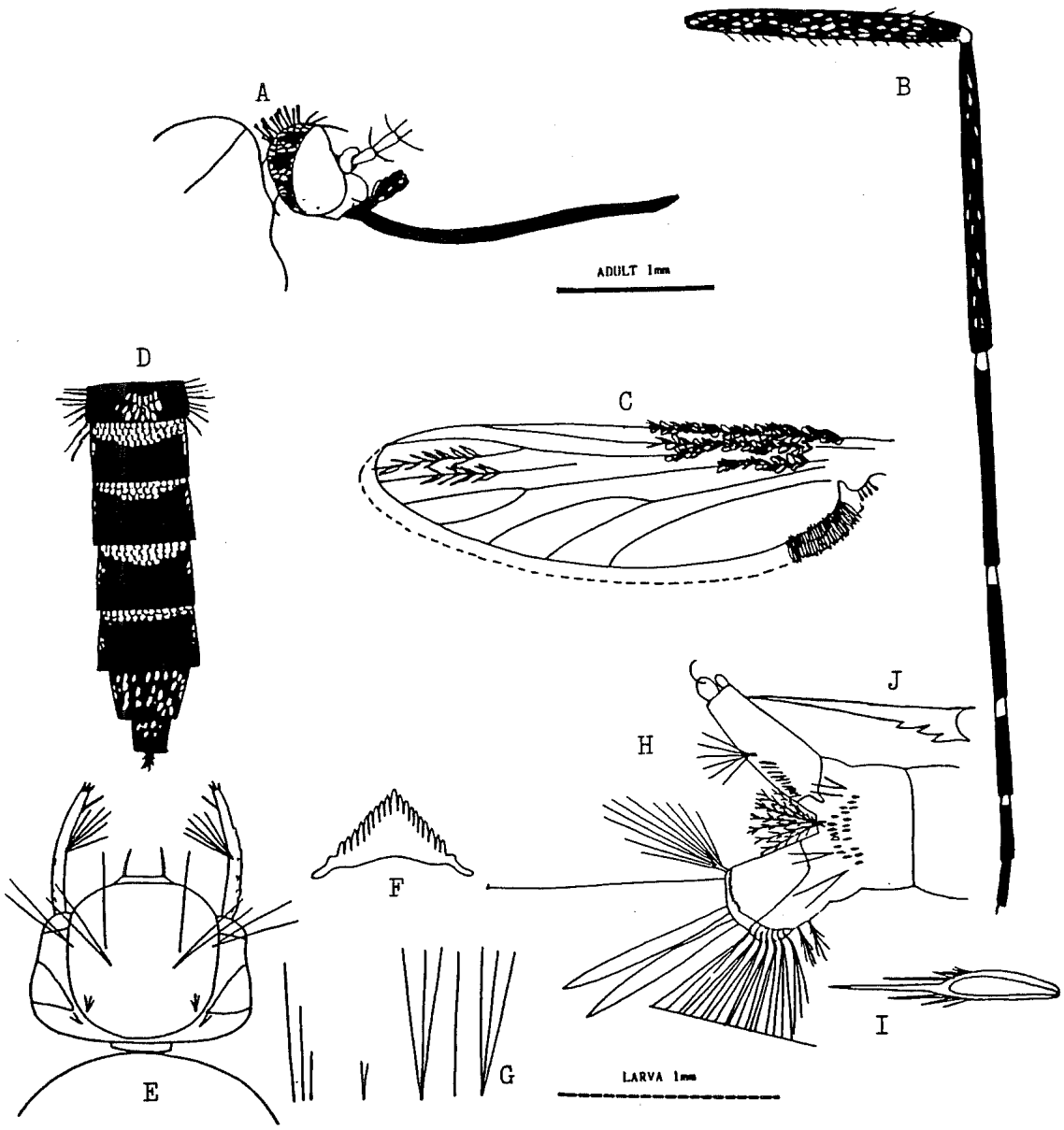
Taylor, F.H., 1915. *Proc. Linn. Soc. N.S.W., 40:* 182.
Type locality: Normanton, Queensland, Australia.
Synonymy: None.

ADULT FEMALE

A medium sized species which is seasonally very common in the moderately dry areas of the tropics and subtropics. Head with narrow dark scales on eye border, pale behind and on occiput; broad pale scales with brown band on side of head; upright forked scales dark, numerous. Torus dark scaled. Clypeus bare. Scutum with brown integument; clothed in bronzy narrow scales, some pale scales around prescutellar space. Scutellum sparsely covered with narrow pale scales on all lobes. Pleura with brown integument; pale narrow scales on anterior and posterior pronotum, propleuron, subspiracular area, postspiracular area and paratergite; broad appressed pale scales on upper and posterior sternopleuron, anterior and posterior mesepimeron and lower prealar area; 4 postspiracular bristles. Abdominal tergites dark with pale basal bands on II-V sometimes constricted laterally separating lateral patches, tergite VI mottled with lateral basal pale patches, VII dark, VIII withdrawn; sternites dark scaled with narrow basal pale bands; cerci dark. Coxae with broad pale and dark scales. Hindleg with femur mottled; tibia dark; tarsi dark with narrow basal pale bands on I-IV, V dark. Wing dark with sparse mottling on costa, subcosta and radius 1. Haltere with pale stem, pale scaling on club.

LARVA

Antenna brown, darker at tip; about 0.66x length of head; seta 1-A with 5 branches, inserted at 0.58 from base; antenna strongly spiculate. Head 0.67x as long as wide; about 0.71x width of thorax; seta 4-C with 4-9 very small branches; 5-C bifid; 6-C single; 7-C bifid; 8-C with 3 branches; 9-C with 2 branches. Prothoracic setae as follows: 1-P, 2-P and 3-P all single; 4-P with 1-2 branches; 5-P with 3 branches; 6-P single; 7-P with 3 branches. Abdominal segment VIII with lateral comb of 20+ fringed scales in roughly triangular patch, 2-3 scales deep; setae 1-VIII bifid; 2-VIII single; 3-VIII with 7 pectinate branches; 4-VIII bifid; 5-VIII with 2-3 branches. Siphon with acus, valve hairs modified into hooks; siphon index about 3.0; siphon about 1.8x length of saddle; seta 1-S a single pair of 6 branched setae inserted at 0.47 from base; pecten with 11 basal denticulate spines reaching to 0.33 from base. Anal segment with saddle covering dorsal half of segment; seta 1-X single; 2-X with 10 branches; 3-X single; 4-X with 7 pairs of tufts on grid and 1-2 precratal tufts. Anal papillae long and pointed; about 2.0x length of saddle.



Aedes (Ochlerotatus) normanensis

A: Adult head (dorsal); B: Hindleg; C: Wing (detail of scaling on some veins shown); D: Abdomen (dorsal); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

BIOLOGY

This northern species breeds in a variety of fresh water breeding sites, ranging from temporary ground pools, animal foot prints, to large temporary swamps. Breeding sites may be open, sunlit, partially shaded, clear or discoloured, muddy or polluted. The time from hatching to emergence may be as little as 8 days. Adults bite man during the day and evening, and will bite a range of mammals and birds. The species is often taken in light and CO_2 baited traps, and has been taken in animal and bird baited traps. The species is found throughout the year, depending on local conditions, and population resurgences are seen following sporadic rainfall, particularly in the early wet season. It is most abundant in the early and late wet seasons.

RELATION TO DISEASE

This species has yielded a number of arboviruses, including a series of isolates of MVEv and RRV from collections made in the Ord valley of W.A.. The species is under investigation as to its possible role in the maintenance of this virus.

DISTRIBUTION

Balgo Mission, Jun 1978, AEW; Jul 1978, AEW; Mar 1981, AEW. Billiluna, Mar 1981, AEW. Camballin, May 1979, AEW; Aug 1979, AEW. Cherrabun, May 1979, AEW. De Grey R. Crossing, Jun 1978, AEW. De Grey Station Rd, Jun 1978, AEW; Mar 1979, AEW. Derby, Mar-Apr 1977, AEW; Mar 1985, AEW. Fitzroy R., Mar-Apr 1977, AEW. Forest R. Mission, Oct 1950, EJB. Fossil Downs, Nov 1953, RL. Gibb R. Rd, 22km, Apr 1977, AEW. Goose Hill, Mar 1952, RL. Kalumburu, Mar 1954, EPH/EJB; Jul 1978, AEW. Karratha, Jun 1980, MW/TH; Sep 1980, MW/TH. Kimberly Downs Station, Mar 1954, EPH/EJB; May 1979, AEW. Kununurra, Dec 1972, PFSL; Apr 1973, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Oct 1976, AEW; Apr-May 1977, AEW; Nov 1977, AEW; Jul 1978, PFSL/AEW; Feb-Mar 1982, AEW; Apr-May 1982, AEW; Nov-Dec 1982, AEW; Jan-Mar 1983, AEW; May 1983, AEW; Nov-Dec 1983, AEW; Jan-Mar 1984, AEW. Lake Argyle, Dec 1972, PFSL; Mar-May 1982, AEW; Nov-Dec 1982, AEW; Jan-Feb 1983, AEW; May 1983, AEW; Nov 1983, AEW; Jan-Feb 1984, AEW. Lake Argyle, NE, Jul 1978, PFSL/AEW. Lake Argyle, SW, Jul 1978, PFSL/AEW. Lissadell, Jul 1978, PFSL/AEW. Louisa Downs, May 1979, AEW. Meda, Apr 1977, AEW. Millstream Station, Jun 1954, EPH/EJB. Minnie River, Mar-Apr 1977, AEW. Munkayarra Pool, Apr 1977, AEW. Newman, Mar 1979, AEW; Mar 1981, PF. Ord River, Jul 1978, PFSL/AEW. Parry's Creek, Dec 1972, PFSL; Apr 1973, PFSL; Jul 1978, AEW; Feb-Mar 1982, AEW; Jun-Jul 1982, AEW; Sep 1982, AEW; Nov-Dec 1982, AEW; Jan-Mar 1983, AEW; Jun 1983, AEW; Nov-Dec 1983, AEW; Jan-Feb 1984, AEW. Peedamulla Creek, Jun 1955, EJB. Pt.Hedland, Jan-Feb 1980, BB. Roeborne, Jun 1954, EPH. Strelley River, Jun 1978, AEW. Strelley River Crossing, Mar 1979, AEW. Tom Price, Mar 1979, AEW; Aug 1980, AD. Wyndham, Mar 1982, AEW; Nov-Dec 1982, AEW; Jan-Feb 1983, AEW. Yarraloola, Jun 1955, EJB. Yeeda, Apr 1977, AEW. Yeeda, 5km N, Mar 1977, AEW. Yeeda, 20km N, Mar-Apr 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is part of a group of closely related species found in tropical Australia, all of which are quite similar morphologically. The species include *Ae normanensis, Ae pseudonormanensis,* and *Ae* ENM's sp. No.159. It is clear that these will cause some confusion for the novice attempting identification. Check with a medical entomologist for confirmation of your identification. The characters used in the key are those used by professional entomologists for discriminating between these species.

Aedes (Ochlerotatus) pseudonormanensis Marks 1949

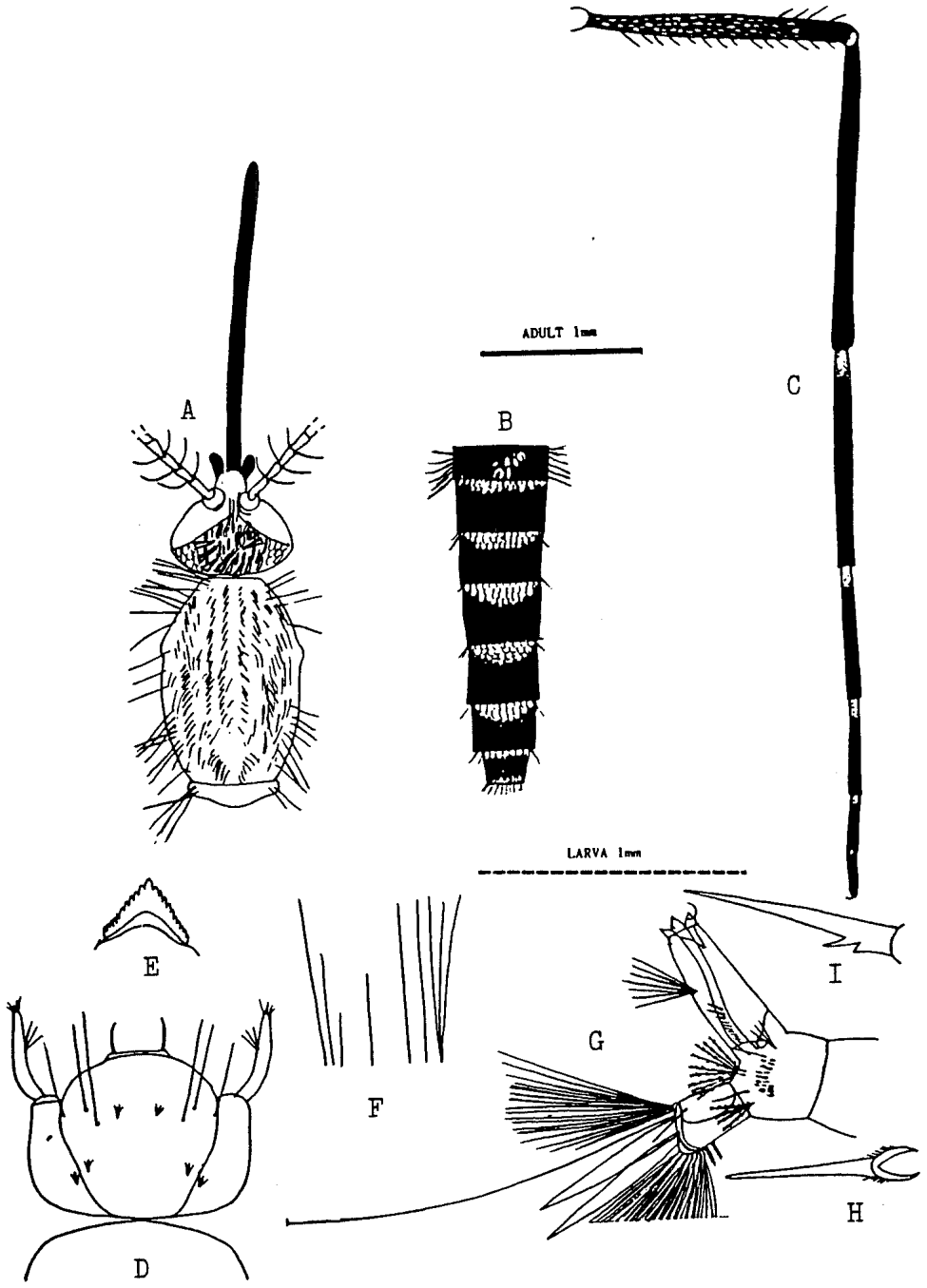
Marks, E.N., 1949. *Pap. Dep. Biol. Univ. Qld., 2 (11):* 26.
Type locality: Eidsvold, Queensland, Australia.
Synonymy: None.

ADULT FEMALE

This medium sized species is occasionally seen in the more arid portions of the tropics and subtropics. Head with narrow pale to golden scales on vertex, broad mottled appressed scales on sides; upright forked scales numerous. Torus dark scaled. Clypeus bare. Palp dark scaled and short; about 0.11x length of proboscis. Proboscis dark scaled; about 1.25x length of forefemur. Scutum with light brown integument, sparsely clothed in narrow golden scales. Scutellum with narrow golden scales on all lobes. Pleura with brown integument; broad pale appressed scales on anterior pronotum, posterior pronotum, propleuron, subspiracular area, postspiracular area, prealar area, upper and posterior sternopleuron, and anterior and posterior mesepimeron; some dark broad scales on posterior pronotum; 3 postspiracular bristles. Abdomen dark with pale basal bands on II-VI; sternites with broad pale basal band, darker apically, segment VIII small retracted; cerci dark. Coxae with broad pale scales. Hindleg with femur mottled, pale below on basal 0.67; tibia dark; tarsi dark with narrow basal bands on I-III, IV with small pale basal spot, V dark. Wing dark scaled with a few pale scales on base of subcosta and radius. Haltere pale with pale scaling on knob.

LARVA

Antenna same colour as head, about 0.58x its length.; seta 1-A with 3 branches inserted dorsally at midpoint; antenna spiculate. Head about 0.8x as long as wide; about 0.95x width of thorax; seta 4-C with 4-6 minute branches; 5-C to 7-C single; 8-C and 9-C with 3 branches. Abdominal segment VIII with lateral comb of about 20 spines with basolateral fringe in a triangular patch of 2-3 rows; seta 1-VIII with 3 branches; 2-VIII single; 3-VIII with 9 pectinate branches; 4-VIII single; 5-VIII with 4 pectinate branches. Siphon with small acus; seta 1-S a single pair of setae with about 7 branches, inserted at midpoint; pecten with 12-15 basally denticulate spines on basal 0.33 of siphon. Anal segment with saddle covering dorsal half of segment; seta 1-X single; 2-X with about 15 branches; 3-X single; 4-X with 7 pairs of tufts on grid and 2 precratal tufts. Anal papillae long, pointed; about 2x length of saddle.



Aedes (Ochlerotatus) pseudonormanensis

A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

BIOLOGY

Larvae have been found in rock holes, clear fresh ground pools, roadside drains, creek bed pools. Adults bite man readily during the day, and are attracted to feed by a variety of mammals, but not birds. Adults have been taken in light and CO_2 baited traps. This species is in greatest numbers following rains which fill such temporary breeding sites.

RELATION TO DISEASE

No direct evidence available, though several isolates of Mapputta group viruses have been made from pools containing a mixture of species including *Ae pseudonormanensis* collected in Queensland.

DISTRIBUTION

Ashburton, Jun 1955, EJB. Balgo Mission, Jun-Jul 1978, AEW; Mar 1981, AEW. Balgo Mission, 24km W, Mar 1981, AEW. Balgo Mission, Darbai R., Mar 1981, AEW. Billiluna, Sturt R. Crossing, Mar 1981, AEW. Derby, Apr 1951, EJB. Kalumburu, Mar 1954, EPH/EJB. Lake Argyle, Mar 1982, AEW. Marble Bar, 10km E, Mar 1979, AEW. Millstream, Jan 1975, PFSL. Millstream, Creek Summit Tanks, Jan 1975, PFSL. Millstream, Kanjieangie, Jun 1954, EPH. Millstream Station, Jun 1954, EPH/EJB. Newman, Mar 1979, AEW; Mar 1981, PF. Onslow, 1967, ENM/EPH. Roebourne, 1967, ENM/EPH; Apr 1979, AEW. Tom Price, Mar 1979, AEW. Whim Creek, Jun 1984, MEC. Woodstock, Jan 1955, EHME.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species looks superficially like *Ae normanensis,* but is separated by the scutal scaling. It also resembles *Ae* ENM's sp. No.159. See comments under *Ae normanensis.*

Aedes (Ochlerotatus) purpureifemur Marks 1959

Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 132.
Type locality: Forrestdale, 15 miles south-east of Perth, W.A.
Synonymy: none.

ADULT FEMALE

(Not seen for this manual, the description here is adapted from Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 132.) This is a very rare species known only from the type specimen. *Ae purpureifemur* is a fairly large species with dark wings and distinctive hindfemora which are entirely dark anteriorly. Head with narrow curved white scales on nape extending between eyes dividing band of black narrow curved scales; flat white scales laterally with some dark; upright forked scales black. Torus with black scales mesially. Clypeus dark. Palp black scaled, about 0.17x length of proboscis. Proboscis black, about 1.3x length of forefemur. Scutum with reddish brown integument; scutal scaling a mixture of narrow curved golden and dark scales, with larger creamy scale patches above wing roots and around prescutellar space. Scutellum with narrow curved creamy scales. Pleura with brown integument; anterior pronotum with broad curved scales, dark above and pale below; posterior pronotum and propleuron with similar scaling to anterior pronotum; flat white scales on subspiracular area and postspiracular area, and a continuous patch of flat white scales below prealar area over upper sternopleuron and lower posterior sternopleuron, and patches on upper and middle mesepimeron which are almost confluent; 3-6 postspiracular bristles; 1 lower mesepimeral bristle. Abdomen with tergites purplish/black; tergite I with pale scales laterally; II to VII dark mesially with basal and apical pale patches on II-IV extending to complete lateral white border on V-VII; sternites dark with basal and apical lateral white patches which extend to complete lateral and apical white border on VI-VII; segment VIII narrow, retracted. Hindfemur dark scaled with purplish reflections anteriorly, pale streak posteriorly narrowing to apex; tibia dark; tarsi all dark. Wings dark scaled. Haltere with pale stem, dark and pale scales on knob.

LARVA

Not known.

BIOLOGY

No information.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

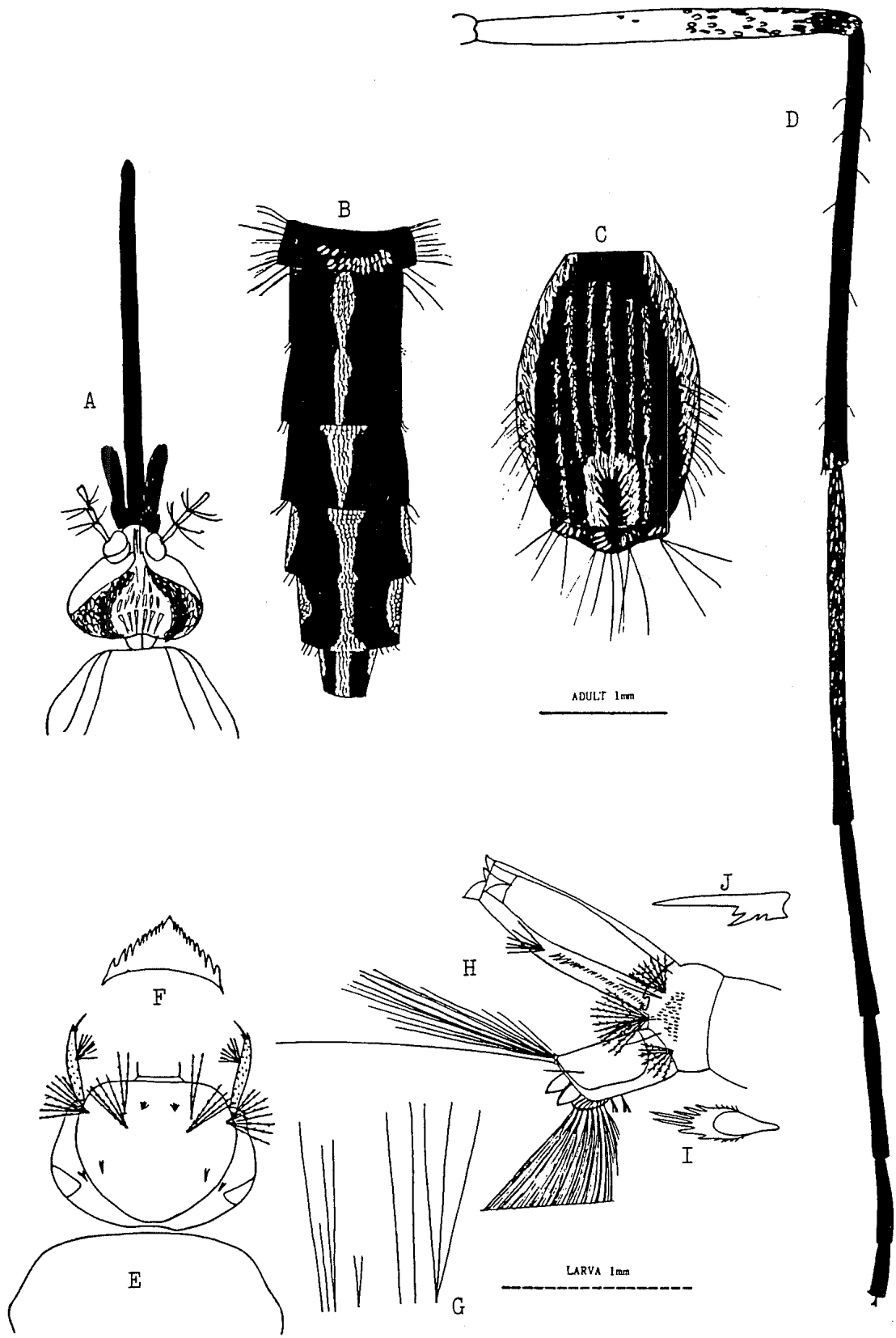
Forrestdale, Sep 1953, DLM.

SPECIES WITH WHICH IT MAY BE CONFUSED

The hind femur of this species is unique among Australian *Aedes (Ochlerotatus)* species. If you identify a specimen as being this species, it should be referred to a medical entomologist for confirmation.

Aedes (Ochlerotatus) ratcliffei Marks 1959

Marks, E.N., 1959. *Pap. Dep. Ent. Univ. Qld., 1:* 123.
Type locality: Gnangara, 12 miles north of Perth, W.A.
Synonymy: none.



Aedes (Ochlerotatus) ratcliffei

A: Adult head (dorsal); B: Abdomen (dorsal); C: Thorax (dorsal); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

ADULT FEMALE

This species is medium sized and is frequently collected in the south west of W.A. Head with narrow pale scales along eye border, darker behind with wide patches of narrow pale scales from occiput to vertex; broad pale scales laterally; upright forked scales numerous. Torus with dark scales. Clypeus bare. Palp dark scaled with a few scattered pale scales; about 0.2x length of proboscis. Proboscis black; about 1.3x length of forefemur. Scutum with integument brown; broad creamy white lateral bands along whole length, dark mesially with some pale narrow bands above and around prescutellar space. Scutellum with patches of long creamy white scales on all lobes. Pleura with narrow creamy gold scales on anterior pronotum; narrow creamy white scales basally, dark mesially and gold apically on posterior pronotum; broad white scales on propleuron, subspiracular area, paratergite, upper and posterior sternopleuron, prealar area and anterior and posterior mesepimeron; 8 postspiracular bristles. Abdomen with tergites dark with median pale patches extended from base to apex of segment forming a longitudinal median pale stripe on abdomen, and lateral basal pale patches almost reaching apex of segment; sternites pale scaled. Coxae with densely appressed narrow pale scales. Hindleg with femur pale scaled with dark scales above and below on apical 0.33-0.25, ochre knee spot; tibia dark; tarsi dark with tarsus I having a few pale (bluish) scales basally. Wing dark scaled. Haltere clothed in pale scales.

LARVA

Antenna brown, same colour as head; about 0.47x length of head; seta 1-A with 9-10 branches, inserted at midpoint; antenna covered in spicules. Head 0.73x as long as wide; about 0.77x width of thorax; seta 4-C with 4 small branches; 5-C with 4 pectinate branches; 6-C pectinate and bifid; 7-C with 8 pectinate branches; 9-C with 1-2 branches; 9-C bifid. Propleural bristles as follows: 1-P and 2-P single; 3-P and 4-P bifid; 5-P and 6-P single; 7-P with 3 branches. Abdominal segment VIII with lateral comb of 35-55 apically denticulate scales forming a triangular patch; seta 1-VIII with 7 pectinate branches; 2-VIII bifid and simple; 3-VIII with 12 pectinate branches; 4-VIII single and simple; 5-VIII with 7 weakly pectinate branches. Siphon covered in fine spicules and with small acus; siphon index about 2.54; siphon about 2.44x length of saddle; seta 1-S a single pair of setae with 6-9 pectinate branches inserted just above midpoint; pecten with 25-29 toothed spines, with basal tooth larger than rest reaching to 0.5 of siphon. Anal segment with saddle incomplete, covering dorsal 0.67 of segment, covered in fine spicules; setae 1-X and 3-X single; 2-X with 13 branches; 4-X with 8 pairs of tufts on grid; 1 precratal tuft. Anal papillae short, pointed; about 0.2x length of saddle.

BIOLOGY

This species breeds in fresh ground pools, large or small, water discoloured or clear, with or without vegetation. The larvae occur during the winter, and adults emerge and are active in spring. It appears that the species has one generation in each year. The adults will enter light and CO_2 baited traps. Little is known of the adult biology. The species is generally active as adults in the August-October period, but is never very abundant. The species is widely distributed throughout the southwest corner of W.A.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

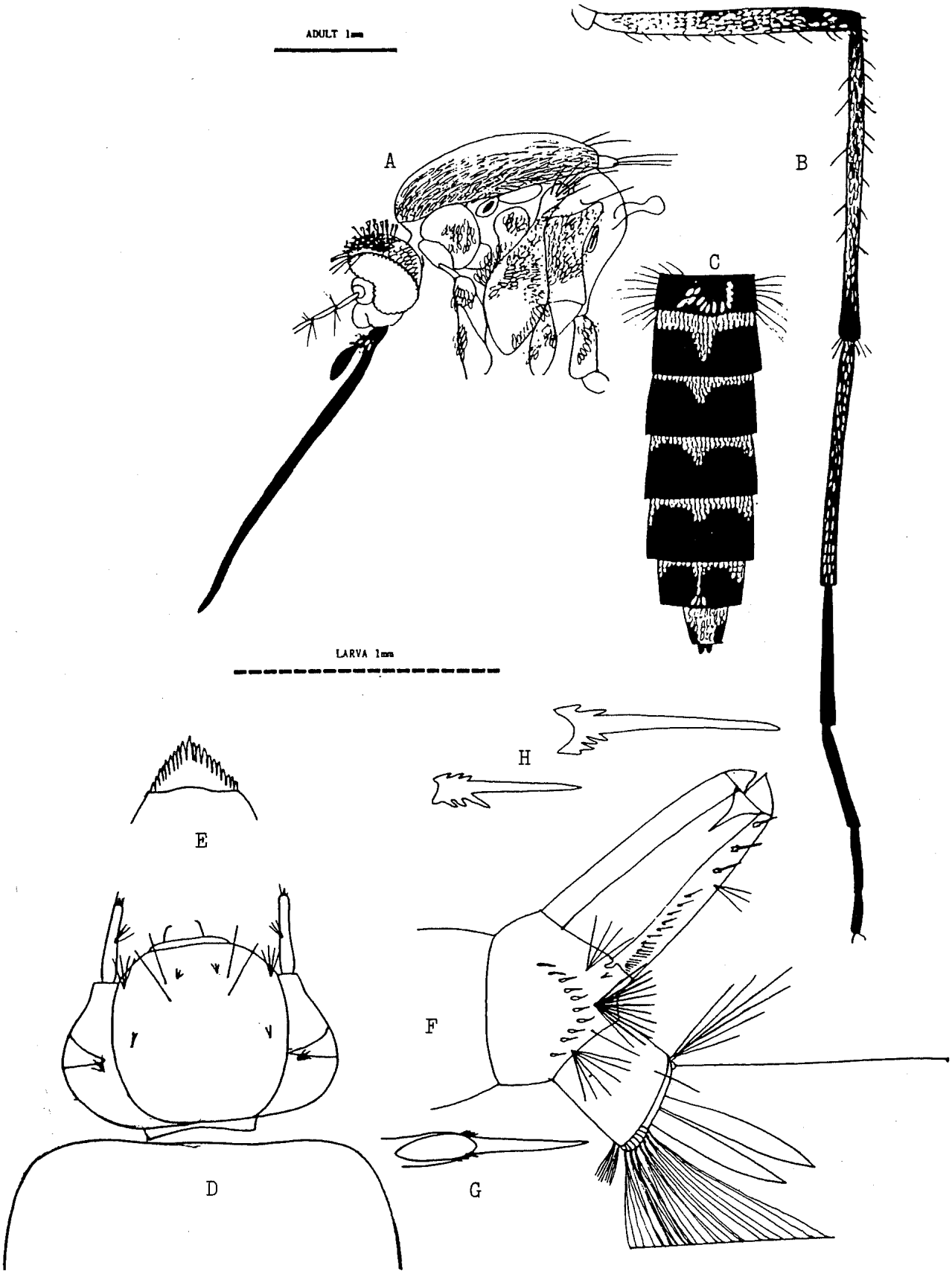
Albany, Nov 1938, AJT; Aug 1956, EJB. Augusta, Oct 1974, PFSL. Beverly, 32km SW, Oct 1952, DLM. Bullsbrook, Sep 1980, AEW; Oct 1980, PFSL. Cattamarra, Jul 1985, MEC. Bunbury, Aug-Nov 1985, MEC. Denmark, Aug 1956, EJB. Forrestdale, Oct 1952, DLM; Sep 1953, DLM. Gingin, Jul 1955, EJB; 1958, EJB. Gleneagle, 11km SSE, Sep 1956, DLM. Gnangara, Oct 1954, FNR; Aug-Sep 1955, DLM; Aug 1956, DLM. Gnangara Pine Plantation, Oct 1954, EPH. Gnowangerup, 1958, EJB. Jarrahdale, 12km E, Sep 1956, DLM. Lake Chandala, Sep 1980, AEW; Oct 1980, PFSL. Lancelin Lake, Sep 1956, AMCU. Leschenault Inlet, 1986, AEW. Mandurah, Aug-Oct 1985, MEC. Manjimup, Sep 1943, AWW. Muchea, 4km N, Sep 1980, AEW. Peaceful Bay, HEP. Pemberton, Cascades, Nov 1975, KAS. Perth, City Beach, Oct 1953, JHC/DLM. Perth, Kings Park, Oct 1952, DLM; Oct 1953, DLM/FNR. Perth, Welshpool, Jul 1973, PFSL; Sep 1973, PFSL. Plantagenet, 1958, EJB. Yanchep National Park, Nov 1985, ALD.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species superficially resembles *Ae hodgkini* and *Ae mackintoshi*. The characters given in the keys will readily distinguish between these species.

Aedes (Ochlerotatus) sagax (Skuse) 1889

Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1744.
Type locality: Murrumbidgie, New South Wales, Australia.
Synonymy: *Culicada wilsoni* Taylor, F.H. 1919. *Proc. Linn. Soc. N.S.W., 43:* 1744.



Aedes (Ochlerotatus) sagax

A: Adult head and thorax (lateral); B: Hindleg; C: Abdomen (dorsal); D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail of basal and apical teeth).

ADULT FEMALE

This moderately large species is common in the southern half of W.A. Head with narrow pale scales on eye border, golden brown behind and white on occiput; broad pale scales on side of head; upright forked scales numerous. Torus with narrow white scales above. Clypeus bare. Palp dark with pale mottling at base; about 0.2x length of proboscis. Proboscis dark scaled. Scutum with integument black; clothed in long, narrow golden bronze scales; white patches above wing root and prescutellar space. Scutellum with narrow white scales on all three lobes. Pleura with integument brown; narrow pale scales on anterior and posterior pronotum, posterior pronotum with some brown scales mesially and dorsally; broad pale scales on posterior of the posterior pronotum, propleuron, subspiracular area, postspiracular area, paratergite, prealar area, upper and posterior sternopleuron, and anterior, upper and posterior mesepimeron; 4 postspiracular bristles. Abdomen with tergites dark scaled with scattered pale scales on tergite I; II-VII with pale basal bands extending medially to point; VII with some apical pale scales; VIII contracted within abdomen and not visible; sternites pale with small apicolateral dark patches. Coxae with appressed white scales. Hindleg with femur pale on basal 0.75, mottled above and dark at tip; tibia mottled; tarsi dark, tarsus I with some mottling. Wing dark scaled, a few pale scales on the base of subcosta and radius. Haltere pale with narrow pale scales on knob.

LARVA

Antenna same colour as head, about 0.36x its length; seta 1-A with 3 branches, inserted at 0.4 from base; antenna slightly swollen basally and covered in spicules. Head about 0.75x as long as wide; about 0.6x width of thorax; seta 4-C with 3 small fine branches; 5-C single or sometimes forked; 6-C single; 7- C with 4-6 branches; 8-C bifid; 9-C with 2-3 branches. Abdominal segment VIII with lateral comb of 8-12 strong spines with minute basal fringe forming a single row; seta 1-VIII with 4-5 branches; 2-VIII with 2 very small branches; 3-VIII with 12 branches; 4-VIII single; 5-VIII with 6 branches. Siphon with small acus; siphon index about 1.64; siphon about 2.2x length of saddle; seta 1-S a single pair of tufts with 3 branches inserted at midpoint of siphon; pecten with 16-18 teeth extending to tip of siphon, most forming a compact line of basally denticulate spines on basal half of siphon, but with 3 simple spines more widely separated on the dorsal half of the siphon. Anal segment with saddle forming complete ring; seta 1-X small single; 2-X with 6 branches; 3-X single; 4-X with 7 pairs of tufts on grid; 1-2 precratal tufts. Anal papillae long and pointed; about 1.4x length of saddle.

BIOLOGY

This species breeds in fresh clear to turbid temporary waters, roadside ditches, with or without vegetation. The adults appear in the spring/summer period, and larvae can be found through the winter. Adults will readily bite man, and have been implicated as major pests in arid areas following isolated rain storms. Adults are taken in light and CO_2 traps. Adults will also feed on domestic animals.

RELATION TO DISEASE

This species was discounted as a major vector for myxomatosis in south east Australia, and there is no evidence to suggest that the species is a vector of human disease.

DISTRIBUTION

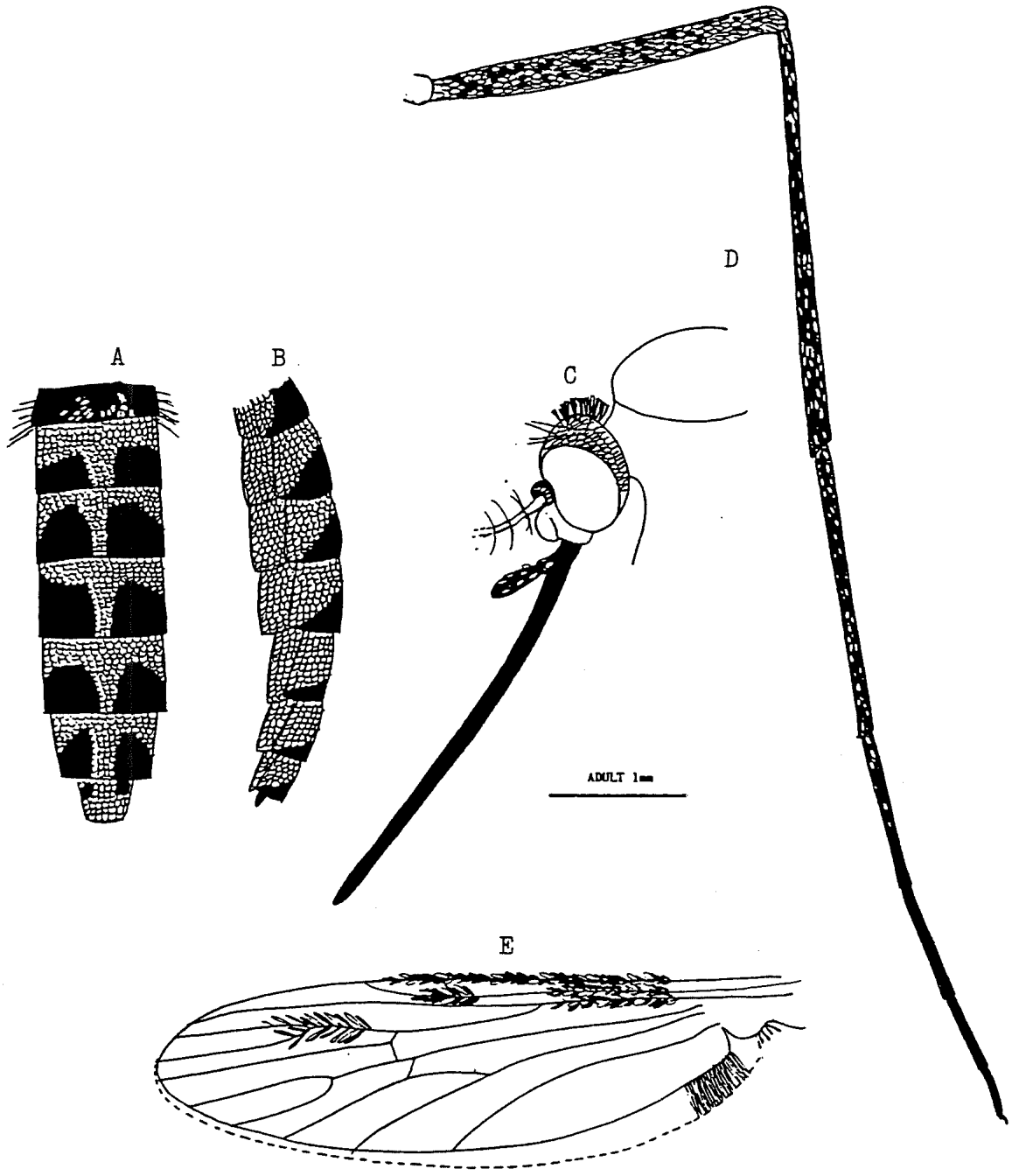
Albany, Aug 1956, EJB. Ashburton, Jun 1955, EJB. Boyup Brook, Sep 1974, PFSL. Brickhouse Mill, Jun 1985, MEC. Brookton, Jun 1955, EJB. Carnarvon, Jun 1984, MEC. Chittering, Jul 1955, EJB. Coolgardie, Aug 1956, EJB. Corrigin, Jun 1955, EJB. Cranbrook, Aug 1956, EJB. Dandaragan, Jul 1955, EJB. Dundas, Aug 1956, EJB. Esperance, Aug 1956, EJB. Esperence, 32km N, Aug 1964, GL. Gingin, Jul 1955, EJB. Gnowangerup, Jul 1956, EJB. Goomalling, Jul 1955, EJB. Harvey, Apr 1955, EJB. Irwin, May 1955, EJB. Jerramungup, Oct 1974, PFSL. Katanning, Aug 1956, EJB. Kellerberrin, Jul 1956, EJB. Kondinin, Mar 1955, EJB. Kununoppin/Trayning, Jul 1956, EJB. Lake Cronin, Sep 1978, TFH. Lake Grace, Mar 1955, EJB. Laverton, Aug 1956, EJB. Leonora, Jun 1956, EJB. Leschenault Inlet, 1986, AEW. Meckering, Sep 1952. Menzies, Jun 1956, EJB. Merredin, Jul 1956, EJB. Mingulla Village, May 1985, MEC. Moora, Jun 1955, EJB. Mullewa, May 1955, EJB. Narrogin, Mar 1955, EJB. Nyabing, Sep 1952, DLM. Perenjori, May 1955, EJB. Phillips R., Aug 1956, EJB. Tammin, Jul 1956, EJB. Westonia, 1943, CFHJ. Williams, Mar 1955, EJB. Wiluna, Jun 1956, EJB. Winning Pool, May 1955, EJB. Woodanilling, Aug 1956, EJB. Yilgarn, Aug 1956, EJB. York, Jun 1955, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is superficially like *Ae camptorhynchus,* but should be readily separated using the keys provided. *Ae nigrithorax* is closely related to *Ae sagax*, the larvae are indistinguishable, and adults are very similar except for the broad dark median stripe on the scutum of *Ae nigrithorax.*

Aedes (Ochlerotatus) sapiens Marks 1964

Marks, E.N., 1964. *Pap. Dep. Ent. Univ. Qld., 2:* 66.
Type locality: 20 miles north of Bourke, New South Wales, Australia.
Synonymy: None.



Aedes (Ochlerotatus) sapiens
A: Adult abdomen (dorsal); B: Abdomen (lateral); C: Head (lateral); D: Hindleg; E: Wing (detail of scaling on some veins shown).

ADULT FEMALE

This medium sized species is collected regularly in the Carnarvon area, and may occur elsewhere in the State. Head with decumbent scales narrow and pale medially, dark to side; sides of head clothed in broad pale scales; upright forked scales numerous. Torus with narrow pale scales. Palp dark with a few pale scales; about 0.2x length of proboscis. Proboscis dark scaled; slightly longer than forefemur. Scutum clothed in narrow dark and bronze scales; pale scales along anterior margin and fossa; yellow/brown scaling above wing root and prescutellar space. Scutellum with narrow pale scales on all lobes. Pleura with integument dark brown; elongate, shaggy pale scaling on anterior pronotum, propleuron, posterior pronotum, upper sternopleuron, and upper mesepimeron. Abdomen with tergites dark with basal lateral pale patches almost reaching apex and median basal triangular patches extended to apex with a few pale scales apically on II-VI; VII mottled; VIII contracted and not visible; sternites pale scaled. Coxae densely covered in pale and brown narrow scales. Hindleg with femur and tibia mottled; hind tarsus I mottled, basal mottling on hindtarsi II-III, IV-V dark. Wing extensively mottled on all veins.

LARVA

Not known.

BIOLOGY

Pupae collected from roadside pool. Adults occur as large plagues in arid zones following rain. They bite man readily during the day and at dusk. Adults are sometimes taken in CO_2 baited traps.

RELATION TO DISEASE

No information.

DISTRIBUTION

Carnarvon, May 1984, JWOB; Jun-Jul 1984, MEC. Exmouth, Mar 1985, MEC. No Tree Hill, Aug 1964, GL.

SPECIES WITH WHICH IT MAY BE CONFUSED

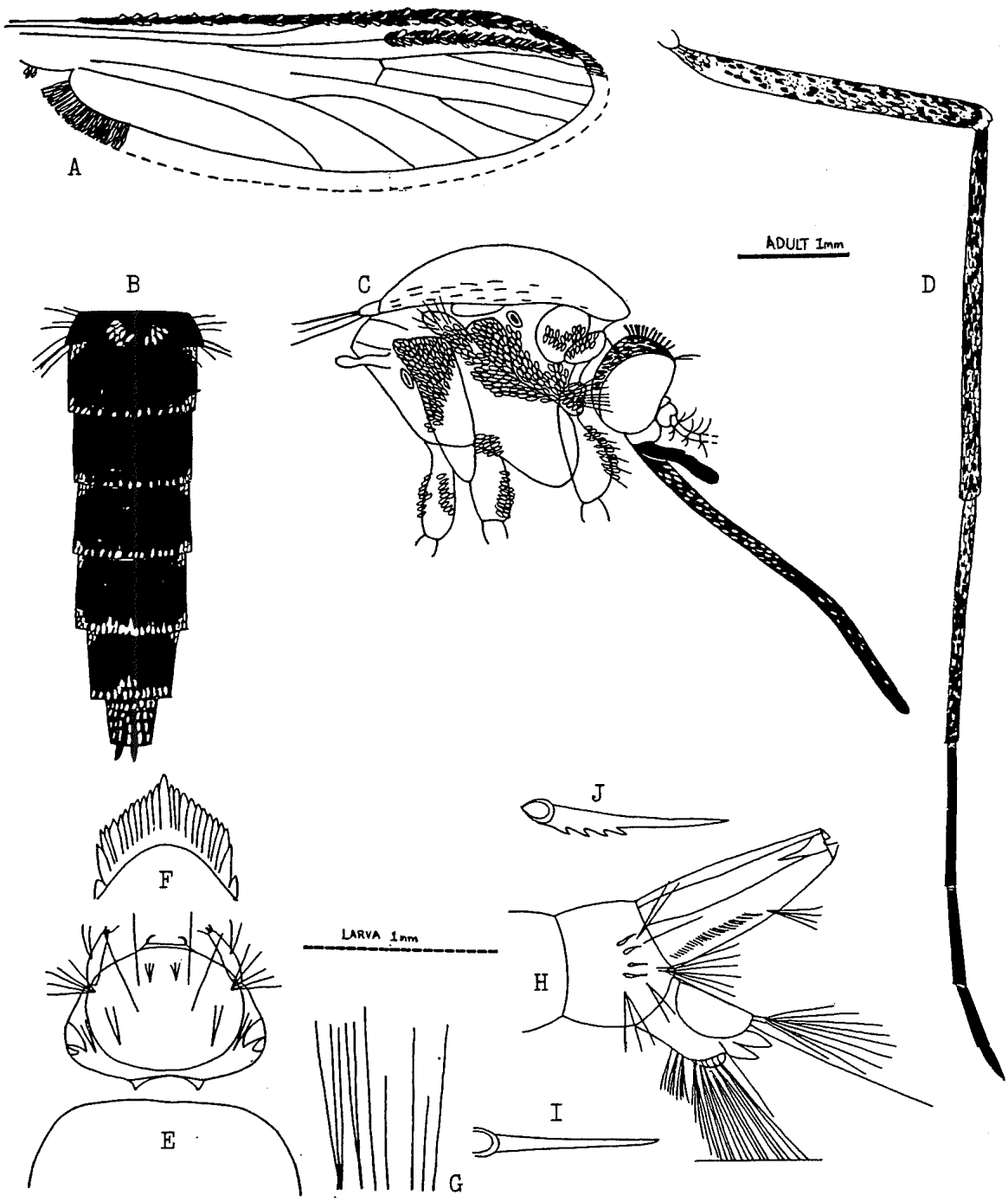
This species is separated from others by the characters used in the keys.

Aedes (Ochlerotatus) stricklandi (Edwards) 1912

Edwards, F.W., 1912. *Ann. Mag. Nat. Hist., 9:* 523.
Type locality: Serpentine, Darling Range, near Perth, W.A.
Synonymy: *Grabhamia australis* Strickland, E.H., 1911. *Entomologist, 44:* 133.
Grabhamia flindersi Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond., 1913 :* 686.

ADULT FEMALE

Moderately large species, which occurs in the south west of W.A.. It is not a dominant species, but is frequently collected in surveys. Head integument dark, decumbent scales narrow, dark on vertex, pale on occiput; upright forked scales numerous, dark. Torus dark scaled. Palp dark scaled; about 0.29x length of proboscis. Proboscis dark with a few scattered pale scales on basal 0.4; about 1.3x length of forefemur. Scutum with dark integument; clothed predominantly in dark narrow scales, some narrow pale scales on prescutellar space. Scutellum with a few narrow golden/white scales on all lobes. Pleura with narrow dark scales on upper portions of anterior and posterior pronotum; narrow pale scales basally with broad white scaling on lower 0.25 of posterior pronotum; appressed broad pale scaling in broad band on propleuron, subspiracular area, postspiracular area, upper sternopleuron, prealar area, upper to mid mesepimeron; a few pale scales on posterior sternopleuron; 2 postspiracular bristles. Abdomen with tergites dark scaled with a few mesial pale scales on tergite I; tergites II-VI with apical and basal lateral pale patches with a scattered row of pale scales along apical border; sternites mainly pale scaled with mottling of dark scales. Coxae with some pale scales. Hindleg with femur mostly pale with some dark mottling; tibia dark with some pale mottling; tarsi I-III dark and mottled with some pale scales at base, IV-V dark. Wing sparsely mottled with broad pale scales on all veins. Haltere pale brown with some pale scales on knob.



Aedes (Ochlerotatus) stricklandi

A: Adult wing (detail of scaling on some veins shown); B: Abdomen (dorsal); C: Head and thorax (lateral); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

LARVA

Antenna dark, about 0.52x length of head; seta 1-A bifid, inserted at 0.5 from base; antenna strongly spiculate. Head 0.63x as long as wide; about 0.75x width of thorax; seta 4-C with 2 small branches; 5-C and 6-C single, strong; 7-C with 5 pectinate branches; 8-C and 9-C bifid. Abdominal segment VIII with lateral comb of 4-5 strong simple spines in a single row; seta 1-VIII bifid; 2-VIII and 4-VIII with 3 branches; 3-VIII with 9-11 pectinate branches; 5-VIII with 5-7 pectinate branches. Siphon with fine spicules and a small acus; siphon index about 4.8; siphon about 1.95x length of saddle; seta 1-S single pair of tufts with 8

pectinate branches inserted at 0.45 from base; pecten with 36-40 teeth on basal half on siphon, pecten teeth with basal fringe of denticles. Anal segment with saddle complete and covered in fine spicules; setae 1-X and 3-X single; 2-X with about 14 branches; 4-X with 8 pairs of tufts on grid; 1 pre-cratal tuft. Anal papillae short and pointed; about 0.26x length of saddle.

BIOLOGY

Breeds in temporary fresh water ground pools in winter. The adults have been collected in the September to December period, and the species may have only one generation in each year. Adult females will attack man, and are taken in light and CO_2 baited traps. The adults of this species are collected in the September-October period, and larvae can be found in the preceding months.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Bunbury, Sep-Oct 1985, MEC. Busselton, Oct 1960, EJB. Kewdale, Oct 1952, NES. Leschenault Inlet, 1986, MEC. Mandurah, Sep-Oct 1985, MEC. Perth, Sep 1938, AJT. Perth, Kings Park, Oct 1953, DLM/FNR. Serpentine, Oct 1921, JBC.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species, once seen, is not readily confused with other species in the south west of the State. It has a resemblance to the rare species *Ae cacozelus*.

Aedes (Ochlerotatus) turneri Marks 1963

Marks, E.N., 1963. *J. Ent. Soc. Qld., 2:* 42.
Type locality: 4 miles W of Piawanning, (80 miles NNW of Perth), W.A.
Synonymy: None.

ADULT FEMALE

This moderately sized species appears in some spring collections in the south west of W.A. It has a characteristic ash grey/black colour which, once seen, is readily recognised. Head with decumbent scales narrow and dark, with some paler reflections on occiput; broad dark and light scales on side of head. Torus dark scaled. Palp dark with a few pale scales; about 0.29x length of proboscis. Proboscis dark, sparsely mottled with pale scales; about 1.5x length of forefemur. Scutum with dark integument; clothed in narrow dark scales with some pale scales around prescutellar space. Scutellum narrow pale scales and some dark scales on all lobes. Pleura with dark integument; narrow dark scales on anterior and posterior pronotum; dark and pale scales on propleuron; pale scaling on upper and posterior sternopleuron, prealar area and upper half of mesepimeron; 2 postspiracular bristles. Abdomen with tergites ash grey in colour, mottled with white scales and with apical and basal lateral pale patches; sternites mottled, pale with darker portions apicolaterally. Coxae with pale scales. Hindleg with femur and tibia mottled; tarsus I mottled, II-V dark. Wing sparsely mottled on all veins.

LARVA

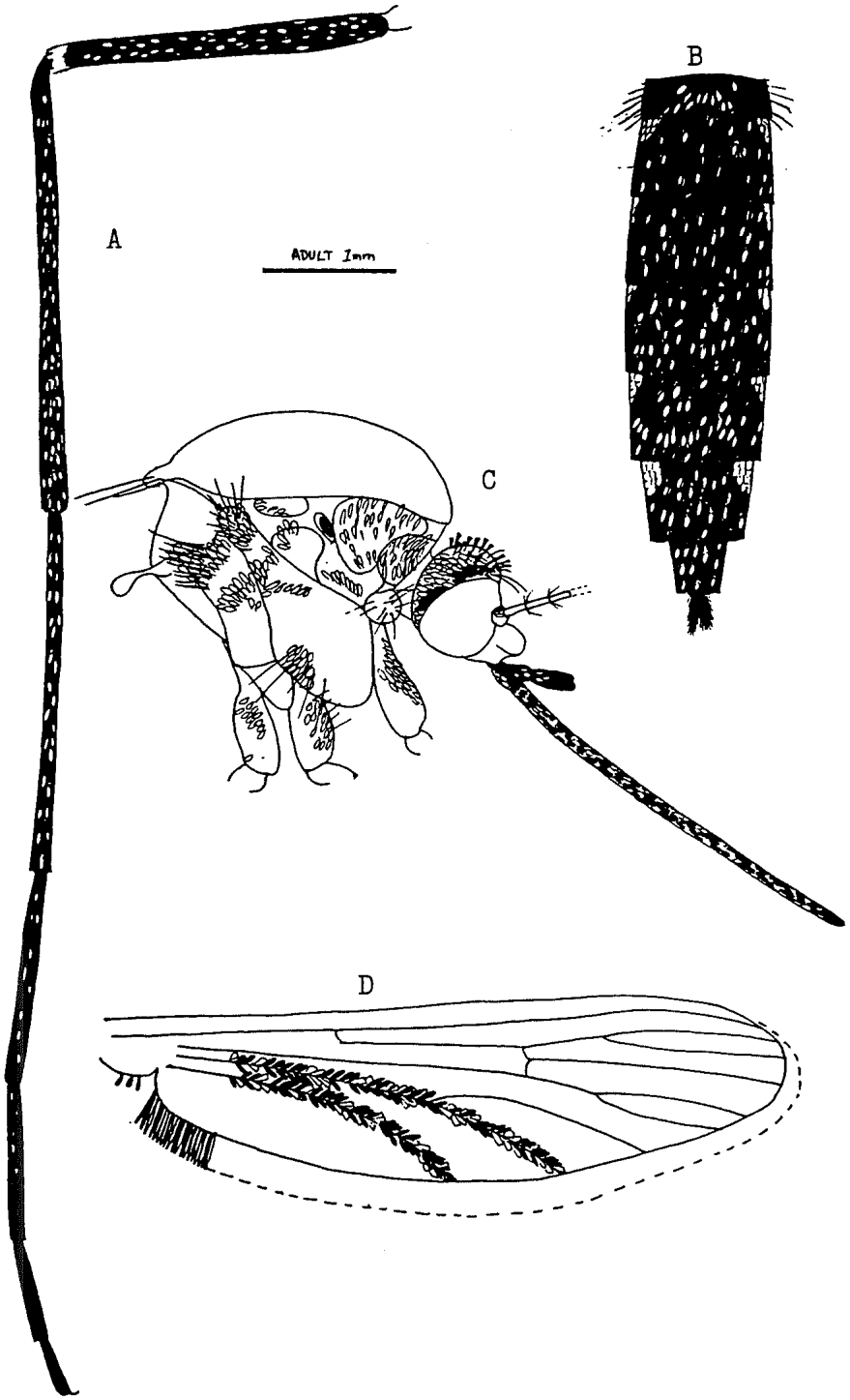
Unknown.

BIOLOGY

Some females have been taken biting man. This species is collected as adults during the spring (August-October), and it may be that the species has winter larvae and only one generation in each year. Adults have been taken in CO_2 baited traps. The larva described by Dr E.N. Marks in the literature as "near prom" (in the same paper as this species is described) may be the larvae of this species as it has been collected from the same area as the adults, but this must be confirmed by link breeding the larva to the adult. It should be noted that the same larva was collected in both Mandurah and Bunbury by Tony Wright's group during the evaluation of mosquito populations in those areas.

RELATION TO DISEASE

None known or suspected.



Aedes (Ochlerotatus) turneri

A: Hindleg; B: Abdomen (dorsal); C: Adult head and thorax (lateral); D: Wing (detail of scaling on some veins shown).

DISTRIBUTION

Bunbury, Sep-Oct 1985, MEC. Busselton, Oct 1960, EJB. Kewdale, Oct 1952, NES; Oct 1953, DLM. Leschenault Inlet, 1986, MEC. Mandurah, Sep-Oct 1985, MEC. Perth, Sep 1938, AJT. Piawaning, 7km W, Sep 1956, DLM.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Aedes (Ochlerotatus) vigilax (Skuse) 1889

Skuse. F.A.A., 1889. *Proc. Linn. Soc. N.S.W.,3:* 1731.
Type locality: Gosford, and Kiama National Park in New South Wales; and Brisbane, Queensland.
Synonymy: *Culex albirostris* Macquart, J., 1850. *Mem. Soc. Sci. Agric. Arts Lille., 1849:* 10.
Culex marinus Theobald, F.V., 1901. *Mon. Cul., 1:* 396.
Culex annulifera Ludlow, C.S., 1903. *J. N.Y. Ent. Soc., 11:* 141.
Culex ludlowae Blanchard, R., 1905. *Les Moustiques Histoire Naturelle et Medicale,* p.630.
Culicelsa pseudovigilax Theobald, F.V., 1907. *Mon. Cul., 4* 382.
Culicelsa uniformis Strickland, E.H., 1911. *Entomologist, 44:* 131.
Aedes vansomerenae Mattingly, P.F., 1955. *Bull. Ent. Res., 46:* 78.

ADULT FEMALE

This is a small to medium dark species which is the most common and serious coastal pest species for much of the State. Head with narrow dark scales on eye border, pale behind on occiput; erect scales dark, numerous; broad pale scaling on side of head interrupted by dark band. Torus with dark scales. Clypeus bare. Palp mainly dark, mottled with pale tip; about 0.14-0.17x length of proboscis. Proboscis dark at tip and mottled to pale on basal 0.75; about 1.6x length of forefemur. Scutum with dark integument; scaling narrow dark to bronze with some pale scales above prescutellar space. Scutellum with narrow pale scales on all lobes. Pleura with brown integument; anterior pronotum with narrow curved pale scales; posterior pronotum with narrow pale and dark curved scales above, broad pale scales below posteriorly; broad pale scales on propleuron, postspiracular area, prealar area, paratergite, upper and posterior sternopleuron, and anterior mesepimeron; 4 postspiracular bristles. Abdomen with tergites dark with pale basal bands and lateral basal pale patches wider in midsegment than near base, tergite VII with pale apical scales; sternites pale scaled with large apicolateral dark patches; cerci dark. Coxae pale scaled. Hindleg with femur and tibia mottled; tarsi dark with pale basal bands. Wing dark with sparse pale mottling on all veins. Haltere pale with pale scales on knob.

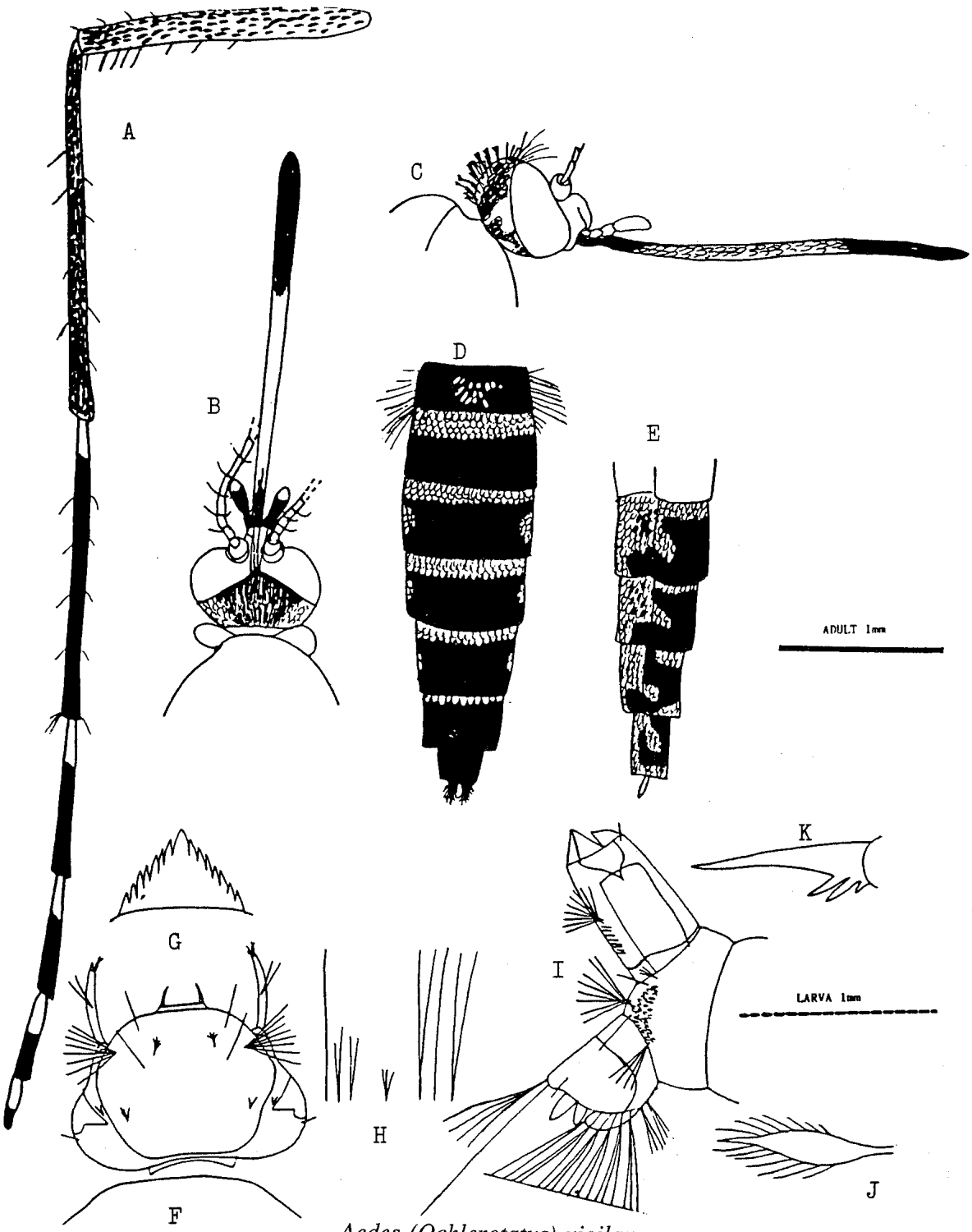
LARVA

Antenna same colour as head, about 0.58x its length; seta 1-A bifid inserted at 0.49 from base. Head 0.61x as long as wide; about 0.8x width of thorax; seta 4-C with 3-4 branches; 5-C and 6-C single; 7-C with about 8 branches; 8-C and 9-C bifid. Abdominal segment VIII with lateral comb of 21-32 basally fringed scales in triangular patch; seta 1-VIII with 3 small branches; 2-VIII and 4-VIII single; 3-VIII with 8 branches; 5-VIII with 4 branches. Siphon short and conical; siphon index about 1.55; siphon about 1.4x length of saddle; seta 1-S a single pair of tufts with about 10 branches inserted at 0.45 from base; pecten with 8-12 toothed spines reaching to 0.36 from base. Anal segment with saddle almost forming complete ring; setae 1-X and 3-X single; 2-X with 4 branches; 4-X with 6 pairs of tufts on grid; 4 precratal tufts. Anal papillae short and globular; about 0.15x length saddle.

BIOLOGY

This species breeds in the saline to brackish waters left stranded after peak spring tides, generally the largest tides of the year. The species is associated with mangroves, and with tidal salt marshes characterised by species such as *Salicornia, Sarcocornia* and *Spirobolus virginicus*. Eggs are laid on the mud substrate and on the bases of plants in the breeding site. The species is autogenous, producing a small batch of eggs on emergence without the need to take a blood meal. The larvae pupate in about 10 days, and adults emerge 2-3 days later. The species has been found breeding in association with a large variety of coastal, salt tolerant mosquitoes including *Ae alternans, Cx sitiens,* and *An farauti*. In northern parts of the State, the species is recorded in greatest numbers in the February to June period, when the spring tides are still high but the flushing and dilution effects of monsoonal rain are absent. In the southern parts of the State, *Ae vigilax* is most abundant in the October to April period.

Male swarming occurs about half an hour after sunset in columns reaching 2-5m above the ground. Adults are strong fliers and are known to undertake migratory flights of up to 100Km upon emergence. Females will bite readily during the day and particularly at dusk. This species appears as regular plagues in the spring/summer period. The species feeds on man and a variety of mammals and birds. It is readily captured in animal baited traps, light traps and CO_2 baited traps.



Aedes (Ochlerotatus) vigilax

A: Hindleg; B: Head (dorsal); C: Head (lateral); D: Abdomen (dorsal); E: Abdomen (lateral); F: Larval head (dorsal); G: Mentum; H: Prothoracic setae 1-P to 7-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); K: Pecten teeth (detail).

RELATION TO DISEASE

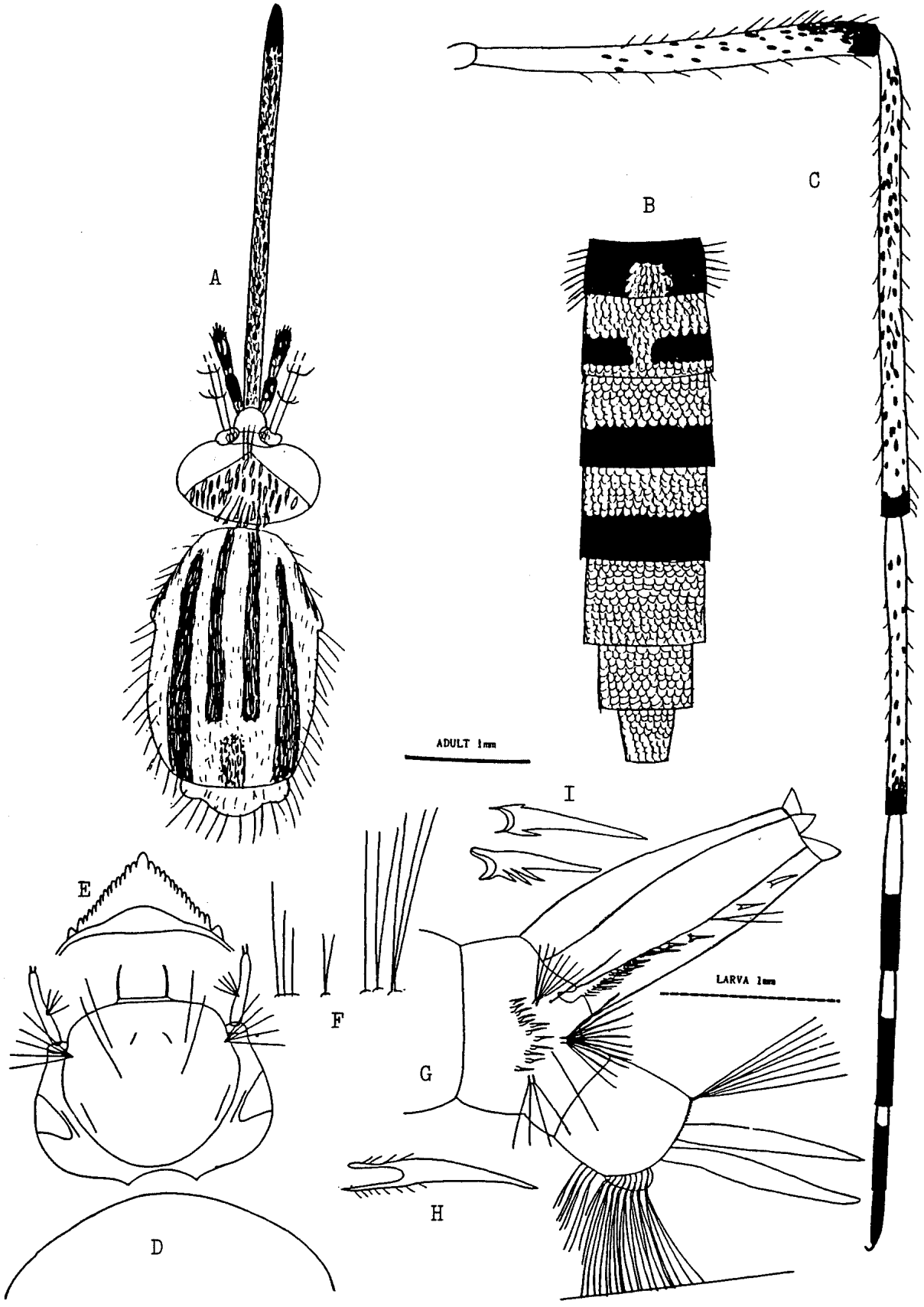
Ae vigilax is implicated in the transmission of the filarial worm *Wuchereria bancrofti*, though the vector capacity is variable. It is a capable vector of the filarial parasite *Dirofilaria immitis* (dog heart worm). *Ae vigilax* is a major vector of RRv, and a number of arboviruses have been isolated from this species. Under laboratory conditions, the species has been shown capable of transmitting a number of arboviruses including MVEv. The species may also be a mechanical vector of myxomatosis in some areas.

DISTRIBUTION

Ashburton, Jun 1955, EJB. Avon R., Apr 1963, JBF. Balgo Mission, Mar 1981, AEW. Barradale Crossing, Jun 1955, EJB. Beagle Bay, Oct 1950, EJB. Brickhouse Mill, Jun 1985, MEC. Broome, Jun 1944, CFHJ; Oct 1950, EJB; Feb 1984, MEC; Jul-Oct 1985, SH. Bunbury, Jan 1972, HEP; Jan-May 1985, MEC; Nov- Dec 1985, MEC. Canning R., Mar 1975, PFSL; Apr 1975, RH; May 1975, PFSL; Feb-Mar 1977, AB; Mar 1979, PFSL; Jun 1979, AEW; Mar 1980, FWH. Canning R., Bull Creek, Apr 1963, JBF. Canning R., Clontarf, Apr 1963, JBF; Jan 1972, PFSL; Mar 1972, PFSL; Oct 1973, PFSL; Feb 1974, PFSL. Canning R., Kent St Weir, Mar 1975, PFSL. Canning R., Kent St. Weir, Apr 1963, JBF; Oct 1973, PFSL; Feb 1974, PFSL; Mar 1975, PFSL. Canning R., Manning, Jun 1979, AEW. Canning R., Riverton, Apr 1963, JBF; Feb-Mar 1975, PFSL. Canning R., Rossmoyne, Apr 1963, JBF. Canning R., Surrey Rd., Mar-Apr 1975, PFSL. Cape Lambert, May 1984, MEC. Carnarvon, Apr 1954, Cr; Jul 1964, LEK; Apr 1979, AEW; Feb 1980, AH/CS; Apr-Aug 1980; AH/CS; Dec 1980, AH/CS; Feb-Mar 1984, MEC; May 1984, JWOB; May-Aug 1984, MEC; Oct 1984, MEC; Mar-Apr 1985, MEC. Carnarvon, Aboriginal Reserve, Apr 1979, AEW. Carnarvon, Babbage Is., Apr 1979, AEW; Dec 1979, AH/CS; Feb 1980, AH/CS; May-Aug 1980, AH/CS; Nov-Dec 1980, AH/CS; Jan 1981, AH/CS; Apr 1981, AH/CS; Jun-Jul 1981, AH/CS. Cygnet Bay, Oct 1978, AEW. Dampier, Mar 1979, AEW; May-Jun 1984, MEC. De Grey Station, 8km S, Jun 1978, AEW. Derby, Sep 1950, EJB; Jan 1967, GB; Mar-Apr 1977, AEW; Aug, 1978; Oct 1978, AEW; Feb-May 1980, RN/JR; Aug 1980, RN/JR; Jan-Feb 1981, RN/JR; Apr-May 1981, RN/JR; Mar 1984, MEC; Nov 1984, MEC; Mar 1985, AEW; Mar 1985, MEC. Derby, 40km S, Apr 1977, AEW. Derby, Black Rock, Oct 1978, AEW. Derby, Millards Soak, Apr 1977, AEW. Derby, Myalls Bore, Oct 1978, AEW. Derby, Prison Boab, Mar-Apr 1977, AEW. Exmouth, Jan 1980, PS; Mar 1980, PS; May-Jul 1980, PS; Dec 1980, PS; Jan 1981, PS; Aug 1984, MEC; Mar 1985, MEC. Exmouth, US Navy Base, Jan-Aug 1980, PS; Nov 1980, PS; Feb 1981, PS. Forrest River Mission, Oct 1950, EJB; Mar 1953, RL. Gascoyne Research Station, Apr 1979, AEW. Goose Hill, Feb 1953, RL. Halls Creek, May 1951, EJB. Kalumburu, Mar 1954, EPH/EJB; Jul 1978, AEW. Karratha, Jun-Aug 1980, MW/TH; Nov 1980, MWTH; Apr 1981, MW/TH; Mar 1984, MEC; May-Jul 1984, MEC. Kimberley Research Station, Apr 1953, RL. Kunmunya Mission, May 1944, Da. Kununurra, Dec 1972, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov 1974, PFSL; Oct 1976, AEW; Apr 1977, AEW; Nov 1977, AEW; Jul 1978, PFSL/AEW; Feb 1981, OA; Feb-Mar 1982, AEW; Dec 1982, AEW; Jan-Mar 1983, AEW; Oct 1983, AEW; Jan-Mar 1984, AEW. Lake Argyle, SW, Jul 1978, PFSL/AEW. La Grange, Oct 1978, AEW. Lake Argyle, Nov 1977, AEW; Mar-May 1982, AEW; Dec 1982, AEW; Jan-Feb 1983, AEW; Oct 1983, AEW. Leschenault Inlet, 1986, MEC. Mandurah, Apr 1971, CFHJ; Jan-Apr 1985, MEC; Oct-Dec 1985, MEC. Meda, Apr 1977, AEW. Minnie River, Apr 1977, AEW. Mitchell Plateau, Jul 1981, AEW. Munkayarra Pool, Mar-Apr 1977, AEW. Murchison R., Apr 1985, MEC. North West Cape, Jun 1972, TW. Ord River, Jul 1978, PFSL/AEW. Ord River, C.S.I.R.O., Mar 1954, EPH/EJB. Pago Mission, Aug 1979, AEW. Parry's Creek, Dec 1972, PFSL; Oct 1976, AEW; Feb-Mar 1982, AEW; Jun 1982, AEW; Sep 1982, AEW; Nov-Dec 1982, AEW; Jan-Mar 1983, AEW; Nov-Dec 1983, AEW; Jan 1984, AEW; Mar 1984, AEW. Peaceful Bay, HEP. Perth, Jun 1955, EJB. Perth, Attadale, Oct 1951, JAB. Perth, Belmont, Jun 1955, EJB. Perth, Castledare, Mar 1975, PFSL. Perth, Castledare/Kent St Weir, Mar 1975, PFSL. Perth, Fernwood, Mar-Apr 1975, PFSL. Perth, Nedlands, Jan 1956, DLM. Perth, South Perth, Mar 1935. Perth, Subiaco, Mar 1985, MEC. Petermarer Creek, Jun 1978, AEW. Pt.Hedland, Jun 1978, AEW; Sep 1978, AEW; Mar 1979, AEW; Jan-Apr 1980, BB; May-Jul 1984, MEC; Sep 1984, MEC; Nov 1984, MEC. Pt.Hedland, McGregor Swamp, Jun 1978, AEW. Shark Bay, 1985, MEC. Shay Gap, Dec 1980, NC/CM. Swan R., Alfred Cove, Apr 1963, JBF. Swan R., Attadale, Apr 1963, JBF. Swan R., Bassendean, Apr 1963, JBF; Dec 1969. Swan R., Bayswater, Apr 1963, JBF; Dec 1969. Swan R., Belmont, Apr 1963, JBF; Dec 1969. Swan R., Bennett's Brook, Apr 1963, JBF. Swan R., Burswood Is., Feb 1935, CFHJ; Apr 1963, JBF. Swan R., East Perth, Apr 1963, JBF. Swan R., Guildford, Apr 1963, JBF. Swan R., Maylands, Apr 1963, JBF; Dec 1969. Swan R., Midland, Apr 1963, JBF. Swan R., Mt Lawley, Apr 1963, JBF; Dec 1969. Swan R., Pelican Point, Apr 1963, JBF. Swan R., Point Walter, Apr 1963, JBF. Swan R., Redcliffe, Apr 1963, JBF. Wickham, Jul 1984, MEC; Apr 1986, PFSL. Wyndham, LJN; May 1926, MM; Oct-Dec 1929, TGC; Dec 1929, AKO; Jan 1930, AKO; Jan 1930, TGC; Mar 1930, TGC; Sep 1943, He; Apr 1953, AKO; Dec 1972, PFSL; Nov 1973, PFSL; Nov 1977, AEW; Jul 1978, AEW; Apr-May 1980, OA; Jul 1980, OA; Nov 1980, OA; Mar 1981, OA; May-Jun 1981, OA; Feb-Mar 1982, AEW; May-Jul 1982, AEW; Sep-Dec 1982, AEW; Jan-Feb 1983, AEW; Jun-Jul 1983, AEW; Mar 1984, AEW. Yeeda, Apr 1977, AEW. Yeeda, 15km N, Mar-Apr 1977, AEW. Yeeda R., Mar 1977, AEW. Yunderup, Apr 1971, CFHJ.

SPECIES WITH WHICH IT MAY BE CONFUSED

The tergal markings are diagnostic of this species.



Aedes (Ochlerotatus) vittiger

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail of basal and apical teeth).

Aedes (Ochlerotatus) vittiger (Skuse) 1889

Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1728.
Type locality: Gosford, New South Wales, Australia.
Synonymy: None.

ADULT FEMALE

This large species with striking scutal ornamentation is rarely collected in W.A., but may be quite common in the arid interior. Head with brown integument; narrow white scales on vertex; broad white scales on side of head; upright forked scales numerous, pale. Palp mainly pale to mottled on basal 0.67, darker at tip; about 0.2x length of proboscis. Proboscis pale on basal 0.75, darker at tip; about 1.38x length of forefemur. Scutum with integument dark brown; scaling with narrow white scales with 4 striking black stripes and darker area around prescutellar space. Scutellum with narrow pale scales on all lobes. Pleura with brown integument; narrow white scales on anterior and posterior pronotum, and propleuron; broad pale scales on upper and posterior sternopleuron, prealar area, postspiracular area, subspiracular area, paratergite and upper, lower and anterior mesepimeron; 7-8 postspiracular bristles. Abdomen with tergites white and with subapical lateral patches on tergite II; dark apical bands on tergites III-IV; sternites pale scaled with diffuse apical dark band. Coxae with broad pale scales. Hindleg with femur and tibia pale and mottled with darker scaling near tip; tarsi with broad pale bands. Wing dark scaled. Haltere dark.

LARVA

Not known from W.A. This description is based on specimens from New South Wales. Antenna same colour as head, about 0.43x its length; seta 1-A with 3-5 branches, inserted at 0.4 from base. Head 0.7x as long as wide; about 0.68x width of thorax; setae 4-C and 5-C single; 6-C single or occasionally bifid; 7-C with 5 branches; 8-C and 9-C single. Pleural groups as follows: 1-P to 3- P single; 4-P bifid; 5-P single; 6-P bifid; 7-P with 3 branches. Abdominal segment VIII with lateral comb of 10-12 basally fringed strong spines in single row; seta 1-VIII with 7 branches; 2-VIII and 4-VIII single; 3-VIII with 11-12 branches; 5-VIII with 3-4 branches. Siphon with small acus; siphon index about 2.5; siphon about 2.9x length of saddle; seta 1-S single pair of tufts with 2 branches inserted at 0.52 from base; pecten with 18-19 spines with small basal fringe reaching almost to tip of siphon with 2 pecten teeth widely separated from main group and dorsal of seta 1-S. Anal segment with complete saddle; setae 1-X and 3-X single; 2-X with 6-9 branches; 4-X with 8-10 pairs of tufts on grid; 2-4 precratal tufts. Anal papillae long pointed; about 1.5x length of saddle.

BIOLOGY

The populations of this species in eastern Australia breed in temporary ground pools with marginal vegetation, generally sunlit. The adults bite man and mammals in the day and at dusk, and the species can be a serious pest. Adults are taken in light and CO_2 baited traps. The species has only been collected from the Balgo area, but it may show up in other arid zone collections.

RELATION TO DISEASE

The species is a capable vector of MVEv under laboratory conditions, but there is no evidence of such a role in the field.

DISTRIBUTION

Balgo, Jun 1978, AEW. Balgo, 9.6km creek, Jun 1978, AEW. Balgo, Acacia Creek, Jun 1978, AEW. Broome, Feb 1984, MEC*. Kununurra, Feb 1984, MEC*.
(*: specimen not seen or verified by an experienced medical entomologist)

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Aedes (Ochlerotatus) ENM's sp. No. 71

ADULT FEMALE and LARVA

This is a species of Australia's arid zone. The characters in the key will separate this species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation.

BIOLOGY

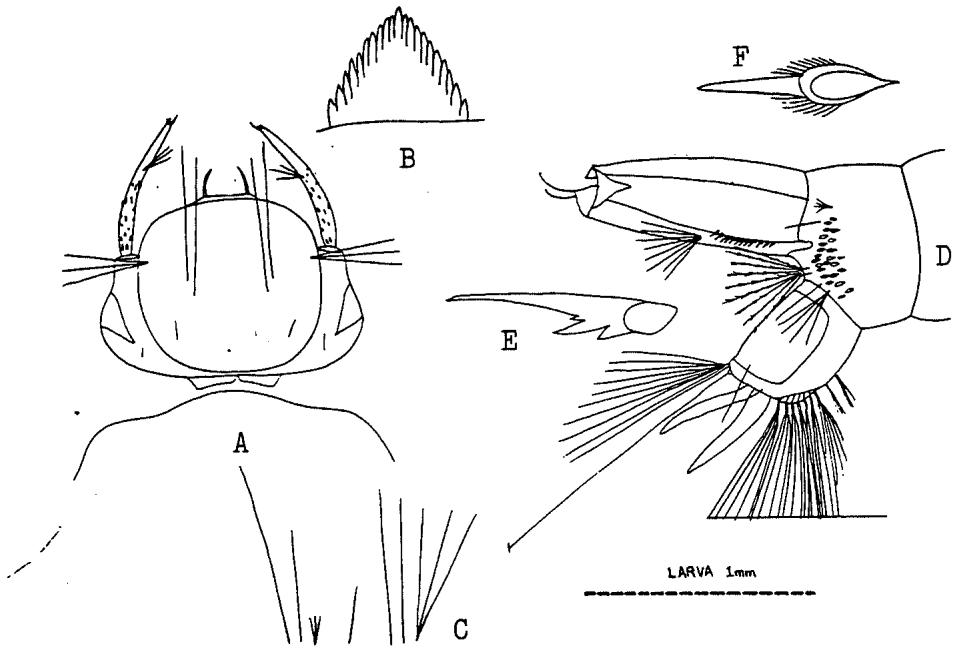
The species is found after rains in the arid zone, and will bite man and other mammals. The females have been collected in light and CO_2 baited traps, in truck traps and crush traps with calf bait.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Balgo Mission, Acacia Creek, Jun 1978, AEW. Balgo Mission, Our Lady Bore, Jun 1978, AEW. Chittering, Jul 1955, EJB. Coolgardie, 1967, ENM. Murchison R., Jun 1988, AEW. Leonora, Jun 1956, EJB. Onslow, Jun 1955, EJB. Yalgoo, Jun 1988, AEW. Yilgarn, Aug 1956, EJB.



Aedes (Ochlerotatus) ENM's sp. No. 71

A: Larval head (dorsal); B: Mentum; C: Prothoracic setae 1-P to 7-P (shoulder hairs); D: Abdominal segment VIII (lateral); E: Lateral comb scale (detail); F: Pecten teeth (detail of basal and apical teeth).

Aedes (Ochlerotatus) ENM's sp. No. 85

ADULT FEMALE and LARVA

This is a species of Australia's arid zone. The characters in the key will separate this species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation.

BIOLOGY

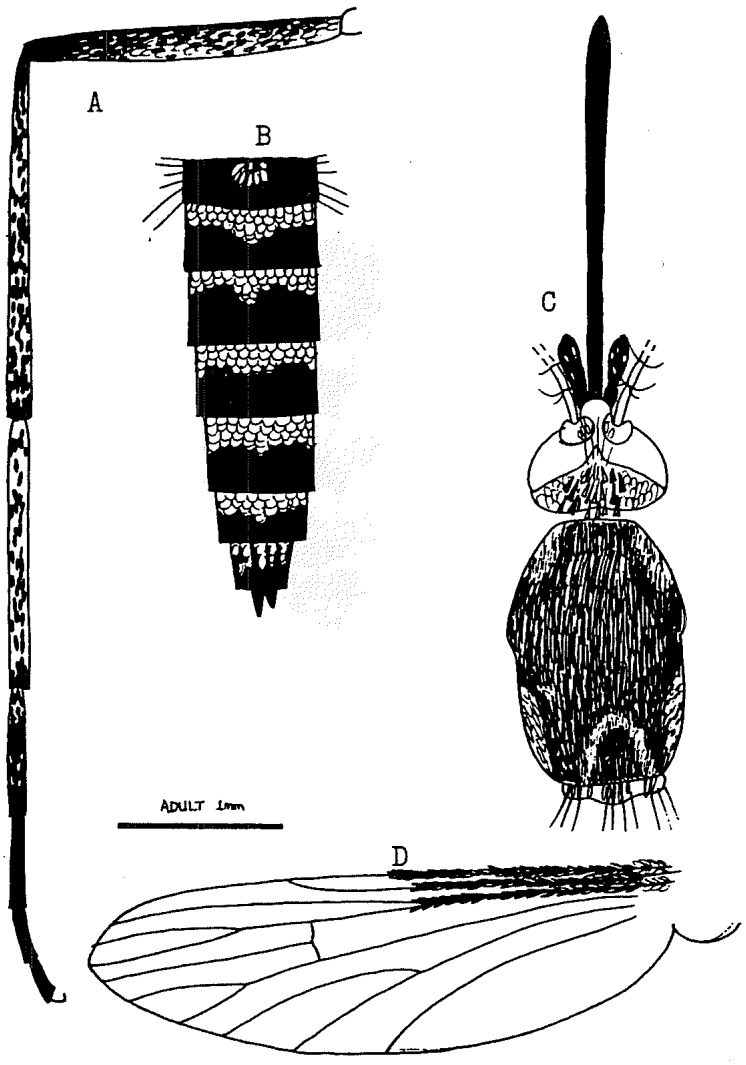
The species is found after rains in the arid zone, and will bite man and other mammals. Larvae have been found in rain filled ground pools, roadside pools and flooded fields. The females have been collected in light and CO_2 baited traps. This species can be a severe nuisance following heavy rains in the arid zone.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Carnarvon, Jul 1964, LEK; May 1984, JWOB. Balgo Mission, Jun 1978, AEW. Balgo Mission, Acacia creek, Jun 1978, AEW; Mar 1981, AEW. Lake Argyle, Jun 1983, AEW. Miaree Pools, Jun 1984, MEC. Millstream, Apr 1971, DHC. Newman, Mar 1979, AEW; Mar 1981, PF. Port Hedland, Jun 1984, MEC. Rudall R., Jul 1971, KTR.



Aedes (Ochlerotatus) ENM's sp. No. 85

A: Hindleg; B: Abdomen (dorsal); C: Head and thorax (dorsal); D: Wing (detail of scaling on some veins shown).

Aedes (Ochlerotatus) ENM's sp. No. 159

ADULT FEMALE and LARVA

The characters in the key will separate this species. This species has been collected from several localities in W.A.'s north. It is never a dominant species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation.

BIOLOGY

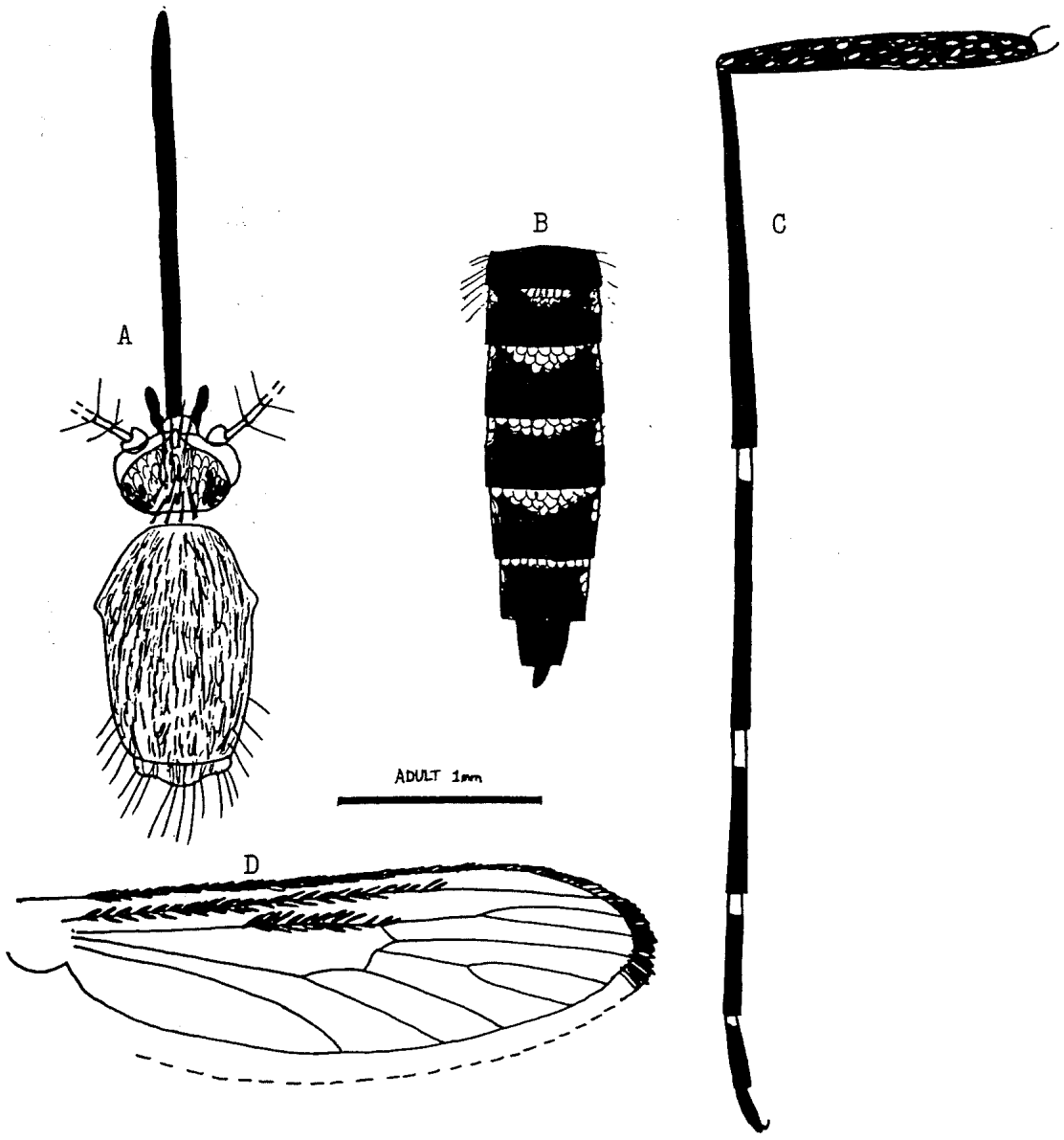
The adults of this species have been taken in CO_2 baited traps. The species is very closely related to *Ae pseudonormanensis*, and it is difficult to distinguish it.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Kalumburu, Jul 1978 PFSL/AEW; Lake Argyle, Mar 1982, AEW; Dec 1982, AEW; Jan-Feb 1983, AEW; Oct-Nov 1983, AEW; Feb 1984, AEW. Ord River, PFSL. Millstream, Jun 1954, EPH.



Aedes (Ochlerotatus) ENM's sp. No. 159
A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Wing (detail of scaling on some veins shown).

Aedes (Ochlerotatus) ENM's sp. 'Koorda'

ADULT FEMALE and LARVA

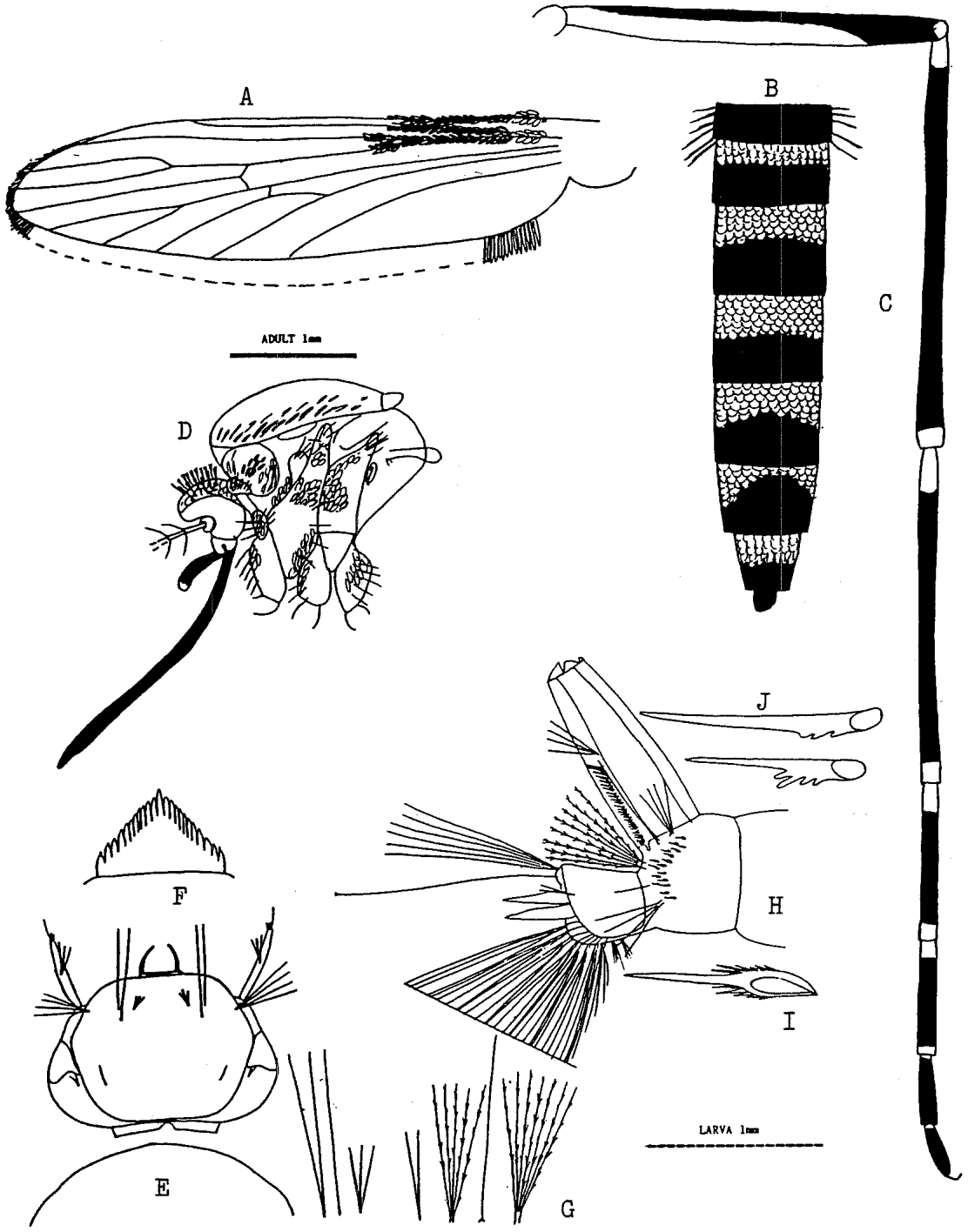
The characters in the key will separate this species. This species has been collected from several localities in W.A.'s south. It is never a dominant species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation.

BIOLOGY

This species has been taken breeding in a freshwater dam, flooded rabbit burrows, a freshwater grassy pool and a fresh water soak. The adults have been link bred but little is known of the biology of the species.

RELATION TO DISEASE

None known or suspected.



Aedes (Ochlerotatus) ENM's sp. 'Koorda'

A: Wing (detail of scaling on some veins shown); B: Abdomen (dorsal); C: Hindleg; D: Head and thorax (lateral); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail of basal and apical teeth).

DISTRIBUTION

Bruce Rock, Jul 1956, EJB. Coolgardie, Aug 1956, EJB. Kalgoorlie, Jul 1964. Koorda, Jul 1956, EJB. Leonora, 40km S, Jun 1973, SJM. Merridin, Jul 1956, EJB. Mingenew, Aug 1954. Ravensthorpe, 80km N, Aug 1964, GL. Wongan Hills, Aug 1954. Wyalkatchem, Jul 1956, EJB. Yilgarn, Aug 1956, EJB.

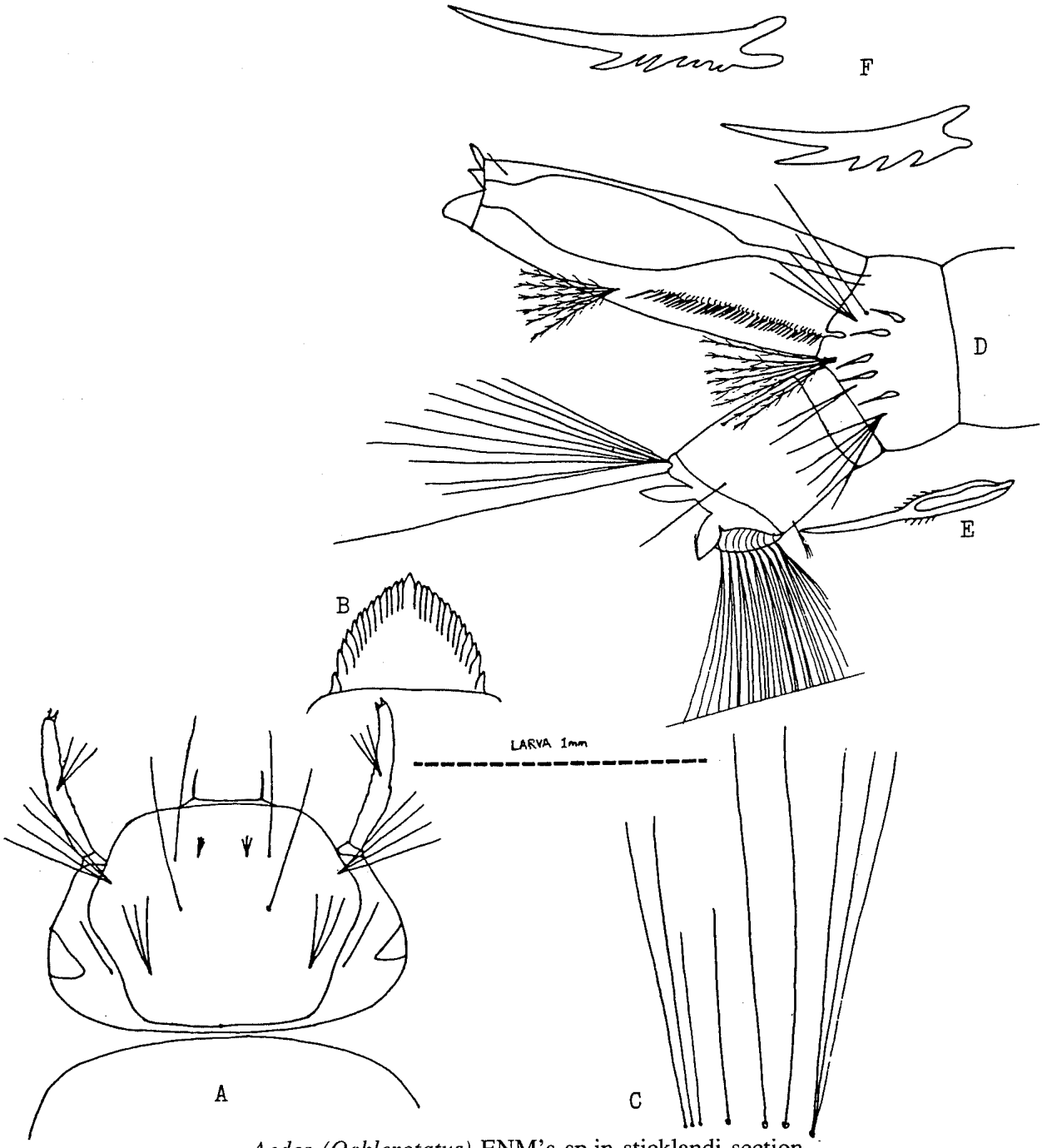
Aedes (Ochlerotatus) ENM's sp.in sticklandi section

ADULT FEMALE

Unknown.

LARVA

This larva has been referred to in the literature by Eric Britten as Ae 'Prom?'. It was described and illustrated by Dr E.N. Marks (1963. J. Ent. Soc. Qld. 2(1963):31-47) who speculated that it may be the larva of *Ae turneri*. The recent intensive studies in the Mandurah and Bunbury areas which showed that the presence of this larva preceded the appearance of *Ae turneri* further supports this suggestion, but link bred material is needed to confirm the relationship. The characters in the key will separate this species. This species has been collected from several localities in W.A.'s south. It is never a dominant species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation.



Aedes (Ochlerotatus) ENM's sp.in sticklandi section

A: Larval head (dorsal); B: Mentum; C: Prothoracic setae 1-P to 7-P (shoulder hairs); D: Abdominal segment VIII (lateral); E: Lateral comb scale (detail); F: Pecten teeth (detail of basal and apical teeth).

Antenna dark, about 0.4-0.5x length of head, spiculate near base; seta 1-A with 3-4 branches, inserted at about 0.5-0.6 from base. Head about 0.64x as long as wide, about 0.68-0.75x as wide as thorax; seta 4-C with 2-5 short branches, 5-C and 6-C single, 7-C with 3-4 simple branches, 8-C with 2-3 branches and 9-C with 1-2 branches. Prothoracic seta 1-P to 5-P all single, 6-P with 1-2 branches, 7-P with 3 branches, 5-P and 7-P pectinate. Abdominal segment VIII with lateral comb of 5-6 strong spines in a single row, each spine arising from sclerotised basal plate and each with basal fringe, seta 1-VIII with 1-3 simple branches, 2-VIII with 1-4 simple branches, 3-VIII with 10-11 pectinate branches, 4-VIII with 2-4 simple branches and 5-VIII with 5-7 simple branches. Siphon index 3.5-4.0, siphon about 2.7x length of saddle; seta 1-S a single pair of setae with 6 pectinate branches, inserted at 0.66 from base; pecten with about 36 strongly denticulate teeth on basal 0.55 of siphon; siphon tracheal tube may be constricted on basal 0.3. Anal segment with saddle complete; seta 1-X single, short, 2-X with about 17-20 branches in strong fan, 3-X single, long, and 4-X with 8-9 pairs of tufts on a grid, 1 precratal tuft. Anal papillae bluntly pointed, about 0.5x length of saddle.

BIOLOGY

This species has been taken breeding in fresh clear water in open swamp sites near Albany and Bunbury.

DISTRIBUTION

Albany, Aug 1956, EJB. Bunbury, 1985, MEC. Mandurah, 1985, MEC. Woodanilling, Aug 1956, EJB.

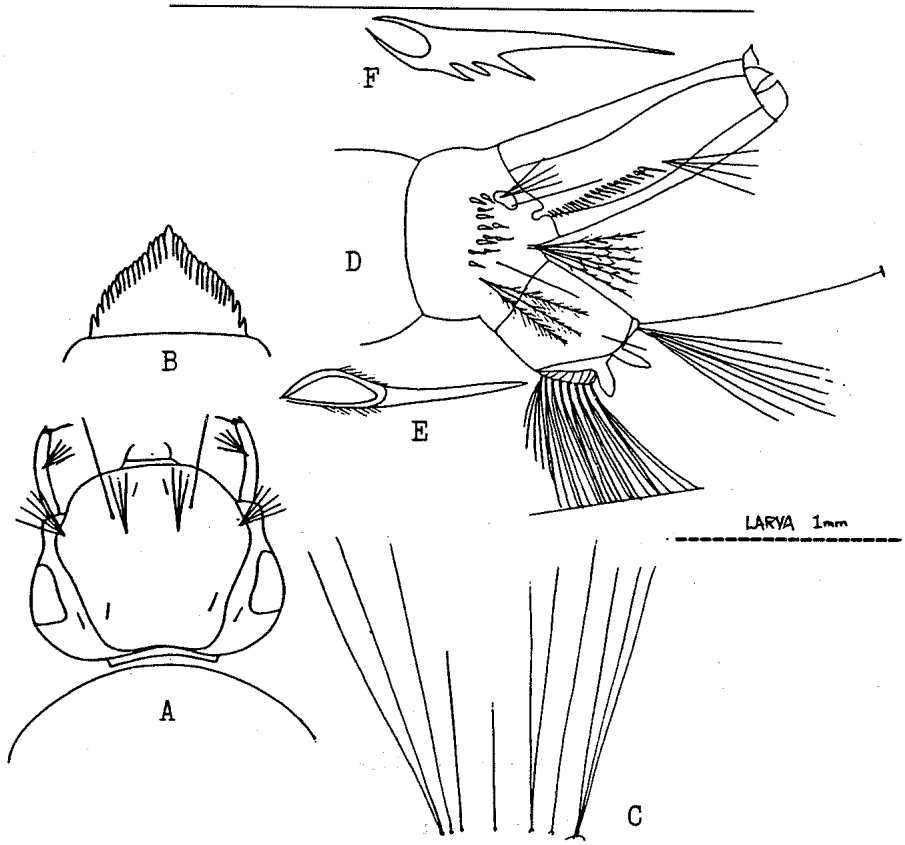
Aedes (Ochlerotatus) PFSL's Bunbury sp.

ADULT FEMALE

Unknown.

LARVA

The characters in the key will separate this species. This species has been collected from several localities near Bunbury and Mandurah in W.A. It is never a dominant species. Any specimens which key out to this species should be referred to a medical entomologist for confirmation. Circumstantial evidence suggests that this larva may be that of *Ae hesperonotius*, but further link bred material is needed to confirm this.



Aedes (Ochlerotatus) PFSL's Bunbury sp.
A: Larval head (dorsal); B: Mentum; C: Prothoracic setae 1-P to 7-P (shoulder hairs); D: Abdominal segment VIII (lateral); E: Lateral comb scale (detail); F: Pecten teeth (detail of basal and apical teeth).

Antenna dark brown, about 0.43x length of head, with strong small spicules; seta 1-A with 3-4 branches inserted at 0.37 from base. Head about 0.8x as long as wide, about 0.85x width of thorax; seta 4-C single, 5-C with 2-3 branches, 6-C single, 7-C with 3-7 branches, 8-C and 9-C single. Prothoracic setae 1-P with 2 branches, 2-P, 3-P, 4-P and 6-P single, 5-P with 1-2 branches and 7-P with 3-4 branches. Abdominal segment VIII with lateral comb of 8-13 simple spines in loose row (1-2 spines may be outside the row); seta 1-VIII 2-4 branches, 2-VIII and 4-VIII single, 3-VIII with 5-9 pectinate branches, 5- VIII with 3-5 branches. Siphon index 1.8-2.9, about 2x length saddle; seta 1-S a single pair with 3-6 branches inserted at 0.56 from base; pecten with 17-24 toothed spines over basal 0.44 of siphon; small acus present. Anal segment with saddle complete, seta 1-X and 3-X single, 2-X with 5-8 branches, 4-X with 8 pairs of tufts (sometimes 7 pairs) on grid, precratal tufts absent. Anal papillae short pointed, about 0.2x length saddle.

BIOLOGY

This species has been taken breeding in fresh clear water in open swamp sites.

DISTRIBUTION

Bunbury, 1985, MEC. Mandurah, 1985, MEC.

Subgenus : *Pseudoskusea*

SUBGENERIC CHARACTERS

Adult: Dark species, no obvious ornamentation. Broad decumbent scales on vertex of head. Proboscis slender, dark, longer than forefemur, palps short. Scutal scaling usually dark, narrow scales. No lower mesepimeral bristles. Abdominal tergites dark with basal pale bands or patches, segment VIII short and retracted, not visible. Hindtarsi unbanded. Wing dark scaled.

Larva: Antenna long, spiculate; seta 1-A branched. Head seta 6-C very long, single or bifid. Lateral comb with a large patch of fringed scales. Siphon variable but with small acus; pecten with evenly spaced teeth extending up siphon. Saddle incomplete; seta 4-X with 6 pairs of tufts on grid.

KEYS: ADULT FEMALES: see key to subgenera of Aedes (page 98).
LARVAE: see key to subgenera of Aedes (page 99).

Aedes (Pseudoskusea) bancroftianus Edwards 1921

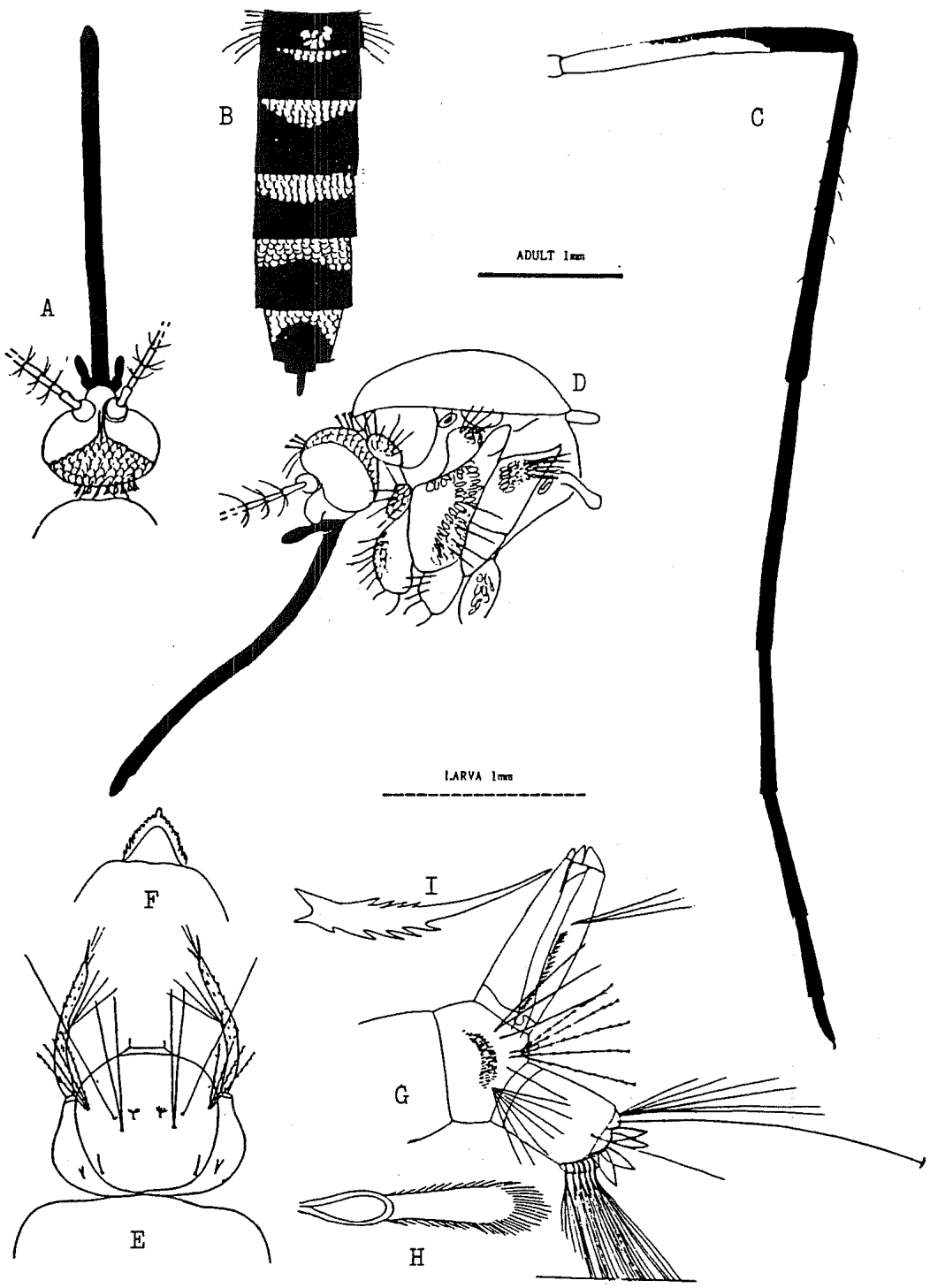
Edwards, F.W., 1921. *Bull. Ent. Res., 12:* 74.
Type locality: Eidsvold, Queensland, Australia.
Synonymy: None.

ADULT FEMALE

This small to moderate sized species is collected throughout W.A., but rarely as a dominant member of the fauna. Head with broad flat light brown/fawn scales on vertex; upright forked scales sparse, confined to occiput. Torus with dark brown scales. Palp dark scaled; about 0.125x length of proboscis. Proboscis dark scaled; about 1.4x length of forefemur. Scutum with brown integument; clothed in fine bronzy scales and some narrow golden scales around prescutellar space. Scutellum with scattered narrow golden scales on all lobes. Pleura with broad brown scale patches on anterior mesepimeron, posterior sternopleuron, and postspiracular area; elongate dark scales on posterior pronotum. Abdomen with tergites dark with creamy basal bands on II- VI slightly broader at lateral margins; sternites pale, segment VIII retracted and not visible. Hindleg with femur pale scaled almost to tip, with dark knee and narrow dark dorsal streak on apical 0.67; tibia and tarsi dark scaled. Wing dark scaled. Haltere light brown without scales.

LARVA

Antenna long, dark spiculate, about same length as head; seta 1-A with 3 branches, inserted at 0.55 from base. Head 0.72x as long as wide; about 0.78x width of thorax; seta 4-C with 6 dendritic branches; 5-C with 2 long branches; 6-C single and long; 7-C with 4 pectinate branches; 8-C single; 9-C bifid. Abdominal segment VIII with lateral comb of about 80 fringed scales in a triangular patch; seta 1-VIII bifid; 2-VIII and 4-VIII single; 3-VIII with 5 branches; 5-VIII with 7 branches. Siphon with small acus; siphon index about 3.8; siphon about 1.75x length of saddle; seta 1-S a single pair of tufts with 3 branches inserted at 0.67 from base; pecten with about 24 toothed spines on the basal half of the siphon. Anal segment with saddle complete; setae 1-X and 3-X single; 2-X with 6 branches; 4-X with 6 pairs of tufts on grid. Anal papillae short and pointed; about 0.27x length of saddle.



Aedes (Pseudoskusea) bancroftianus

A: Adult head (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Head and thorax (lateral); E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

BIOLOGY

Larvae are found in fresh water ground pools along water courses or in roadside ditches. The water may be cloudy or clear, with or without marginal vegetation, sunlit or shaded. The larvae have been recorded breeding with a number of other mosquito species including *Ae alboannulatus, Ae vittiger, Ae alternans, An annulipes,* and *Cx australicus*. The adults will bite man readily in the day and at dusk, and the species may occasionally be a pest. Adults will also bite other mammals, and are taken in light and CO_2 baited traps. The species is widely distributed throughout W.A., but is generally uncommon.

RELATION TO DISEASE

No information available.

DISTRIBUTION

Balgo, Jun 1978, AEW; Mar 1981, AEW. Balgo, Darbai R., Mar 1981, AEW. Carnarvon, May 1984, JWOB; Jun 1984, MEC. Dale Bridge, Jan 1953, JHC. Darkan, Dec 1952, DLM. Kojonup, Mar 1955, DLM. Louisa Downs, May 1979, AEW. Marble Bar, Mar 1979, AEW. Moora, Jun 1955, EJB. Newman, Mar 1979, AEW. Newman, Whaleback Creek, Mar 1979, AEW. Onslow, EJB. Piawanning, Oct 1956, DLM. Tom Price, Mar 1979, AEW. Victoria Plains, Jul 1955, EJB. Whim Creek, Jun 1984, MEC. Williams Creek, Sep 1942. Woodanilling, Aug 1956, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Stegomyia*

SUBGENERIC CHARACTERS

Adult: Ornamented species, usually white scaling on black background. Decumbent scales on head broad and flat. Palps short, dark with white tip. Proboscis dark; about same length as forefemur. Scutum with narrow scales always forming a conspicuous pattern of white and dark scaling. Scutellum with broad scales. Tarsi conspicuously banded. Wing dark scaled.

Larva: Antenna short, smooth. Head setae 5-C and 6-C usually single; 4-C and 6-C anterior to 5-C and 7-C. Lateral comb a single row. Siphon short without acus. Ventral brush with usually 8 pairs of tufts on grid; precratal tufts absent. Anal papillae large and blunt tipped.

KEY TO ADULT FEMALES OF AEDES (STEGOMYIA) IN WESTERN AUSTRALIA

1. – Scutum with silvery lyre; clypeus with paired silvery patches; tergal bands straight ..... *Ae (Stg) aegypti*
   – Scutum without lyre but black with vivid white median stripe on anterior half; clypeus without scales; tergal bands sub basal, curved; mid femur with anterior row of pale scales ..... *Ae (Stg) katherinensis*

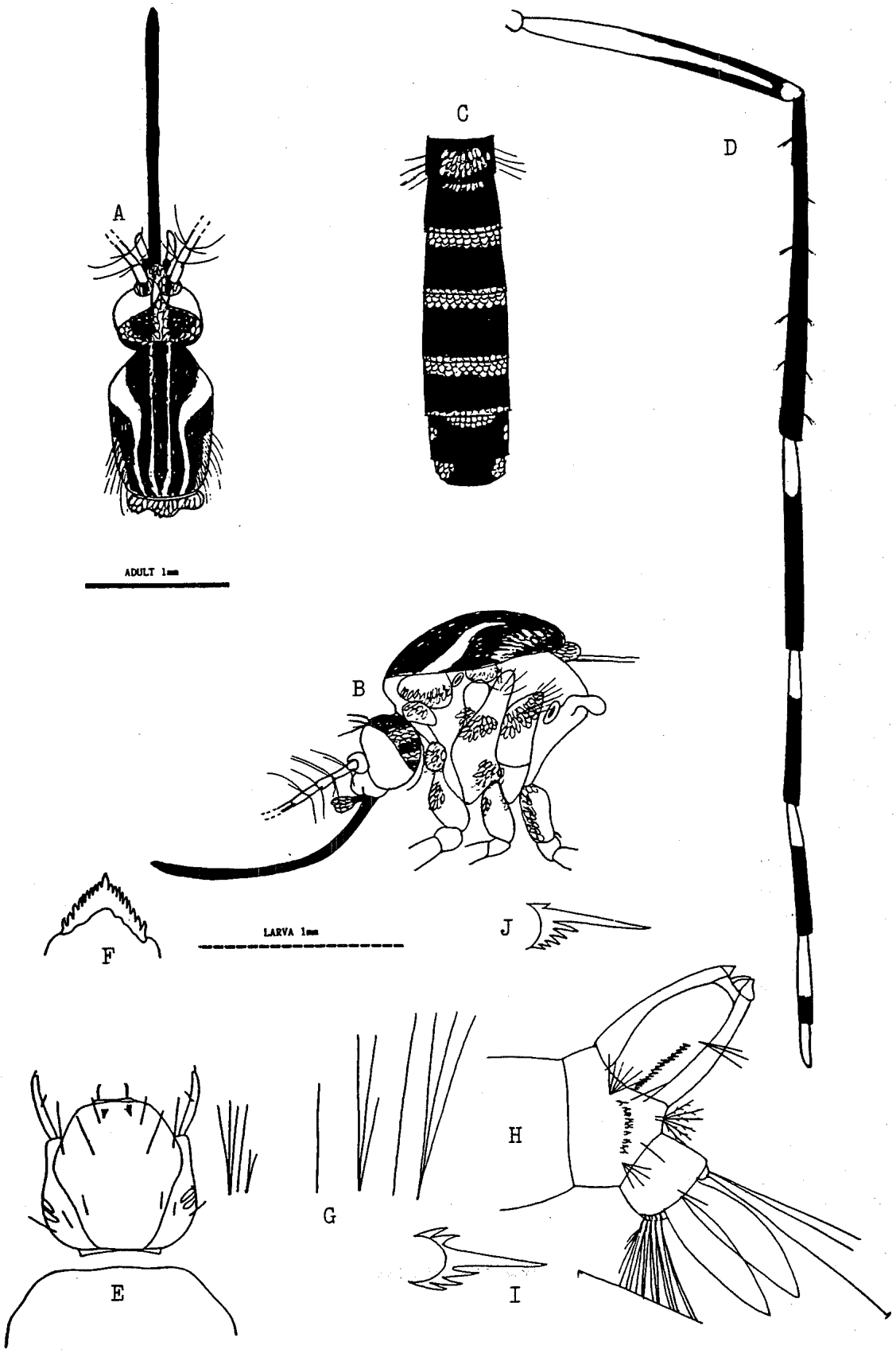
KEYS: LARVAE: see key to subgenera of *Aedes* (page 99).

Aedes (Stegomyia) aegypti (Linnaeus) 1762

Linnaeus, C., 1762. *In* Hasselquist, 1762. Reise nach Palestina : 470.
(Note: this description was not of the species now recognised as *Ae aegypti*. See Mattingley, Stone and Knight, 1962. *Bull. Zool. Nomen., 19: 212.)*
Type locality: Kuala Lumpur, Selangor, Malaya.
Synonymy: (Knight and Stone, 1973. *[A Catalogue of the Mosquitoes of the World* Thomas Say Foundation] list 29 synonyms of *Ae aegypti:* the following synonyms are those pertaining to Australia, and the reader is referred to the above work for full synonymy.)

Cx bancrofti Skuse, F.A.A. 1889. *Proc. Linn. Soc. N.S.W., 3:* 1740.
Stegomyia fasciata var. *Queenslandensis* Theobald, F.V., 1901. *Mon. Cul., 1:* 297.
Mimetomyia pulcherrima Taylor, F.H., 1919. *Proc. Linn. Soc. N.S.W., 43:* 830.

This small and striking mosquito is one of the most important vectors of arboviruses in the world. It has a pan tropical distribution, and was formerly widespread in W.A.. However, it appears to have died out following the introduction of scheme water supplies and the introduction of motor mowers, both of which resulted in the cleaning up and removal of the favoured breeding sites for this species. It has not shown up in collections since 1979, and was not collected in the 1985 Mosquito Eradication Campaign (MEC) surveys of container breeding mosquitoes in northern W.A.. It is included here as the species is of major importance as a vector, and because of the potential for reintroduction and reestablishment in W.A.



Aedes (Stegomyia) aegypti

A: Adult head and thorax (dorsal); B: Head and thorax (lateral); C: Abdomen (dorsal); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Prothoracic setae 1-P to 7-P (shoulder hairs); H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

ADULT FEMALE

Head with broad flat decumbent scales, pale in midline and on eye border and with 2 lateral pale bands, the rest black; upright forked scales pale, restricted to occiput. Torus pale scaled. Palps dark, pale dorsally on apical 0.5; about 0.2x length of proboscis. Proboscis dark scaled, about same length as forefemur. Scutum with narrow vivid white scales forming a broad lyre pattern, and with submedian pale stripes. Scutellum with broad white scales on all lobes. Pleura with patches of silvery/white scales on anterior pronotum, propleuron, paratergite, upper and lower sternopleuron, anterior mesepimeron and lower prealar area; 2 postspiracular bristles. Abdomen with tergites dark with basal sublateral white patches, pale yellowish scales in basal median patches or bands not connected to sublateral patches, apicolateral patches and apical row of pale scales on some segments; sternites dark with basal median silver/white patches and apical pale patches covering most of midline on segments II-IV. Coxae with white scale patches. Hindleg with femur pale anteriorly on basal 0.5, median pale stripe reaching almost to knee, white knee spot; tibia dark; tarsi with broad basal pale bands, V with a few dark scales at tip. Wing dark scaled.

LARVA

Antenna pale brown, about 0.4x length of head; seta 1-A single inserted at 0.65 from base. Head 0.87x as long as wide; about 0.7x width of thorax; seta 4-C with 3-4 short branches; 5-C to 9-C all single. Pleural groups as follows: 1-P with 3 branches; 2-P single; 3-P bifid; 4-P single; 5-P with 2-3 branches; 6-P single; 7-P with 3 branches. Abdominal segment VIII with lateral comb of 8-9 spines with strong basal denticles in a single row; seta 1-VIII with 6 branches; 2-VIII and 4-VIII single; 3-VIII with 6 branches; 5- VIII with 3-4 branches. Siphon with index about 1.3; about 2.5x length of saddle; seta 1-S a single pair of tufts with 3 branches inserted at 0.55 from base; pecten with 16-19 basally denticulate spines on basal half of siphon. Anal segment with saddle incomplete, short, covering dorsal 0.75 of segment; setae 1-X and 2-X bifid; 3-X single; 4-X with 5 pairs of tufts on grid. Anal papillae long rounded; about 2.8x length of saddle.

BIOLOGY

This species is closely associated with urban and domestic container breeding sites, though the species will also colonise natural tree holes near urban development. The dominant breeding sites are rain water tanks, gutters, discarded drums and refuse which can be filled by rain. Recently, the increased use of indoor plants in home decorating has provided a new and important site for breeding, i.e. in the drip trays beneath the plant pots. The species occurs throughout the year, but populations surge following rains.

This species is easily transported and spreads readily as a result of human activities. For example, adults may be dispersed whilst resting in vehicles or as larvae or eggs when containers are moved. The adults bite man readily in the day, but are often cryptic and the biting goes unnoticed. The adults are not strong fliers, and dispersal by flight is quite limited.

RELATION TO DISEASE

Ae aegypti is the major vector of yellow fever and dengue. Dengue occurs in Australia, but is restricted to Queensland, where *Ae aegypti* is currently distributed. Experimentally, the species is an efficient vector of RRv, and has supported replication of a large array of arboviruses including MVEv and Kunjin virus. The role of this species in the natural transmission cycles of these viruses in Australia is unclear.

DISTRIBUTION

Beagle Bay, Oct 1950, EJB. Beverley, Dale R., Feb 1947, PNF. Broome, 1928, FHT; 1929, LEC; 1944, CFHJ; Nov 1950, EJB; Apr 1953 AKO; Aug 1953 EJB; 1956, AKO; Jan 1965, EJB; Mar 1967, EJB; Apr 1970 EJB. Cannington, Mar 1943, CFHJ. Derby, 1924, LEC; 1928, FHT; Mar 1954, EJB; Mar 1954, EPH; 1956, AKO. Geraldton, Jan 1943, FNR. Halls Creek, 1944, CFHJ. Harvey, Feb 1947 PNF. Meekatharra, 1944, CFHJ; Jun 1944, CFJ. Moora, Jan 1943, FNR. Perth, Jan 1935, LJN; Apr 1935, LJN; Jan 1943, FNR; Mar 1943, PNF; Apr 1953, PNF. Port Hedland, EPH; Apr 1951, EJB; Sep 1953, EJB; Apr 1956, WC; 1956, AKO; Apr 1970, EJB. Wyndham, Apr 1970, EJB. Yeeda Station, 1928, FHT; Mar 1954, EPH/EJB; 1956, AKO.

SPECIES WITH WHICH IT MAY BE CONFUSED

To the novice, this species superficially resembles *Ae notoscriptus*, but may be readily separated as it has a dark proboscis whilst *Ae notoscriptus* has a pale band on the proboscis.

Aedes (Stegomyia) katherinensis Woodhill 1949

Woodhill, A.R., 1949. *Proc. Linn. Soc. N.S.W., 74:* 141.
Type locality: Katherine, Northern Territory, Australia.
Synonymy: None.

ADULT FEMALE

This small to medium ornamented species is collected from time to time in container surveys in tropical Australia, but never as a dominant species. Head with decumbent scales broad and pale in midline with 2 lateral transverse bands, otherwise black; upright forked scales dark and restricted to occiput. Torus pale scaled. Palp dark with pale scales dorsally on apical 0.5; palp about 0.17x length of proboscis. Proboscis dark scaled; about 1.1x length of forefemur. Scutum dark with median pale stripe anteriorly reaching to point at level of wing roots; pale scales above wing root. Scutellum with broad flat white scales on all lobes. Pleura with black integument; broad pale scales in three transverse bands: band 1 from anterior pronotum through upper posterior pronotum, paratergite and continues on scutum above wing root; band 2 from propleuron through upper sternopleuron to upper mesepimeron; band 3 less distinct and extends from forecoxa through lower sternopleuron to lower mesepimeron. Abdomen with tergites dark with subapical white bands, may be curved laterally and reach base of segment, tergite VII black; sternites dark with basal pale bands. Coxae with patches of pale scales. Midleg with row of scales forming a median stripe on femur, femur with small knee spot; tibia dark; tarsi I-II banded, rest dark. Hindleg with femur dark with pale streak anteriorly, white knee spot; tibia dark; tarsi with pale basal bands on hind tarsi I-IV, V all white. Wing dark scaled. Haltere integument brown, knob dark scaled.

LARVA

Antenna brown, about 0.4x length of head; seta 1-A single inserted at 0.58 from base. Head about same length as width; about 0.6x width of thorax; seta 4-C with about 9 short, curved branches; 5-C and 6-C single; 7-C bifid; 8-C and 9-C single. Prothoracic setae as follows: 1-P with 3 branches; 2-P single; 3-P and 4-P bifid; 5-P and 6-P single; 7-P with 1-2 branches. Abdominal segment VIII with lateral comb of 8 spines with narrow basal fringe in single row, some spines may be split into twin spines; seta 1-VIII with 3-5 branches; 2-VIII and 4-VIII single; 3-VIII with 5 branches; 5-VIII with 2-3 branches. Siphon with index about 1.58; siphon about 2.4x length of saddle; seta 1-S a single pair of setae with 2 branches inserted at midpoint of siphon; pecten with about 9-13 strong multidentate spines on basal 0.4 of siphon. Anal segment with saddle incomplete, covering dorsal 0.7 of segment; setae 1-X and 2-X bifid; 3-X single; 4-X with 4 pairs of tufts on grid. Anal papillae long and blunt ended; about 2x length of saddle.

BIOLOGY

This species has been found breeding in a variety of natural and artificial container habitats. Natural sites include tree holes and depressions in boab trees. Artificial containers include domestic sites such as drums and refuse filled by rain. The adults will bite man at dusk. This species is rarely encountered in great numbers.

RELATION TO DISEASE

There is no evidence indicating that this species is a vector of disease. Some laboratory evidence suggests that it is a poor vector of dengue 2, but other studies indicate that it supports the replication of the dengue viruses.

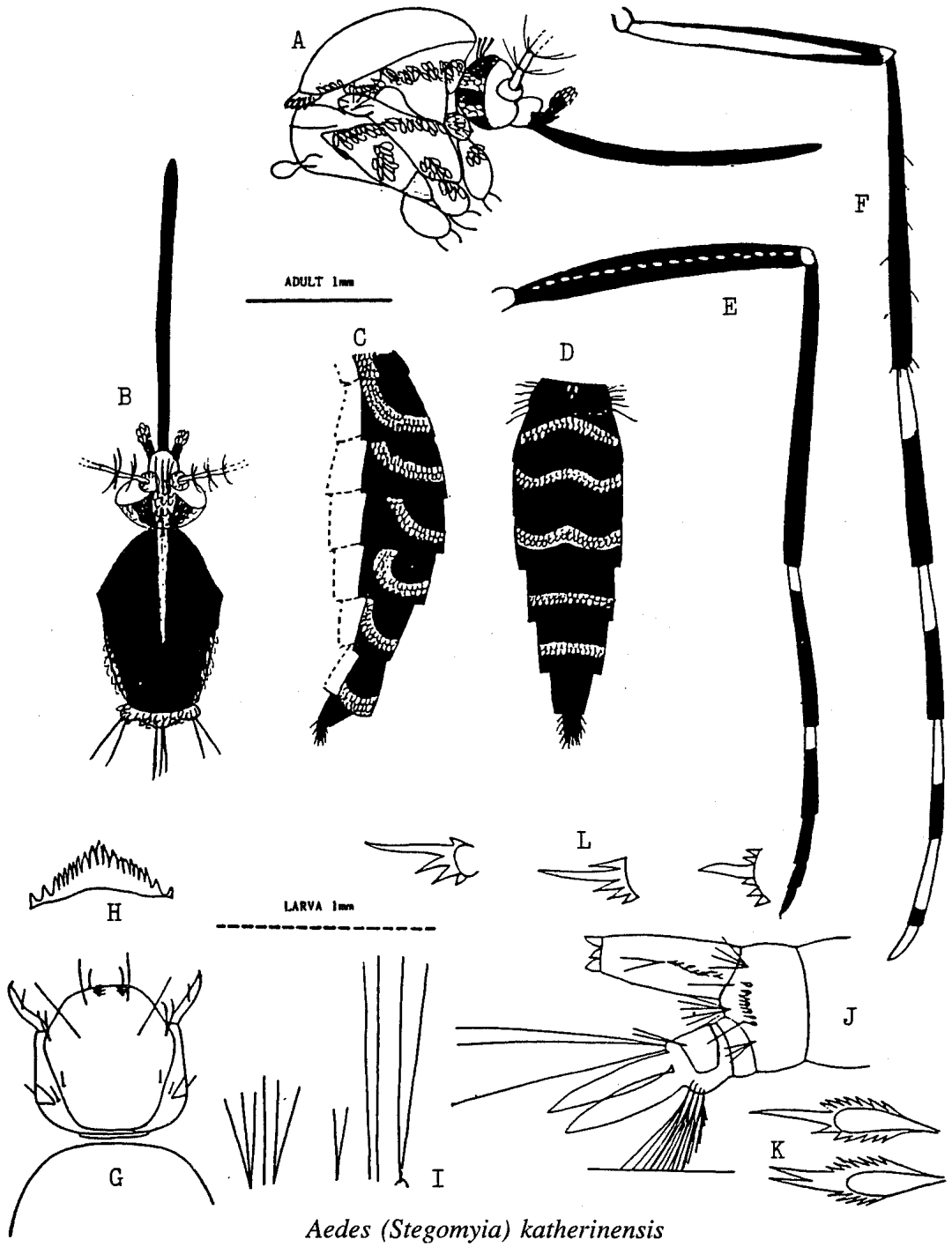
DISTRIBUTION

Derby, Feb 1984, MEC. Halls Creek, May 1951, EJB. Ivanhoe, Apr 1953, AKO. Kunmunya Station, Feb 1944, ARW. Kununurra, Apr 1974, PFSL; Nov 1974, PFSL; Nov 1977, AEW; Feb-Mar 1984, MEC; Feb 1984, AEW. Ord River, C.S.I.R.O., Apr 1953, AKO. Wyndham, Oct 1950, EJB; Nov 1952, DL; Feb 1984, MEC.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species resembles *Aedes (Stg) albopictus*, a species not endemic in Australia, but which has been recorded from several seaports historically. *Ae albopictus* has been recorded from Darwin in 1922, and more recently on incoming vessels in 1985 and 1989; and from imported tyres in Brisbane in 1987. *Ae albopictus* is a major vector of dengue and other arboviruses in Asia and the Pacific. It has been shown to be a vector of RRv during a major epidemic in the Western Pacific in 1979-80. It has recently established populations and spread rapidly in the USA and Brazil. The species is both a domestic container breeder and a sylvan tree hole breeder and its natural range extends from tropical to temperate Asian countries, and there is some concern that if it should establish in Australia, it may result in significant problems with disease transmission.

The adult of *Ae albopictus* has the same thoracic markings as *Ae katherinensis*, but can be distinguished by having basal white tergal bands where the bands of *Ae katherinensis* are subapical. The larvae of *Ae albopictus* also key to *Ae katherinensis* in the keys in this manual, and can be distinguished by comparing the



Aedes (Stegomyia) katherinensis

A: Adult head and thorax (lateral); B: Head and thorax (lateral); C: Abdomen (lateral); D: Abdomen (dorsal); E: Midleg; F: Hindleg; G: Larval head (dorsal); H: Mentum; I: Prothoracic setae 1-P to 7-P (shoulder hairs); J: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); L: Pecten teeth (detail of basal, mid and apical teeth).

setae on abdominal segment VII. In *Ae albopictus* seta 1-VII has 3-4 short branches, less than 2x the length of seta 5-VII. Whilst in *Ae katherinensis*, seta 1-VII has 2 (2-3) branches, which are at least 2.5x the length of seta 5-VII. Any specimens which may be *Ae albopictus* should be forwarded to a medical entomologist for confirmation as soon as possible.

Subgenus : *Verrallina*

SUBGENERIC CHARACTERS

Adult: Head with decumbent scales largely broad and flat. Proboscis dark scaled. Palps short and dark. Scutum with scaling narrow. Scutellum with narrow scales on all lobes. Pleura with reduced scaling. Abdominal segment VIII partly retractile. Tibiae and tarsi dark scaled. Wing dark scaled.

Larva: Antennae spiculate. Lateral comb usually a single row of fringed scales. Siphon with acus; pecten evenly spaced with 2-3 distal teeth more widely separated. Saddle incomplete; seta 4-X with 5-7 pairs of tufts on grid and 2-3 precratal tufts.

KEY TO ADULT FEMALES OF *AEDES (VERRALLINA)* IN WESTERN AUSTRALIA

1. – Tergites with sub basal white bands; hind femur with ventral pale streak on basal 0.8 anteriorly ..... *Ae (Ver) funereus*
   – Tergites black with lateral basal white patches; hind femur dark anteriorly ..... *Ae (Ver) reesi*

KEYS: LARVAE: see key to subgenera of *Aedes* (page 99).

Aedes (Verrallina) funereus (Theobald) 1903

Theobald, F.V., 1903. *Mon. Cul., 3:* 292.
Type locality: Mrs Bell's Scrub, Deception Bay, Queensland, Australia.
Synonymy: *Pseudoskusea basalis* Taylor, F.H., 1912. *Appendix 6 Ann. Rep. Commnr. Publ. Hlth. Qd.,* to 30th June, 1912 : 27.

ADULT FEMALE

This small dark mosquito is found in coastal areas in the tropical north of the State. Head with broad dark scales dorsally and with pale stripe laterally. Torus and clypeus bare. Palps black scaled, short; about 0.1x length of proboscis. Proboscis black; about 1.34x length of forefemur. Scutum with black integument, clothed in narrow black scales. Scutellum with narrow black scales on all lobes. Pleura with dark integument; a few translucent scales on anterior pronotum and upper sternopleuron; white scales on propleuron, lower and upper sternopleuron, and upper mesepimeron; 2 postspiracular bristles. Abdomen with tergites dark scaled with subbasal pale white bands; sternites dark with some scattered pale scales on basal half of segment. Coxae with appressed broad white scales. Hindleg with femur having pale ventral streak; tibia and tarsi dark. Wing dark scaled. Haltere with pale stem and knob dark.

LARVA

Antenna pale, about 0.5x length of head; seta 1-A with 3 branches inserted at 0.44 from base. Head 0.7x as long as wide; about 0.78x width of thorax; seta 4-C with 5 branches; 5-C with 4 branches; 6-C with 3 branches; 7-C with 7 branches; 8-C bifid; 9-C with 3 branches. Prothoracic setae as follows: 1-P and 2-P single; 3-P and 4-P bifid; 5-P and 6-P single; 7-P with 2 branches. Abdominal segment VIII with lateral comb of about 25 fringed scales in triangular patch; seta 1-VIII with 3 branches; 2-VIII and 4-VIII single; 3-VIII with 7 pectinate branches; 5-VIII with 7 pectinate branches. Siphon covered in fine spicules; siphon index about 2.38; siphon about 2x length of saddle; seta 1-S a single pair of tufts with 3 branches inserted at 0.7 from base; pecten with 12 denticulate spines on basal 0.58 of siphon, the last tooth of which is more widely separated. Anal segment with saddle incomplete, covering dorsal 0.5 of segment only; setae 1-X and 3-X single; 2-X with 3 branches; 4-X with 5 pairs of tufts on grid; 2 precratal tufts. Anal papillae long and pointed; about 0.8x length of saddle.

BIOLOGY

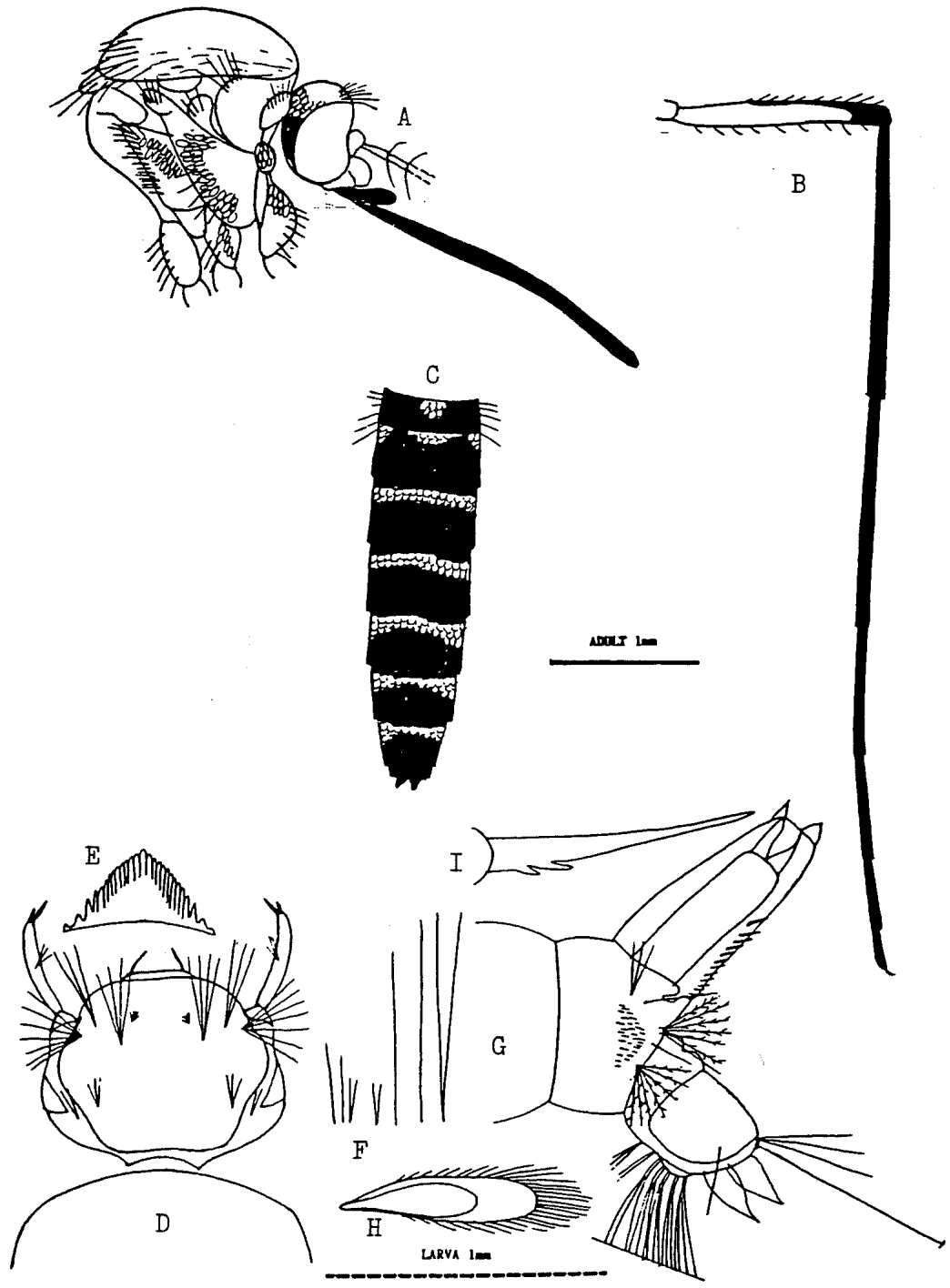
This tropical species is found breeding in shaded to open pools, fresh to brackish. It generally occurs just inland of typical *Ae vigilax* breeding sites. The adults bite man and other mammals, and the species may be a local pest in some places. Adults have been taken in light traps and CO_2 baited traps. The species is generally collected in the November to March period. It is only known from one locality in W.A. at Wyndham. Elsewhere in its range, the species may be a pest locally.

RELATION TO DISEASE

There is no conclusive evidence of the vector status of this species. A couple of arboviruses have been isolated from this species in New Guinea, but not on mainland Australia. In addition, experimental data shows that the species can support replication of a number of arboviruses.

DISTRIBUTION

Wyndham, 1984, AEW.



Aedes (Verrallina) funereus

A: Adult head and thorax (lateral); B: Hindleg; C: Abdomen (dorsal); D: Larval head (dorsal); E: Mentum; F: Prothoracic setae 1-P to 7-P (shoulder hairs); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Aedes (Verrallina) reesi King and Hoogstraal 1947

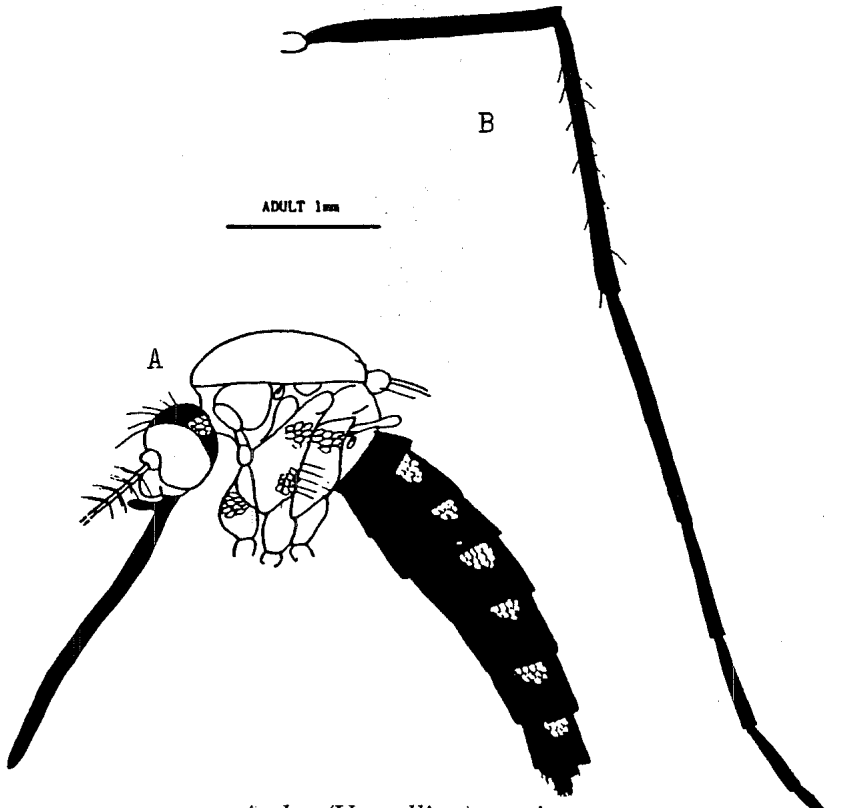
King, W.V. and Hoogstraal, H., 1947. *J. Wash. Acad. Sci., 37:* 127.
Type locality: Vivigani, Goodenough Island, Southeast [Papua] New Guinea.
Synonymy: None.

ADULT FEMALE

This small to moderate, very dark drab species has been collected in the Ord valley of W.A. It is relatively common in collections. Head with decumbent scales broad flat and black above, some pale on side; upright forked scales dark, confined to occiput. Palp dark scaled; about 0.1x length of proboscis. Proboscis dark scaled; about 1.2x length of forefemur. Scutum with black integument; clothed in narrow black scales. Scutellum with fine black scales on all lobes. Pleura with dark integument; with small patches of dark translucent scales on upper sternopleuron and anterior mesepimeron; 1 postspiracular bristle. Abdomen with tergites dark scaled with basal lateral rounded pale scale patches which extend on basal margin and almost meet in midline on IV-V; sternites dark with some palish scales on basal 0.5 of segment. Hindleg completely black. Wing dark scaled. Haltere with pale stem, knob dark.

LARVA

Larva not described in the literature nor has it been collected from W.A.. The larva is known from Queensland, but has not been sighted.



Aedes (Verrallina) reesi

A: Adult head and thorax (lateral); B: Hindleg.

BIOLOGY

The larvae have been taken from small muddy partly shaded temporary pools at Lockhart River Mission, Queensland. The adults are taken in light and CO_2 baited traps, and females appear to be generalised mammal feeders. This species is only known from the Ord valley in W.A.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Kununurra, Dec 1979, OA; Mar 1980, OA; May-Jun 1980, OA; Aug 1980, OA; Dec 1980, OA; Mar-Apr 1981, OA; Jun 1981, OA; Feb-Mar 1982, AEW; May-Jun 1982, AEW; Oct-Dec 1982, AEW; Jan-Mar 1983, AEW; May-Jun 1983, AEW; Oct-Dec 1983, AEW; Jan-Mar 1984, AEW. Lake Argyle, Mar 1982, AEW; Dec 1982, AEW. Parry's Creek, Feb-Mar 1982, AEW; Mar 1983, AEW; Nov 1983, AEW; Jan 1984, AEW. Wyndham, Jun 1981, OA; Mar 1982, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Aedes species not within recognised subgenera.

The following two species, one described and one undescribed, do not fit any of the known subgenera of *Aedes*.

KEYS: ADULT FEMALES: see key to subgenera of *Aedes* (page 98).
LARVAE: see key to subgenera of *Aedes* (page 99).

Aedes (?) daliensis (Taylor) 1916

Taylor, F.H., 1916. *Proc. Linn. Soc. N.S.W., 41:* 565.
Type locality: Daly River, Northern Territory, Australia.
Synonymy: None.

(This species was originally described as a member of what is now the subgenus *Geoskusea*, but a review of this subgenus by Dr E.N. Marks revealed that this species belongs in a separate and new subgenus related to the subgenus *Luvea).*

ADULT FEMALE

This is a small cryptic and drab species found in mangrove areas along the coastline north from Carnarvon. Head with broad flat dark scales; upright forked scales absent. Torus with a few dark scales. Clypeus bare. Palps short, dark; about 0.1x length of proboscis. Proboscis dark and very slightly swollen at tip; about 1.1x length of forefemur. Scutum with integument brown; sparsely clothed in narrow dark scales. Scutellum with a few dark broad scales on all lobes. Pleura with light brown/tan integument; dark scales on upper posterior pronotum and patch of appressed translucent (purplish) scales on upper sternopleuron; 2 postspiracular bristles. Abdomen with tergites dark with bluish/mauve reflections in some light, palish lateral basal patches, strong bristles; sternites palish scaled. Hindleg dark with paler streak on basal 0.4 of femur; tibia and tarsi dark. Wing dark scaled. Haltere with pale stem and knob with dark scales.

LARVA

Antenna brown, about 0.56x length of head; seta 1-A with 3-4 branches, inserted at 0.52 from base. Head 0.82x as long as wide; about 0.59x width of thorax; seta 4-C with 2-3 fine branches; 5-C with 3 branches; 6-C single; 7-C as broad fan with 9 branches; 8-C single; 9-C bifid. Prothoracic setae all single except 7-C which is bifid. Abdominal segment VIII with lateral comb of about 75 fringed scales in triangular patch; seta 1-VIII bifid; 2-VIII and 4- VIII single; 3-VIII with 6 branches; 5-VIII with 4 branches. Siphon with acus; siphon index about 2.4; siphon about 1.2x length saddle; seta 1-S a single pair of 3-4 branched setae inserted at 0.58 from base; pecten with about 16 strong spines with single basal denticle reaching to midpoint of siphon. Anal segment with saddle reduced and covering dorsal 0.2 of segment; setae 1-X and 3-X single; 2-X fan-like with 12 branches; 4-X with 6 pairs of tufts on grid; no precratal tufts. Anal papillae very short and globular.

BIOLOGY

This species breeds in crab holes at or near the landward edge of the mangrove zone. The larvae are cryptic and dive readily when disturbed, using the pleural groups of setae to anchor themselves to the sides of the flooded crab burrows. Larvae are easiest to find following rains when the crab burrows are flooded. The adults do not appear to disperse far from the breeding areas and are rarely taken outside the mangrove zone. On one occasion, adults were taken 'in-copula' in the entrance to a crab burrow near Darwin. Adults are occasionally taken in light and CO_2 baited traps if these are set in or next to mangroves.

RELATION TO DISEASE

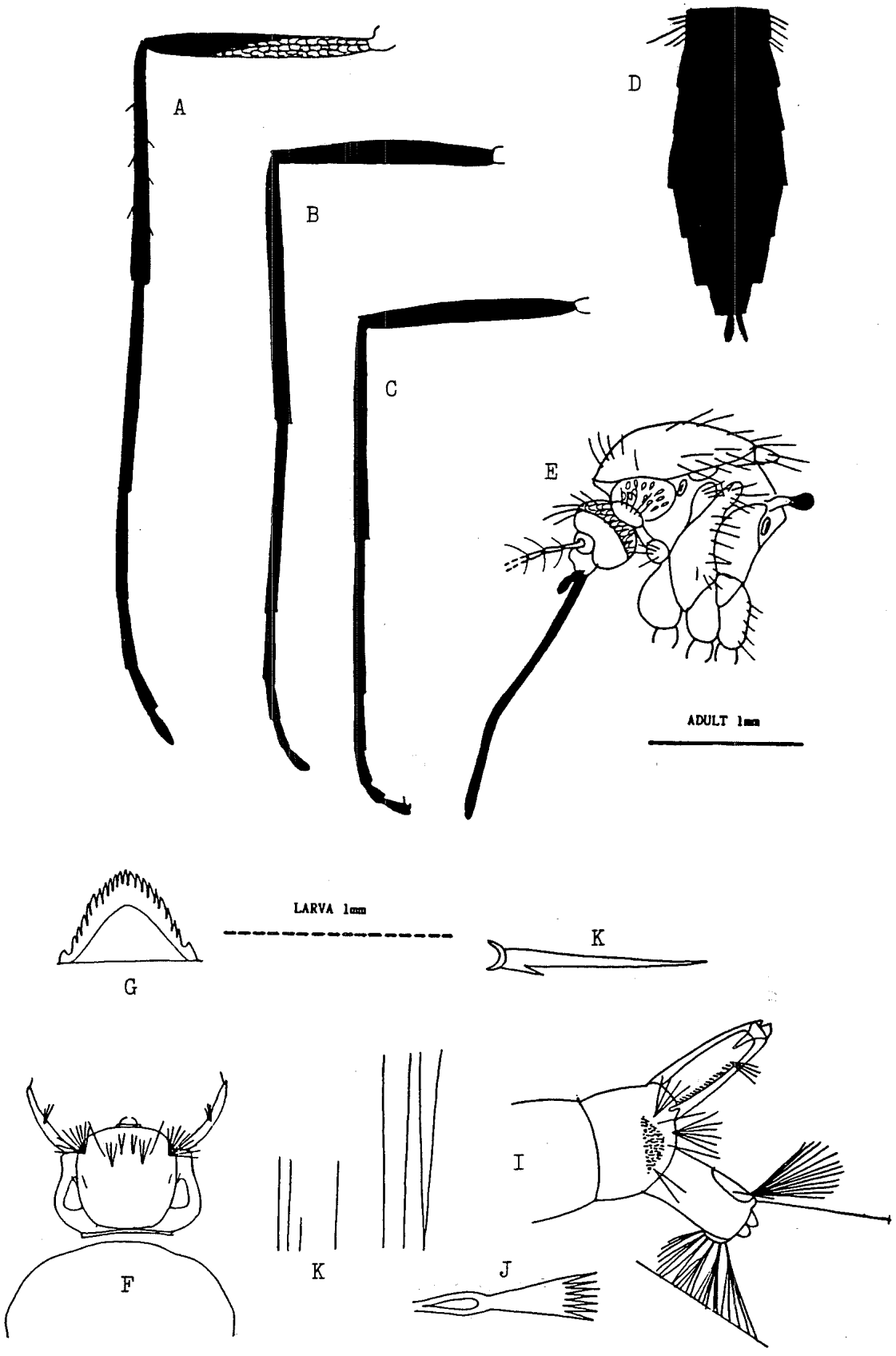
None known or suspected.

DISTRIBUTION

Broome, Jul-Aug 1985, SH. Carnarvon, May 1984, JWOB. Wickham, Apr 1986, PFSL.

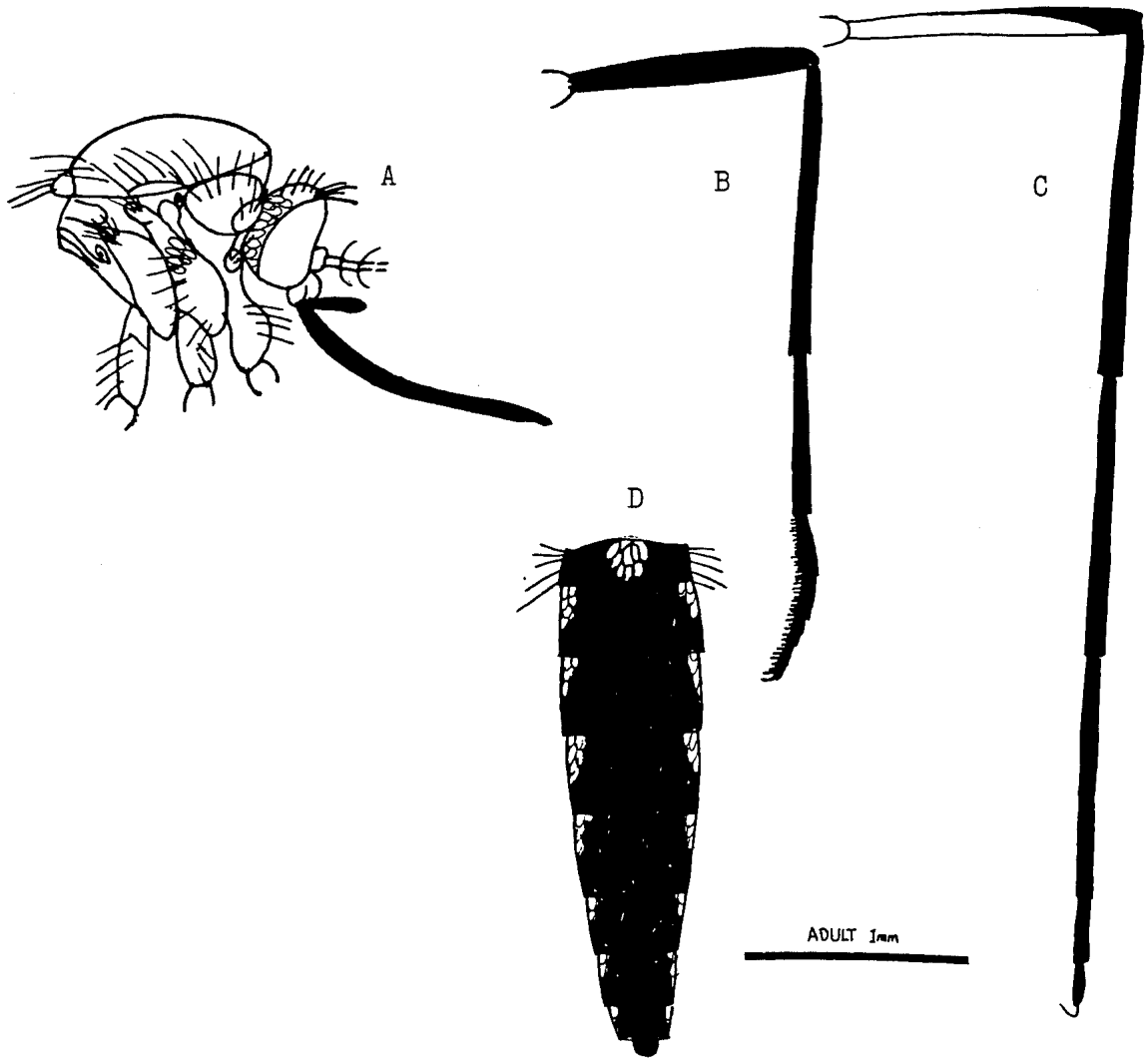
SPECIES WITH WHICH IT MAY BE CONFUSED

None.



Aedes (?) daliensis

A: Hindleg; B: Midleg; C: Foreleg; D: Abdomen (dorsal); E: Head and thorax (lateral); F: Larval head (dorsal); G: Mentum; H: Prothoracic setae 1-P to 7-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); K: Pecten teeth (detail).



Aedes (?) ENM's sp. No. 160
A: Adult head and thorax (lateral); B: Midleg; C: Hindleg; D: Abdomen (dorsal).

Aedes (?) ENM's sp. No. 160

This rare species is found in parts of the Kimberley Region and is also known from the Northern Territory and Queensland. It is known only from adults. The adults have been taken in chicken baited traps, and CO_2 baited traps. Adults have also been taken resting within a chicken coop. Little is known of the biology of the species.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Billiluna, Nov 1988, AEW; Apr 1989, AEW; Apr 1990 AEW; Apr 1991 AEW. Ord River, May 1972, PFSL; Dec 1972, PFSL; Nov 1973, PFSL; July 1978 PFSL/AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

CHAPTER 18 : Genus *ANOPHELES*

Anopheles is a widespread genus in W.A. with much greater species diversity in the northern half compared to the south. The subgenus *Cellia* is characterised by having a number of sibling species complexes, the members of which can be very difficult to separate on purely morphological grounds. These sibling species can be separated by analysis of banding sequences in preparations of polytene chromosomes from larval salivary glands, by electrophoretic analysis of larval or adult enzyme systems, or by cross mating experiments with known colony material. These techniques are difficult and time consuming, and are currently used for research rather than for routine field identification. It should also be noted that none of the sibling species have been described formally, and in many cases, morphological characters for separating the member species have not been determined. However, knowledge of the local fauna can often allow recognition of the species present.

GENERIC CHARACTERS

Adult: Clypeus longer than broad, rounded anteriorly. Palps of female as long as proboscis. Scutellum evenly rounded, without distinct lobes. Abdomen usually without scales, or with a few loosely applied scales.

Larva: Head longer than broad, rotates freely. Seta 2-C close to apical margin of head; setae 5-C to 7-C are pinnate and aligned in a distinct row across the middle of the head. Mentum generally long and narrow Abdomen with dorsal palmate tufts on all segments. Siphon absent. Pecten on posterior margin of distinc triangular chitinous plate. Setae 2-X and 4-X irregularly branched.

KEYS TO ADULT FEMALES OF *ANOPHELES* IN WESTERN AUSTRALIA

(Adapted from Lee and Woodhill, 1944).

1. – Wings uniformly dark scaled, or predominantly dark with no more than 2 pale spots on costa ..... [ANOPHELES] 2
   – Wings spotted, costa with at least 4 pale spots ..... [CELLIA] 4
2. – Wings uniformly brown (slender delicate species with brown integument) ..... *An (Ano) powelli*
   – Wings with at least some pale scales (larger species, with grey to black integument) 3
3. – Wing with costa entirely black (southern species) ..... *An (Ano) atratipes*
   – Wing with one pale spot on costal vein at termination of subcosta (northern species) ..... *An (Ano) bancroftii*
4. – Abdominal tergites II to VII with dense flat yellowish scales; sternites II to VII with abundant white to creamy scales 5
   – Abdominal tergites largely bare of scales; sternites bare or with at most a few scales 7
5. – 1-5 propleural bristles on a flat plate (sternites dark with distinct paired subbasal white patches; hind leg with pale spots on midlength of all tarsal segments) ..... *An (Cel) meraukensis*
   – 10-14 propleural bristles on raised boss (sternites creamy or with diffuse yellowish pale patches which extend beyond midpoint of segment; hind tarsi II-IV with basal and/or apical bands only) 6
6. – Hind tarsi II-IV dark with apical white bands only (apical palp largely dark) ..... *An (Cel) amictus*
   – Hind tarsi II-VI dark with both apical and basal pale bands (apical palp largely pale) ..... *An (Cel) hilli*
7. – Scutum bare of scales on lateral margins, black appearance ..... *An (Cel) novaguinensis*
   – Scutum with scales on lateral margins, grey appearance 8
8. – Segment III of palp with white apical portion divided by dark band ..... *An (Cel) farauti* complex
   – Palpi variable, but segment III with apical white portion never divided by dark band ..... [An (Cel) annulipes complex] 9
9. – Thorax and scutum with gingery appearance; proboscis dark (arid zone and Pilbara region) ..... *An (Cel) annulipes B*
   – Scutum with pale grey appearance; proboscis dark or with apical half pale 10

10. – Apical half of proboscis pale; apical half of palps largely pale (northern species) ..... *An (Cel) annulipes D*
– Proboscis dark; apical palp largely dark (south western species) ..... *An (Cel) annulipes A*

KEYS TO 4TH INSTAR LARVAE OF *ANOPHELES* IN WESTERN AUSTRALIA

(Adapted from Lee and Woodhill, 1944)

1. – Hair 1-A obvious, branched and projecting internally ..... [ANOPHELES] 2
– Hair 1-A inconspicuous, simple and projecting externally ..... [CELLIA] 4
2. – Hair 3-C with at least 11 branches, frequently with 50 or more ..... *An (Ano) bancroftii*
– Hair 3-C usually simple, or with not more than 6 branches 3
3. – Palmate tufts (seta 1) of abdomen not noticeably developed ..... *An (Ano) atratipes*
– Palmate tufts (seta 1) of abdomen obvious, at least on segments II to VII ..... *An (Ano) powelli*
4. – One long hair in each pleural group (setae 9-11 of pro-, meso- and metathorax) plumose or at least with 3-6 branches 5
– All long hairs of the pleural groups (setae 9-11 of pro-, meso- and metathorax) simple or at least one long hair of the propleural group with no more than 5 branches 7
5. – Hair 4-C 0.25 as long as 2-C, not projecting beyond the anterior margin of the head and with 5-6 branches ..... *An (Cel) novaguinensis*
– Hair 4-C 0.5 to 0.75 as long as 2-C, projecting beyond the anterior margin of the head, simple or rarely bifid 6
6. – Seta 1 of prothorax with about 4 branches ..... *An (Cel) hilli*
– Seta 1 of Prothorax with about 8 branches ..... *An (Cel) amictus*
7. – Hair 3-C always strongly branched dark tuft; Median plate of scoop elongate anteriorly with lateral projections on each side immediately behind apex ..... *An (Cel) meraukensis*
– Hair 3-C variable, usually simple or with few branches, occasionally a strongly branched dark tuft, then scoop is broad anteriorly without lateral projections 8
8. – Hair 4-C usually simple or bifid, more rarely with 4 branches, 0.1 to 0.5 as long as 2-C; Shaft of 1- P often flattened, and usually pigmented ... *An (Cel) farauti* complex
– Hair 4-C with 4-15 branches, not more than 0.25 as long as 2-C; shaft of 1-P not flattened ..... *An (Cel) annulipes* complex

Subgenus : *Anopheles*

SUBGENERIC CHARACTERS

Adult: Propleural hairs usually numerous; spiracular hairs usually present; prealar hairs present. Wings dark scaled, or at most with a few pale areas; bases of forked cells and areas adjacent to crossveins always dark; not closely spotted with dark and light spots over whole wing.

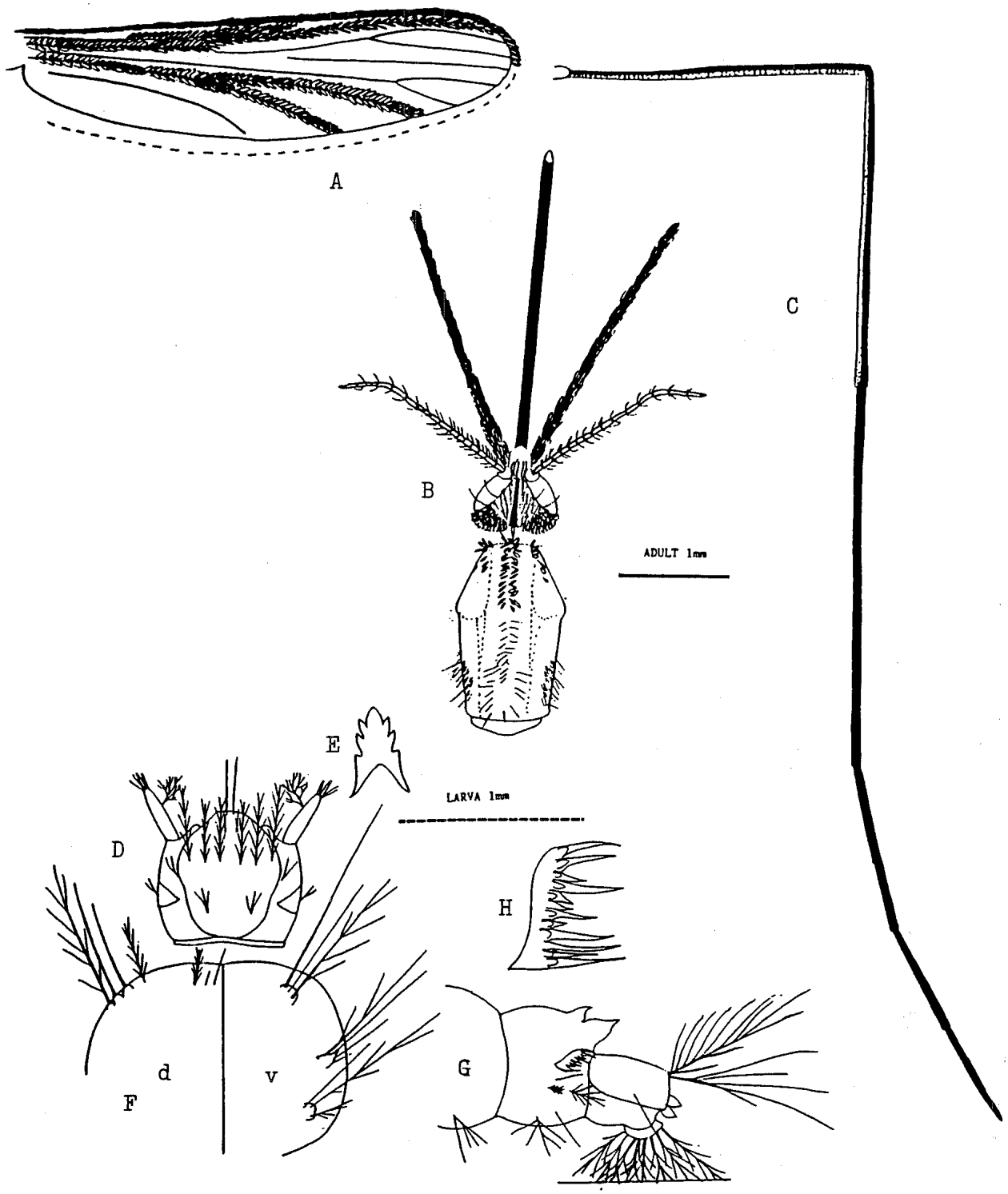
Larva: Antennal seta 1-A always branched. Seta 2-C of head set very close to midline.

Anopheles (Anopheles) atratipes Skuse 1889

Skuse, F., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1755.
Type locality: Berowra, New South Wales.
Synonymy: None.

ADULT FEMALE

A medium sized dark species. Head bare above in midline; pale scales on vertex extending onto frons; upright forked scales pale behind to occiput and dark laterally; broad flat dark scales on side of head. Torus and clypeus bare. Palp is dark black; as long as proboscis excluding labellum. Proboscis long, black; about 1.67x length of forefemur. Scutum largely bare, integument grey with some darker areas; a few long curved scales on anterior margin and in midline. Scutellum bare. Pleural integument grey/brown, with darker bands



Anopheles (Anopheles) atratipes

A: Wing (detail of scaling on some veins shown); B: Head and thorax (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Larval thorax (dorsal and ventral); G: Abdominal segment VIII (lateral); H: Pecten plate (detail).

running from posterior pronotum to upper mesepimeron, and along coxae; no scaling. Abdominal tergites and sternites bare, clothed in fine hairs. Legs dark scaled, pale below on femora and tibiae. Wing largely dark scaled, with dense dark scaling around bases of forked cells and along stem of cubital vein, and with a few long white patches on some veins, but not on bases of forked cells. Haltere with pale stem, club clothed in dense black scales.

LARVA

The larva has a very dark appearance. Antenna dark, slightly swollen at base; about 0.44x length of head; seta 1-A branched, dendritic, and inserted at 0.54 from base of antenna and inwardly projecting. Head about 0.96x as long as broad; about 0.5x width of thorax; seta 2-C single, near midline; 4-C single; 5-C to 7-C plumose with 8, 11 and 14 branches respectively, set in row across midline of head; 8-C and 9-C bifid. Palmate tufts present dorsally on abdomen. Seta 1-VIII plumose with 12 branches; 2-VIII and 4-VIII single; 3-VIII plumose with 8 branches; 5-VIII plumose with 5 branches. Siphon absent; pecten set on chitinous plate. Saddle covers dorsal half of anal segment; seta 1-X single; 2-X, 3-X and 4-X irregularly branched. Anal papillae short and globular.

BIOLOGY

Larvae are found in paperbark swamps, in shaded stained permanent waters. Adults are found from about October to February, but larvae may be collected through the winter months. Adults will enter CO_2 baited traps occasionally. They are day biting and will attack man. *An atratipes* is never a common species.

RELATION TO DISEASE

None known.

DISTRIBUTION

Albany, Aug 1956, EJB/EPH. Augusta/Margaret R., Jun 1955, EJB. Bunbury, Nov 1985, AEW. Bullsbrook, Sep 1980, AEW; Oct 1980, PFSL. Collie, May 1956, EJB. Drakesbrook, Mar 1955, EJB. Dwellingup, Nanga Brook, Feb 1952, EPH. Esperance, 17km N, Nov 1954, EPH. Lake Chandala, Aug-Sep 1980, AEW. Manjimup, May 1956, EJB. Muchea, Sep 1980, AEW. Nannup, May 1956, EJB. Nornalup, Oct 1965, NVD. Perth, Swanbourne, Sep 1946, EPH. Stirling Range, Red Gum Pass, Oct 1965, NVD. Wanneroo, Jun 1955, EJB. Yanchep National Park, Feb 1985, ALD.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Anopheles (Anopheles) bancroftii Giles 1902

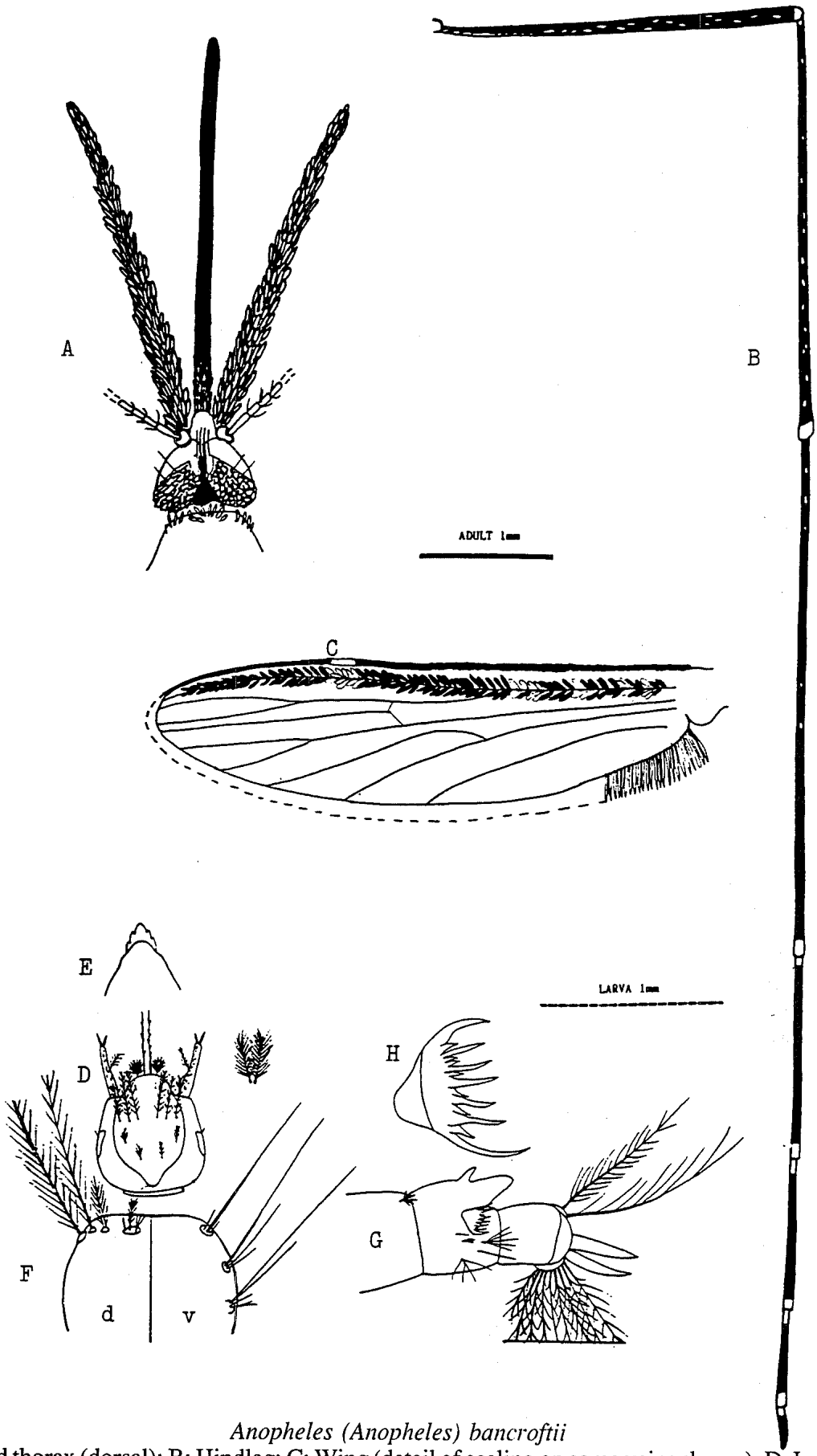
Giles, G.M., 1902. *A handbook of the gnats or mosquitoes* (2nd. edit.) p511.
Type locality: Burpengary, Queensland.
Synonymy: None.

ADULT FEMALE

A large dark shaggy species confined to northern W.A. Head bare in midline, narrow white decumbent scales in small patch extending onto frons; upright forked scales dark. Torus with black scales. Clypeus bare. Palps are clothed in dark brown/black long suberect scales and have a shaggy appearance; about 0.9x length of proboscis. Proboscis is black scaled with suberect scales ventrally near base, about equal in length to forefemur. Scutal integument is dark grey/brown, clothed in fine hairs; long curved suberect scales along anterior margin, above wing root and around prescutellar space. Scutellum bare with posterior fringe of long pale hairs. Pleura are largely bare, with dense patch of erect dark scales on anterior part of anterior pronotum; a few pale scales on the propleuron, posterior sternopleuron and upper mesepimeron. Abdomen with tergites all bare, clothed in fine hairs; sternites largely bare, with subapical median patches of white scales on sternites II to VIII, sternite VIII also with some suberect median apical black scales. Coxae of all legs with small patch of white scales. All legs dark scaled but forefemora and midfemora with some pale scales ventrally. Wings black scaled with small white costal spot about 0.67 from base. Haltere with pale stem; club densely clothed with jet black scales.

LARVA

Antenna same colour as head; about 0.4x length of head; seta 1-A branched, inserted at about midpoint of antenna. Head about 1.17x longer than broad; about 0.5x width of thorax; seta 2-C single and inserted near midline; 3-C short, densely branched; 4-C single; 5-C to 7-C large and plumose and in single row at midpoint of head; 8-C and 9-C smaller and also plumose. Seta 1 of all abdominal segments always palmate. Setae 1-VIII and 4-VIII single; 2-VIII plumose with 10 branches; 3-VIII and 5-VIII with 4-5 branches. Siphon absent; pecten with 16 alternating long and short teeth set on chitinous plate. Saddle covers dorsal half of the anal segment, with a posterior fringe of spines; seta 1-X single, long; 2-X irregularly branched; 3-X plumose; 4-X with 9 pairs of irregularly branched setae. Anal papillae long and pointed; about 1.15x length of saddle.



Anopheles (Anopheles) bancroftii

A: Head and thorax (dorsal); B: Hindleg; C: Wing (detail of scaling on some veins shown); D: Larval head (dorsal); E: Mentum; F: Larval thorax (dorsal and ventral); G: Abdominal segment VIII (lateral); H: Pecten plate (detail).

BIOLOGY

This species breeds in deeply shaded freshwater swamps, commonly among reeds, and are cryptic and difficult to find. Adults bite man readily in W.A. Adults also feed on mammals and birds. Often taken in light or CO_2 baited traps. *An bancroftii* are found throughout the year, but highest numbers occur in the May to November period.

RELATION TO DISEASE

An bancroftii is considered to be a secondary vector of malaria, and has been implicated in malaria transmission in Queensland. It is also a known vector of filariasis.

Three arboviruses, Kunjin, Koongol and Bovine Ephemeral Fever virus have been isolated from *An bancroftii*, and Eubenangee virus from a mixed pool containing some *An bancroftii*. Of these, Kunjin is known to cause Australian Encephalitis in man, and Bovine Ephemeral Fever is an important veterinary disease causing severe losses in epidemics. On present data, the role of *An bancroftii* in the transmission of arboviruses remains unclear.

DISTRIBUTION

Camballin, May 1979, AEW; Jul-Aug 1979, AEW. Carnarvon, Feb 1984, MEC.* Derby, Mar-Apr 1977, AEW; Aug-Sep 1978; Mar-Apr 1980, RN/JR; Apr 1981, RN/JR. Derby, Myalls Bore, Sep-Oct 1978, AEW; May 1980, RN/JR; Feb 1981, RN/JR; Apr 1981, RN/JR. Drysdale R., Aug 1979, AEW. Exmouth, US Navy Base, Aug 1980, PS. Forrest River Mission, Jun 1954, RKC. Isdell. Kalumburu, Aug 1953, EJB; Mar 1954, EPH; Jul 1978, AEW; Aug 1979, AEW. Kimberley Downs, May 1979, AEW. Kunmunya Mission, May 1940, Da. Kununurra, Nov-Dec 1973, PFSL; Apr 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Jul 1976, AEW; Apr-May 1977, AEW; Nov - Dec 1977, AEW; Jul 1978, PFSL/AEW; Dec 1979, OA; Feb 1980, OA; Apr-Sep 1980, OA; Dec 1980, OA; Mar-Jul 1981, OA. Mitchell Plateau, Jul 1981, AEW. Port Hedland, Feb 1984, MEC.* Wyndham, May-Jul 1980, OA.
(* specimens not seen or verified by an experienced entomologist.)

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Anopheles (Anopheles) powelli Lee 1944

Lee, D.J., 1944. *Proc. Linn. Soc. N.S.W., 69:* 21.
Type locality: Adelaide River, Northern Territory.
Synonymy: None.

ADULT FEMALE

A small delicate slender pale brown species. The head is narrow, set on a pronounced neck, with a few upright scales on occiput. Torus and clypeus bare. Palp long and slender, all brown; about 0.9x length proboscis. The proboscis is also long and slender, dark scaled. Scutal integument brown, bare. Scutellum bare with posterior line of short and long bristles. Pleura without scales. Abdominal tergites and sternites brown in colour, without scaling, and clothed in fine hairs. All coxae bare. Legs all dark. Wings uniformly dark scaled. Haltere with pale stem; club with black scales.

LARVA

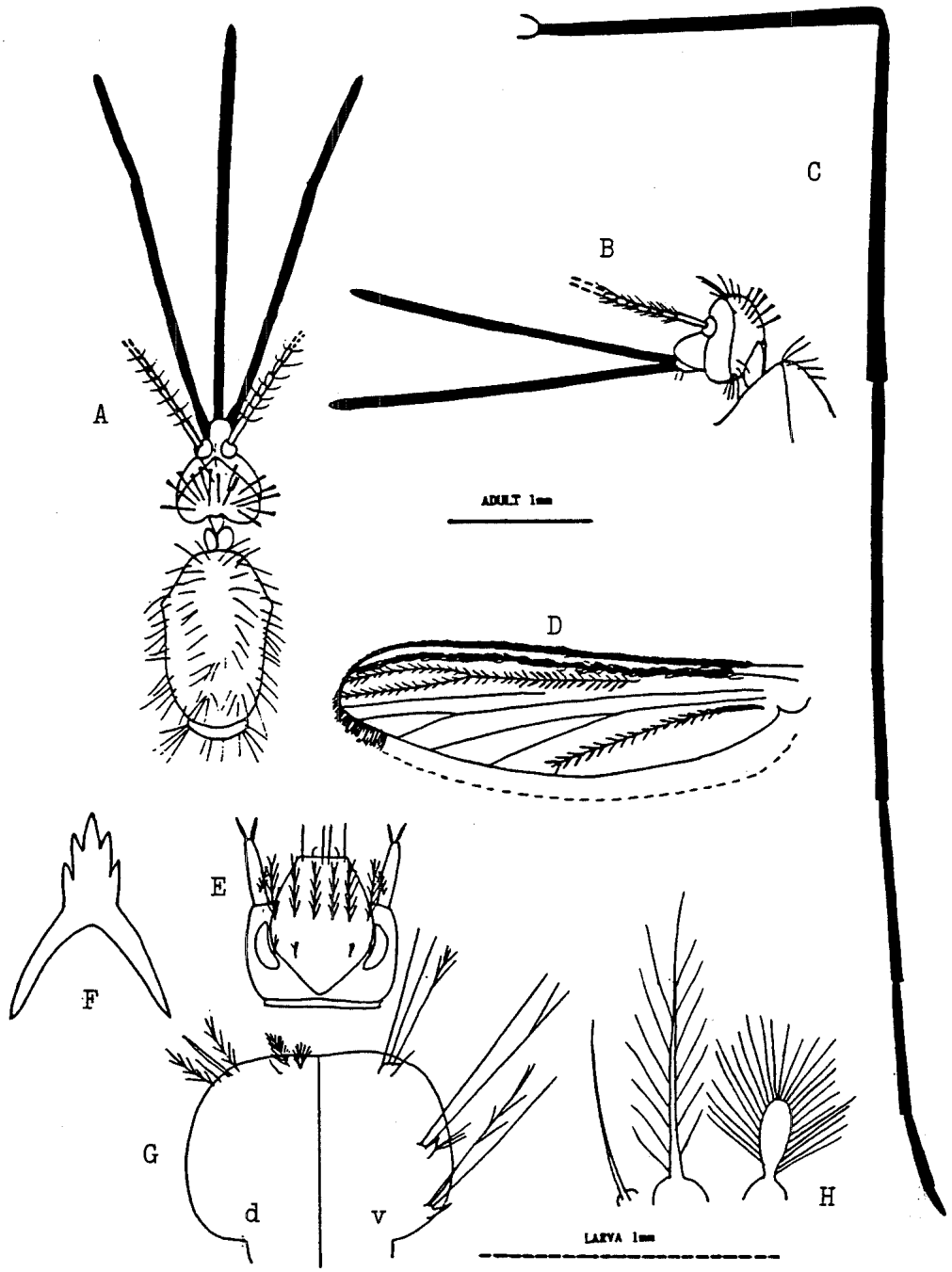
Head and antenna brown; antenna about 0.44x length head; seta 1-A small with 7-8 branches, arising near base. Head about 0.8x as long as broad; about 0.94x width of thorax; setae 2-C and 3-C single, simple, 2-C inserted near midline and occasionally bifid; 4-C very fine with 2-4 branches; 5-C to 7-C plumose and in line, barely reaching level of 4-C. Palmate abdominal setae present. Pecten of about 14 teeth on plate, the outer teeth being longer than those medially.

BIOLOGY

Breeding places are shallow, shaded swampy pools, overgrown with grass. The adults occasionally bite man, but are sometimes caught in CO_2 baited traps. *An powelli* is generally very rare in collections. In the Darwin region, the species is collected in very small numbers during the February-June period.

RELATION TO DISEASE

None known.



Anopheles (Anopheles) powelli

A: Head and thorax (dorsal); B: Head (lateral); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Larval thorax (dorsal and ventral); H: Abdominal segment VIII (lateral); I: Pecten plate (detail).

DISTRIBUTION

Derby, Aug-Sep 1978, AEW. Mitchell Plateau, Jul 1981, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Cellia*

SUBGENERIC CHARACTERS

Adult: Propleural and spiracular bristles variable in number, sometimes absent. Wings almost always spotted with white and dark spots over all veins.

Larva: Antennal seta 1-A always short and simple, usually on outer surface. Head setae 2-C separated from midline by a distance of at least 0.12x their length.

Anopheles (Cellia) amictus Edwards 1921

Edwards, F.W., 1921. *Bull. Ent. Res., 12:* 71.
Type locality: Townsville, Queensland.
Synonymy: None.

ADULT FEMALE

Moderately large species. Vertex with pale eye border; narrow pale decumbent scales medially to mid vertex; dark upright forked scales on occiput. Antenna with some pale scales on basal half. Clypeus bare. Palp as long as proboscis, dark scaled with narrow white basal and apical bands on all segments, and mesial pale patches at midpoint of palp segments I and II. Proboscis all dark; about 0.9x length of forefemur. Scutal integument grey; clothed in sparse scattered white scales. Scutellum with long pale scales. Pleura grey, largely bare with small patches of scales on lower sternopleuron, upper mesepimeron and the prealar area; propleuron is a raised boss with 10-14 fine bristles. Abdomen with tergites densely clothed in flat yellowish scales, some white scales forming subbasal lateral patches and bands; sternites clothed in mixture of white and black scales, with pale median basal patches, median stripe, and apicolateral patches. All coxae with small patches of white scales. Hindfemur dark with about 11 white bands along entire length; hindtibia dark with 9 white bands; hindtarsus I banded on basal half, dark apically with narrow apical band, hindtarsi II to IV black with narrow apical white band, tarsus V all dark. Wing spotted with alternating white and black scale patches on all veins; fringe dark with small white spot at end of each vein.

LARVA

Antenna pale, about 0.36x as long as head; seta 1-A short, simple, inserted about 0.17 from base, directed outwardly. Mentum with 5 teeth on each side. Head about 1.09x longer than broad; about 0.46x width of thorax; setae 2-C to 4-C simple; 5-C to 7-C plumose and in row, 5-C being the longest of the three. Shoulder hairs (1-P, 2-P and 3-P) not on fused base. Pleural groups (setae 9-P to 11-P; 9-M to 11-M; 9-T to 11-T) each with one long hair strongly branched. Setae 1-VIII and 5-VIII with 3 branches; 2-VIII and 4-VIII single; 3-VIII with 3-4 branches. Pecten with 13 teeth on plate. Saddle covers dorsal half of anal segment; seta 1-X single; 2-X and 3-X plumose and irregularly branched; 4-X with 9 pairs of plumose irregularly branched setae. Anal papillae short and blunt.

BIOLOGY

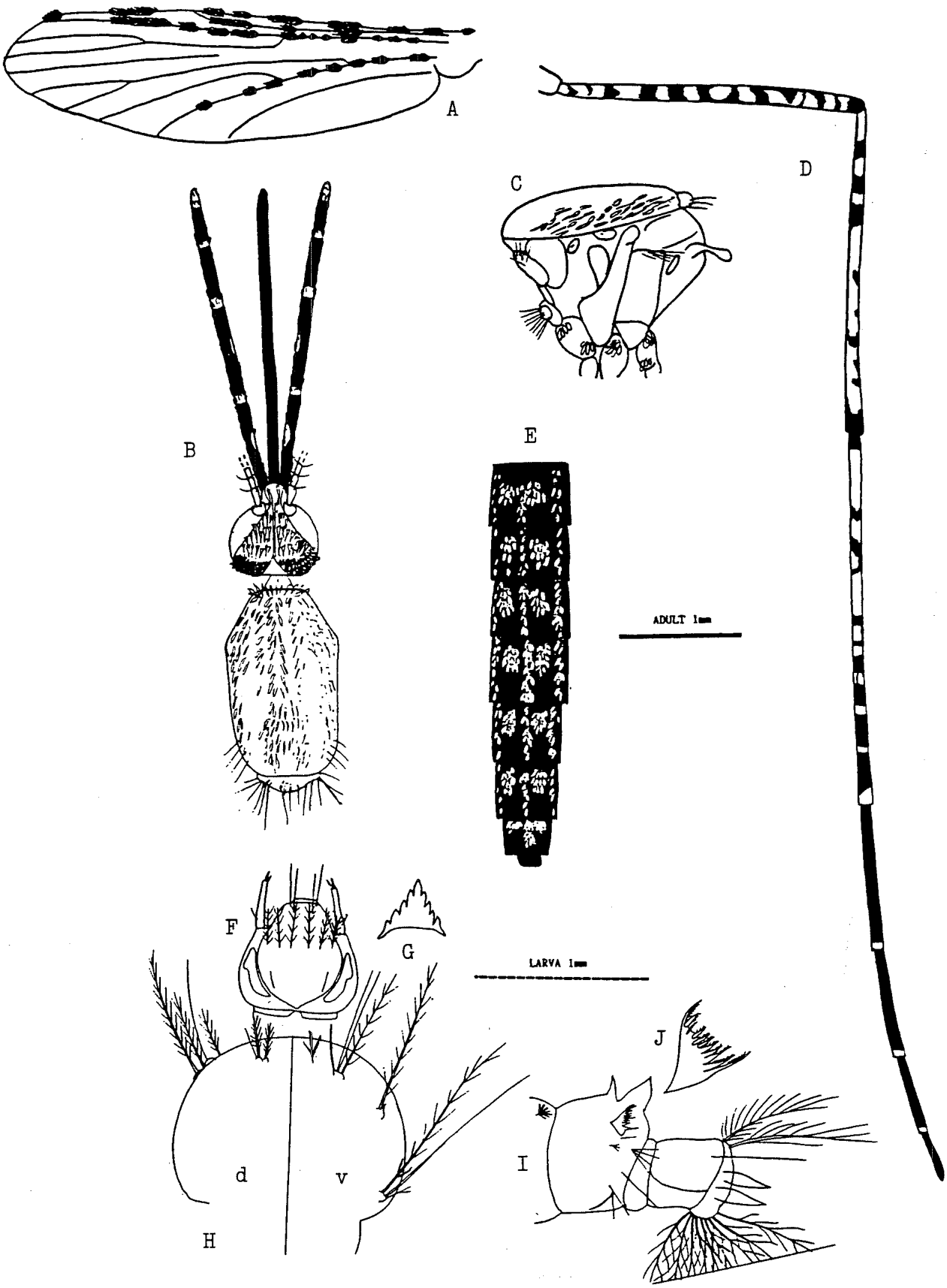
An amictus breeds in fresh water, either natural or man made, sunlit or shaded, in sheltered margins or amongst vegetation. The females will feed on man and will bite cattle. Adults are readily captured in mammal and bird baited traps, in light traps and CO_2 baited traps.

RELATION TO DISEASE

Susceptible to infection with malaria and filariasis experimentally. Suspected vector of malaria in northern W.A. RRv has been isolated from this species, as have Mapputta virus and Kowanyama virus. The vector potential of this species for arboviruses remains uncertain.

DISTRIBUTION

Argyle Downs, RHB. Balgo, Jun 1978, AEW; Mar 1981, AEW. Balgo, 24km W, Mar 1981, AEW. Balgo, Acacia creek, Jun 1978, AEW; Mar 1981, AEW. Balgo, Darbai R., Mar 1981, AEW. Billiluna, Mar 1981, AEW. Broome, Sep 1978, AEW; Sep 1984, MEC. Camballin, May 1979, AEW; Jul-Aug 1979, AEW. Carnarvon, May 1984, WJOB. Cherrabun, May 1979, AEW. Derby, Mar 1953, EPH/EJB; Apr 1953, AKO; Aug 1953, EJB; Aug-Sep 1978, AEW; Apr 1981, RN/JR; Mar 1985, AEW. Derby, Myalls Bore, Mar 1954, EPH; Sep-Oct 1978, AEW; Apr 1980, RN/JR. Drysdale River, Aug 1979, AEW. Forrest River Mission, Aug 1953, EJB. Halls Creek, Apr 1967, EJB; Jul 1984, MEC. Kalumburu, Jul 1978 PFSL/AEW. Karratha, Aug-Sep 1980, MW/TH. Kimberley Downs, Mar 1953, EPH/EJB; Mar 1954, EPH; May 1979, AEW. Kimberley Downs Stn,34km E, Mar 1954, EPH. Kimberley Research Station, Mar 1953, EPH/EJB; Apr 1953, RL; Apr 1953, AKO; Mar 1954, EPH/EJB; Apr 1954; Oct 1961, KTR. Kimberley Research Station, Martins Swamp, Mar 1954, EPH. Kimberley Research Station, Mar 1954, EPH. Kimberley Downs Station, May 1979, AEW. Kununurra, Aug 1962, KC; Oct 1962, KC; Apr-Jun 1972, PFSL; Nov-Dec 1972, PFSL; Jan 1973, PFSL; Apr 1974, PFSL; Aug 1974, JHS; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Jul 1976, AEW; Oct-Nov 1976, AEW; Apr 1977, AEW; Nov-Dec 1977, AEW; Aug 1978, PFSL/AEW; Dec 1979, OA; May-Sep 1980, OA. Lake Argyle, S, Aug 1978, PFSL/AEW. Lissadel, Aug 1978, PFSL/AEW. Louisa Downs, May 1979, AEW. Mitchell Plateau, Aug 1981, AEW. Moola Bulla Station, May 1951, EJB.



Anopheles (Cellia) amictus

A: Wing (detail of scaling on some veins shown); B: Head and thorax (dorsal); C: Thorax (lateral); D: Hindleg; E: Abdomen (ventral); F: Larval head (dorsal); G: Mentum; H: Larval thorax (dorsal and ventral); I: Abdominal segment VIII (lateral); J: Pecten plate (detail).

Newman, Mar 1979, AEW; Mar 1981, PF. Nillibubblica, Aug 1953, EJB. Noonkanbah, Apr 1986, AEW. Parrys Creek, Apr-Jun 1972, PFSL; Apr 1973, PFSL. Port Hedland, Sep 1984, MEC. Sturt Creek Station, Oct 1978, AEW. Tom Price, Mar 1979, AEW. Turkey Creek, Aug 1978, PFSL/AEW. Williambury Stn, Jun 1985, MEC. Wyndham, May 1926, MM; Mar 1953, EPH/EJB; Apr 1953, AKO; LJN; Jun 1981, OA. Wyndham/Kimberley Research Station, Apr 1953, RL. Yeeda Station, Apr 1967, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

An amictus is difficult to distinguish from *An hilli*. These are closely related and were considered to be subspecies for a long time. *An hilli* is distinguished by the banding on the hind tarsi which extends over the join between the segments. *An meraukensis* may also be confused with *An amictus*. *An meraukensis* can be distinguished by the presence of distinct white scale patches on sternites II to VII.

Anopheles (Cellia) annulipes Walker 1856

Walker, F. 1856. *Insecta Saundersiana Vol.I. Diptera.* p433.
Type locality: Van Diemens Land, (Tasmania).
Synonymy: *Anopheles musivus* Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1754.
Anopheles mastersi Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1757.
Anopheles perplexus Taylor, F.H., 1943. *Proc. Linn. Soc. N.S.W., 68:* 153.
Anopheles derricki Taylor, F.H., 1943. *Proc. Linn. Soc. N.S.W., 68:* 155.
Anopheles persimilis Taylor, F.H.,1943. *Proc. Linn. Soc. N.S.W., 68:* 155.

An annulipes is a sibling species complex. Three distinct species have been recognised from W.A. by Dr. C.A. Green (designated species A, B and D). These species have been shown to be distinct in cross mating experiments, chromosomal analyses and studies on enzyme electrophoretic mobility patterns. Other species in the complex are known from elsewhere in Australia and the recent study on the chromosomal patterns seen in the complex indicates the presence of at least 7 chromosomal types (Booth, R.R., Green, C.A., Bryan, J.H. Aust. J. Zool. 35(1987): 247-252). Traditionally, *An annulipes* was known to be a highly variable, and widely distributed species. At least some of this variability can now be explained by the fact that we are dealing with a sibling species complex. It should be recognised that the complex has yet to be fully analysed, and it is possible that more member species await discovery, possibly some within W.A. Much work remains to be done before the various synonyms of *An annulipes* can be assigned to member species. The only sample analysed from Tasmania proved to be a distinct species, and it is possible that the name *An. annulipes* is invalid for all mainland forms currently assigned to the taxon *An annulipes*.

The three W.A. members of the complex (species A, B, and D) are fairly common within their respective ranges. The different species have not been described previously, and will only be briefly described below.

It should be recognised that all of our accumulated knowledge of the behaviour, biology and vector status of *An annulipes* is based on *An annulipes* s.l. and will need to be reevaluated in the light of the recognition of the complex. In addition, many of the historical collection records, where specimens are not available for checking, cannot be placed within any of the newly recognised species with any certainty. What follows is an analysis of the behaviour of *An annulipes* s.l., and the distribution records which have not been separated into the various newly recognised species.

BIOLOGY

An annulipes s.l. exploits a wide array of ground and rockpool breeding sites, generally in fresh water habitats. It has occasionally been found breeding in brackish sites, and in polluted waters. The sites are generally semi- permanent to permanent sites, but the species also colonises temporary ground pools of all sorts. It has been collected breeding in domestic container habitats on occasion. Typical sites are larger pools with filamentous algae, and animal hoof prints on the margins of larger pools. Breeding is often in association with *Cx annulirostris* and *Cx australicus*, though records show that it has been recorded as sharing breeding sites with a wide variety of species. The adults are found throughout the year in southern areas, with a peak in numbers in the summer months. In tropical areas, peak numbers are in the mid dry season. The adults can survive prolonged periods without rain by seeking sheltered resting places. The adults bite man readily, both during the day and with peak biting after sunset. It will also feed on a variety of mammals and birds. *An annulipes* s.l. is the dominant Anopheline mosquito in Australia.

RELATION TO DISEASE

This species group is implicated as a malaria vector, but its status remains uncertain. *An annulipes* s.l. was shown to play an important role in the spread of Myxomatosis in Australia, particularly as a consequence of its use of rabbit burrows as resting sites. A number of arboviruses have been isolated from pools of *An annulipes* s.l. : Kowanyama virus, Trubanaman virus, Mapputta virus, Tilligerry virus and Sindbis virus. Experimental data indicates that MVEv will not replicate in *An annulipes* s.l.

DISTRIBUTION

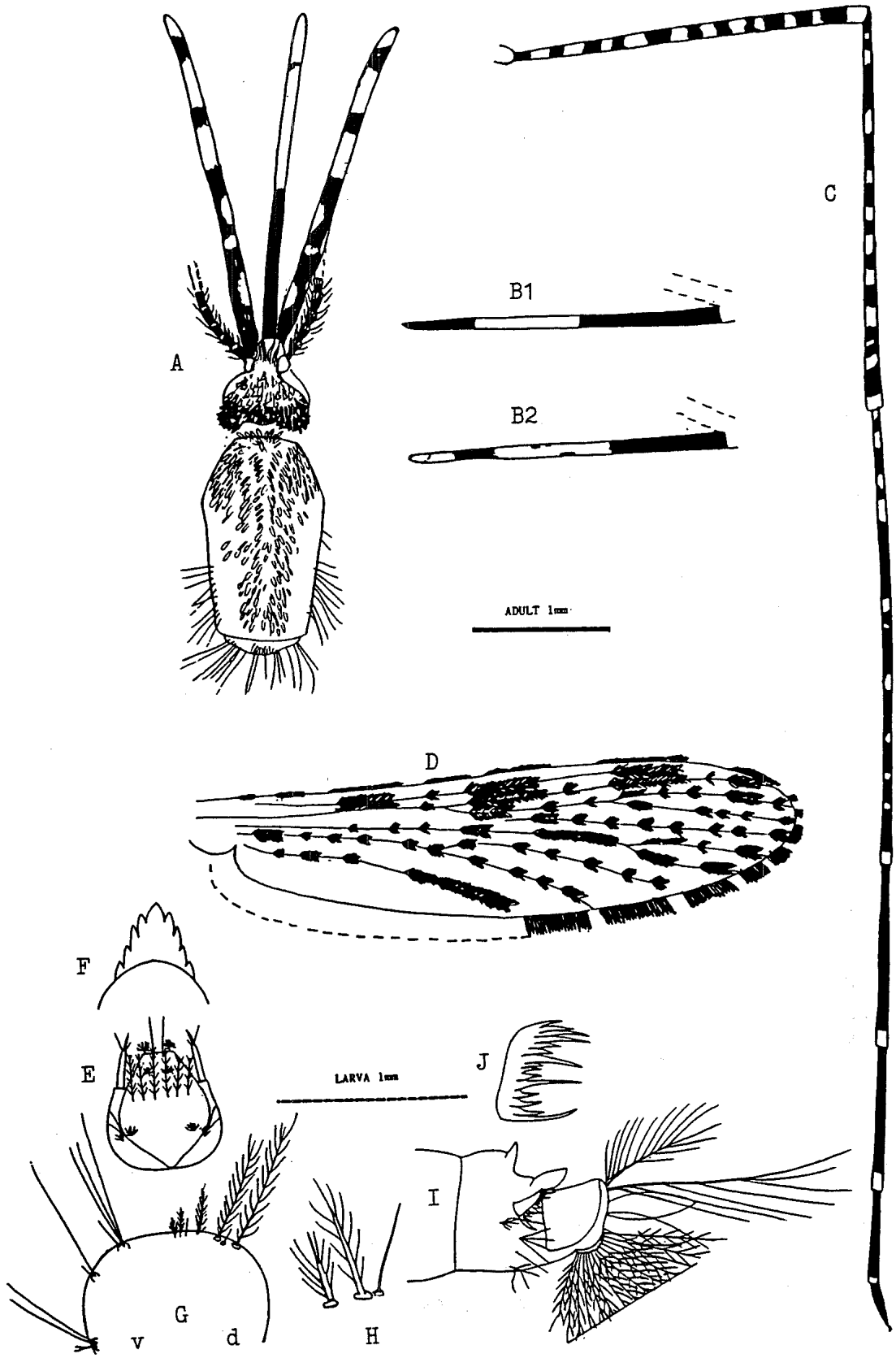
Argyle Downs, RHB. Argyle Station, Jul 1953, EJB. Ashburton, Jun 1955, EJB. Augusta, Oct 1974, PFSL. Augusta/Margaret R., May 1956, EJB. Badgingarra, Jul 1985, MEC. Balgar Plains, Jul 1985, MEC. Balgo, Jun 1978, AEW; Mar 1981, AEW. Balingup, May 1956, EJB. Barradale Crossing, Jun 1955, EJB. Beckenham, Jul 1953, KTR; May 1969, KTR. Bedford Downs Stn, Nov 1984, MEC. Bejoording, May 1951, CFHJ. Beverley, Mar 1952, KRN; Nov 1952, KRN. Beverley, 5km SE, Aug 1973, PFSL. Beverley, Myal Pool, Dec 1952, KRN. Billiluna, Mar 1981, AEW. Binnu, May 1985, MEC. Boddington, Mooradung Brook, Mar 1972, PFSL. Bohemia Downs, RHB. Bolgart, Aug 1952, DG. Boologooro Stn, May-Jun 1985, MEC. Boyup Brook, Oct 1934, KRN. Brickhouse Stn, May-Jun 1985, MEC. Bridgetown, May 1951, EGH; Nov 1951, JF; May 1956, EJB. Brookton, Jun 1955, EJB. Broome, Sep 1978, AEW; May 1984, MEC; Apr 1985, MEC. Bruce Rock, Jul 1956, EJB. Bullsbrook, Sep 1980, AEW. Bunbury, Jan 1985, AEW; Apr-Dec 1985, AEW. Callagidi Stn, May 1985, MEC. Calwynyardah Stn, Oct 1984, MEC. Camballin, May 1979, AEW; Jul 1979, AEW; Aug 1979, AEW. Canning R., Kent St Weir, Feb 1974, PFSL. Capowi, May 1985, MEC. Carnamah, May 1955, EJB. Carnarvon, Apr 1979, AEW; Nov 1980, AH/CS; Jul 1981, AH/CS; May 1984, JWOB; Aug-Sep 1984, MEC; Apr-Jun 1985, MEC. Carnarvon, 36 Mile Bore, Apr 1985, MEC. Carnarvon, Bilbawarra Bore, May 1985, MEC. Cherrabun, May 1979, AEW. Chittering, Jul 1955, EJB. Christmas Creek, RHB. Corrigin, Jun 1955, EJB. Dale R., Jan 1952, KRN. Dalwallinu, Jul 1955, EJB. Dampier, Aug-Oct 1984, MEC; Jan 1985, MEC. Dampier Downs, Oct 1984, MEC. Dandaragan, Jul 1955, EJB. Darkan, Nov 1952, DG; Jan 1953, DG. De Grey Crossing, Sep 1953, EJB; Jun 1978, AEW. De Grey Station, Jun 1978, AEW. Derby, WDD; Mar 1953, EPH/EJB; May 1953, AKO; Mar 1954, EJB; Mar 1954, EPH; Aug-Sep 1978; Aug 1980, RN/JR; Jul-Aug 1984, MEC; Mar 1985, AEW. Derby, 24km E, Apr 1977, AEW. Derby, 40km S, Apr 1977, AEW. Derby, Langie Crossing, Mar 1954, EPH. Derby, Myalls Bore, Sep-Oct 1978, AEW; Apr 1980, RN/JR; Feb 1981, RN/JR. Derby, Yeeda Creek, Mar 1954, EPH. Dogger Gorge, Fortescue R., Jan 1975, PFSL. Donnybrook, Aug 1930, Ma; Jan 1952, Ma; Mar 1952, Boo; Nov 1952, DG; Jan 1953, DG. Doorawarrah Stn, May 1985, MEC. Dowerin, Jul 1956, EJB. Drakesbrook, Mar 1955, EJB. Drysdale R., Aug 1979, AEW. Dundas, Aug 1956, EJB. Edajee Stn, May 1985, MEC. Ellabella Stn, May 1985, MEC. Esperence, Aug 1956, EJB. Exmouth, Apr-Jun 1980, PS; Aug 1980, PS. Exmouth, US Navy Base, Mar 1980, PS; Aug 1980, PS; Nov 1980, PS. Fitzroy Crossing, RHB; Oct 1950, EJB; Jul-Aug 1984, MEC; Apr 1985, MEC; Jul 1985, MEC. Fitzroy R. crossing, Oct 1950, EJB. Flora Valley, RHB. Forrest River Mission, Apr 1955, RKC. Fortescue R., Jan 1975, PFSL; Jan 1985, MEC. Fremantle, Jun 1956, EJB. Fossil Downs Stn, Oct 1984, MEC. Galena, May 1985, MEC. Gascoyne Junction, May 1985, MEC. Gascoyne/Minilya, Jul 1955, EJB. Geraldton, Aug 1985, MEC. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Gingin, 15km E, Sep 1973, PFSL. Glenroy, Sep 1984, MEC. Gnowangerup, Jul 1956, EJB. Goomalling, Jul 1955, EJB. Gordon Downs, RHB. Gregorys Gorge, Jan 1975, PFSL. Guildford, Nov 1953. Halls Creek, RHB; May 1951, EJB; Jul 1984, MEC. Hamilin Stn, Apr 1985, MEC. Harvey, Apr 1955, EJB. Helena R., Guildford, May 1963, JBF. Helena R., Kalamunda, May 1963, JBF. Hutt River, Apr-May 1985, MEC. Irwin, Mar 1954, DLM; May 1955, EJB. Jandakot, Nov 1942; Jan-Apr 1972, JCT; Jun-Dec 1972, JCT; Mar 1974, PFSL; Mar 1975. Jandakot, Russell Swamp, Mar 1974. Jandawaring, Jul 1985, MEC. Jurien Bay, Sep 1974, JHS; Jul 1985, MEC. Kalumburu, Mar 1953, EPH/EJB; Mar 1954, EPH; Aug 1979, AEW; Jul 1978, AEW. Kalumburu, Carson R., Mar 1954, EPH. Kalumburu, Longonye Creek, Mar 1954, EPH. Karratha, Mar 1979, AEW; Apr 1981, MW/TH; May-Oct 1984, MEC; Dec 1984, MEC; Jan 1985, MEC; Jul 1985, MEC. Katanning, Jan 1953, DG; Aug 1956, EJB. Keep R., Sep 1967, BJM. Kellerberrin, Jul 1956, EJB. Kimberley Downs, Mar 1953, EPH/EJB; Mar 1954; May 1979, AEW. Kimberley Downs, 34km E, Mar 1954, EPH. Kimberley Research Station, Jan 1952, RL; Mar 1953, EPH/EJB; Apr 1953; Mar 1954, EPH; Oct 1961, KTR. Kojonup, Mar 1955, DLM. Kondinin, Mar 1955, EJB. Koorda, Jul 1956, EJB; Jul 1974, PFSL. Kununurra, Oct 1961, KTR; Apr-Jun 1972, PFSL; Nov-Dec 1972, PFSL; Jan 1973, PFSL; Nov-Dec 1973, PFSL; Apr 1974, PFSL; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Jul 1976, AEW; Oct-Nov 1976, AEW; Apr-May 1977, AEW; Nov-Dec 1977, AEW; Jul 1978, PFSL/AEW; Jan 1980, OA; Apr-Dec 1980, OA; Jan 1981, OA; Mar-Jul 1981, OA. Lake Argyle, Apr-Jun 1972, PFSL; Nov-Dec 1977, AEW; Jul 1978, PFSL/AEW. Lake Chandala, Aug-Sep 1980, AEW. Lake Cronin, Jun 1978, TFH. Lake Grace, Mar 1955, EJB. Lake Gwelup, Nov 1983, JCT. Lake Joondalup, Dec 1977, AB. Lancelin, Jun 1974, PFSL. Laverton, Aug 1956, EJB. Laverton, Banclya, Jun 1954, EJB.

Leonora, Jun 1956, EJB. Lissa Down Stn, Nov 1984, MEC. Lissadell, Jul 1978, PFSL/AEW. Liveringa, Apr 1953; Jun 1955, AKO. Lockyer Gap, Nov 1984, MEC. Louisa Downs, RHB; May 1979, AEW. Lyndon R., NWC Hwy, Sep 1974, JHS. Lyndon Stn, Jun 1985, MEC. Manjimup, May 1956, EJB. Marble Bar, Sep 1974, JHS; Mar 1979, AEW; Dec 1984, MEC. Margaret R. Stn, RHB. Marron Stn, May 1985, MEC. May River, Mar-Apr 1977, AEW. Meeragoolia Stn, May 1985, MEC. Merredin, Jul 1956, EJB. Mia Mia Stn, Jun 1985, MEC. Miaree Pools, Jun 1984, MEC; Oct 1984, MEC; Jan 1985, MEC. Millars Well, Nov 1984, MEC. Millstream, Jun 1953, EPH/EJB; Sep 1953, EJB; Mar 1954, EPH; Jun 1954, EPH; Sep 1954, EPH; Jan 1975, PFSL; Apr 1979, AEW; Nov 1984, MEC. Millstream, Dawsons Springs, Jun 1954, EPH. Millstream, Palm Pool, Jan 1975, PFSL; Apr 1979, AEW. Millstream, Yearling Pool, Jun 1954, EPH. Millstream/Roebourne, Jun 1954, EPH. Minderoo, Jun 1955, EJB. Minilya R., Sep 1974, JHS. Minilya Roadhouse, May 1985, MEC. Minnie R., Mar-Apr 1977, AEW. Mitchell Plateau, Jul 1981, AEW. Miudja Community, Oct 1984, MEC. Mooka Stn, May 1985, MEC. Moola Bulla, RHB; May 1951, EJB. Moora, Jun 1955, EJB. Morowa, May 1955, EJB. Mt Magnet, Apr 1985, MEC. Mt Marshall, Jul 1956, EJB. Mt Ragged, 24km N, Jul 1953, DLM. Mullewa, Jun 1955, EJB; Apr 1985, MEC. Mumballup, Sep 1974, PFSL. Murray, May 1956, EJB. Murray R., Apr 1971, CAG. Nanutarra, Sep 1974, JHS; Apr 1980, AEW. Narembeen, Jul 1956, EJB. Narrogin, Mar 1955, EJB. New Cherrabun Stn, Oct 1984, MEC. Newman, Oct 1978, AEW; Mar 1979, AEW; Mar 1981, PF. Newman, Gingianna Billabong, Mar 1979, AEW. Newman, Whaleback Creek, Mar 1979, AEW. Nicholson, RHB. Noonkanbah, Oct 1984, MEC; Apr 1986, AEW. North Dandalup River, Jan 1984, PFSL. Northam, Jun 1955, EJB. Northam, 18km NW, Sep 1973, PFSL. Northampton, May 1955, EJB; Apr 1985, MEC. Nyang Stn, May 1985, MEC. One Tree Hill, May 1956, JALW. Onslow, May 1985, MEC. Ord River, CSIRO, RHB; Apr 1953, AKO. Parrow, Jul 1985, MEC. Peedamulla Creek, Jun 1955, EJB. Perenjori, May 1955, EJB. Perth, Oct 1942; Nov 1943, PNF; Apr 1953, FNR; Jun 1955, EJB. Perth, Armadale/Kelmscott, Jun 1955, EJB. Perth, Bayswater, Oct 1974, PFSL. Perth, Belmont, Jun 1955, EJB. Perth, Careniup Swamp, Nov 1983, JCT. Perth, Ferndale, Mar 1980, FWH. Perth, Greenmount, Sep 1973, PFSL. Perth, Jolimont, Feb 1972, PFSL. Perth, Midland, Jan 1954, EJB. Perth, Nedlands, Oct-Dec 1971, SJM; Jan-Apr 1972, SJM; Jul-Dec 1972, SJM; Jan 1973, SJM; Mar 1974, WJB. Perth, Shenton Park, Sep 1977, AEW. Perth, Welshpool, Jul 1974, PFSL. Petermarer Creek, Jun 1978, AEW. Phillips R., Aug 1956, EJB. Preston, Jun 1955, EJB. Port Hedland, Mar 1979, AEW; Jan 1980, BB; Sep 1980, BB; May 1984, MEC; Aug-Nov 1984, MEC. Ringers Soak, Apr 1985, MEC. Rockingham, Jun 1955, EJB. Roebourne, Mar 1953, EPH/EJB; Feb 1954, EPH/MMC; Mar 1954, EJB; Jun 1954, EPH; Aug-Nov 1984, MEC; Jan 1985, MEC. Roleystone/Araluen, Feb 1971, PFSL. Rosewood Stn, Nov 1984, MEC. Serpentine/Jarrahdale, Jun 1955, EJB. Spring Creek Stn, Nov 1984, MEC. Spring Valley Stn, Nov 1984, MEC. Sussex, 1955, EJB. Swan, Jun 1955, EJB. Tabba Tabba Creek, Jun 1978, AEW. Tanila Stn, Apr 1985, MEC. Three Springs, May 1955, EJB. Tom Price, Oct 1978, AEW; Mar 1979, AEW; May 1980, ADa; Aug-Sep 1980, ADa; Nov 1980, ADa. Toodyay, Jan 1954, VCOS; Jun 1955, EJB. Toodyay, 34km NW, Sep 1973, PFSL. Towrana Stn, May 1985, MEC. Turkey Creek, Jul 1978, PFSL/AEW. Turner, RHB. Turners Mill, May 1985, MEC. Uaroo Stn, May 1985, MEC. Upper Blackwood, May 1956, EJB. Upper Chapman, May 1955, EJB. Urala Stn, May 1985, MEC. Victoria Plains, Jul 1955, EJB. Wagin, Aug 1956, EJB. Wandering, Mar 1955, EJB. Wandarrie Stn, May 1985, MEC. Wanneroo, Jun 1955, EJB. Warramboo Creek, Jun 1955, EJB. West Arthur, Mar 1955, EJB. Williambury Stn, Jun 1985, MEC. Williams, Mar 1955, EJB. Wittenoom Gorge, Mar 1953, EPH/EJB; Mar 1954, EPH; Nov 1984, MEC. Wogoola, Jun 1955, EJB. Wongan/Ballidu, Jul 1955, EJB. Woodanilling, Aug 1956, EJB. Woodstock, Port Hedland, Oct 1954, EHME/EPH. Wooramel Stn, Apr-May 1985, MEC. Wooronga Stn, May 1985, MEC. Wyalkatchem, 8km S, Jul 1974, PFSL. Wyndham, Apr 1953, AKO; May 1953, RL; Jul 1953, EJB; Jul 1955, EJB; Apr 1967, EJB; Jan 1980, OA; Jun 1980, OA; Apr 1981, OA; Jul 1981, OA. Wyndham/Kimberley Research Station, Apr 1953, RL. Yalbago Stn, May 1985, MEC. Yalobia, Jun 1985, MEC. Yanchep. Yanrey, Jun 1955, EJB. Yarraloola, Jun 1955, EJB. Yeeda, Mar 1954; Apr 1967, EJB; Mar-Apr 1977, AEW. York, Jun 1955, EJB; Oct 1972, PFSL; May 1973, PFSL.

Anopheles (Cellia) annulipes species A

ADULT FEMALE

An annulipes A is a moderately large species, confined to the wetter parts of the south west corner. Long narrow pale scales on vertex extending to frons; pale upright forked scales on occiput, dark laterally. Antenna with some pale scales on basal half. Palp black scaled with pale markings; segment I dark; II with white dorsal spots at midpoint and apex; III with pale bands from 0.33 to 0.8 from base and from 0.82 to tip; IV dark; palp same length as proboscis. Proboscis about 1.17x length forefemur; dark with some dorsal pale scales on apical half in some specimens. Scutal integument grey; clothed in scattered broad grey scales.



Anopheles (Cellia) annulipes species A

A: Head and thorax (dorsal); B1 and B2: Proboscis (detail of variation seen in the proboscis of this species); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Larval thorax (dorsal and ventral); H: Prothoracic setae 1-P to 3-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Pecten plate (detail).

Scutellum with narrow white scales along posterior margin. Pleural integument grey; largely bare with small patches of white scales on upper mesepimeron, posterior sternopleuron and some longer pale scales on prealar area. Abdomen with tergites bare with a few scattered narrow yellowish scales in VIII; sternites largely bare, with few elongate pale scales on sternites VI and VII; sternite VII dark scaled on apical half with apical white band, VIII with basolateral white patches. Coxae of all legs with a few white scales. Femora and tibiae of all legs with numerous white spots and bands; hindtarsus I predominantly dark with apical white band and a number of pale spots and bands, mainly between 0.2 and 0.5 from base; hind tarsus II to IV dark with narrow apical white band, hind tarsus V dark. Wing spotted over entire length. Haltere with pale stem and dark club.

LARVA

Head and antenna are brown in colour. Antenna about 0.36x length of head; seta 1-A simple, inserted at 0.4 from base antenna. Head 1.17x longer than wide; about 0.5x width of thorax; seta 2-C simple; 3-C and 4-C dendritic; 5-C to 7-C plumose and in row; 8-C with 9 branches; 9-C with 5 branches. Abdominal seta 1-VIII with 5 branches; 2-VIII and 4-VIII single; 3-VIII with 4-5 branches; 5-VIII with 4 branches. Pecten on lateral plate. Saddle covers dorsal half of anal segment; seta 1-X single simple; 2-X plumose; 3-X plumose with 3-4 branches; 4-X with 7-8 pairs of plumose tufts. Anal papillae long and pointed; about equal to saddle.

BIOLOGY

Larvae are found in a variety of natural and man made semipermanent and permanent fresh water habitats, sunlit or shaded, generally amongst debris at margins or in vegetation. They are often found in temporary sites, occasionally in domestic containers. Larvae are usually found breeding in association with *Cx annulirostris* and *Cx australicus*. Adults readily attack man in the evening, but will feed on other mammals. Adults are easily captured in light or CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Augusta, Oct 1974, PFSL. Boddington, Mar 1971, CAG. Busselton, Oct 1965, NVD. Coomberdale, Oct 1971, CAG. Eaton, Oct 1974, PFSL. Gingin, Sep 1971, CAG. Irwin, Oct 1971, CAG. Kendenup, Nov 1971, CAG. Mayanup, Sep 1974, PFSL. Meckering, 8km W, Sep 1965, NVD. Mumballup, 21km E, Sep 1974, PFSL. Noongar Swamp, Sep 1965, NVD. Perth, Feb 1971, CAG. Pingelly, Jun 1971, CAG. Tachinup Creek, Oct 1974, PFSL. Yeagerup, Oct 1965, NVD. Yorkrakine, Sep 1971, CAG.

SPECIES WITH WHICH IT MAY BE CONFUSED

The only species which could be confused with *An annulipes A* is *An annulipes B* in the zone of overlap between the two species. *An annulipes B* is distinguished most easily by its gingery appearance.

Anopheles (Cellia) annulipes species B

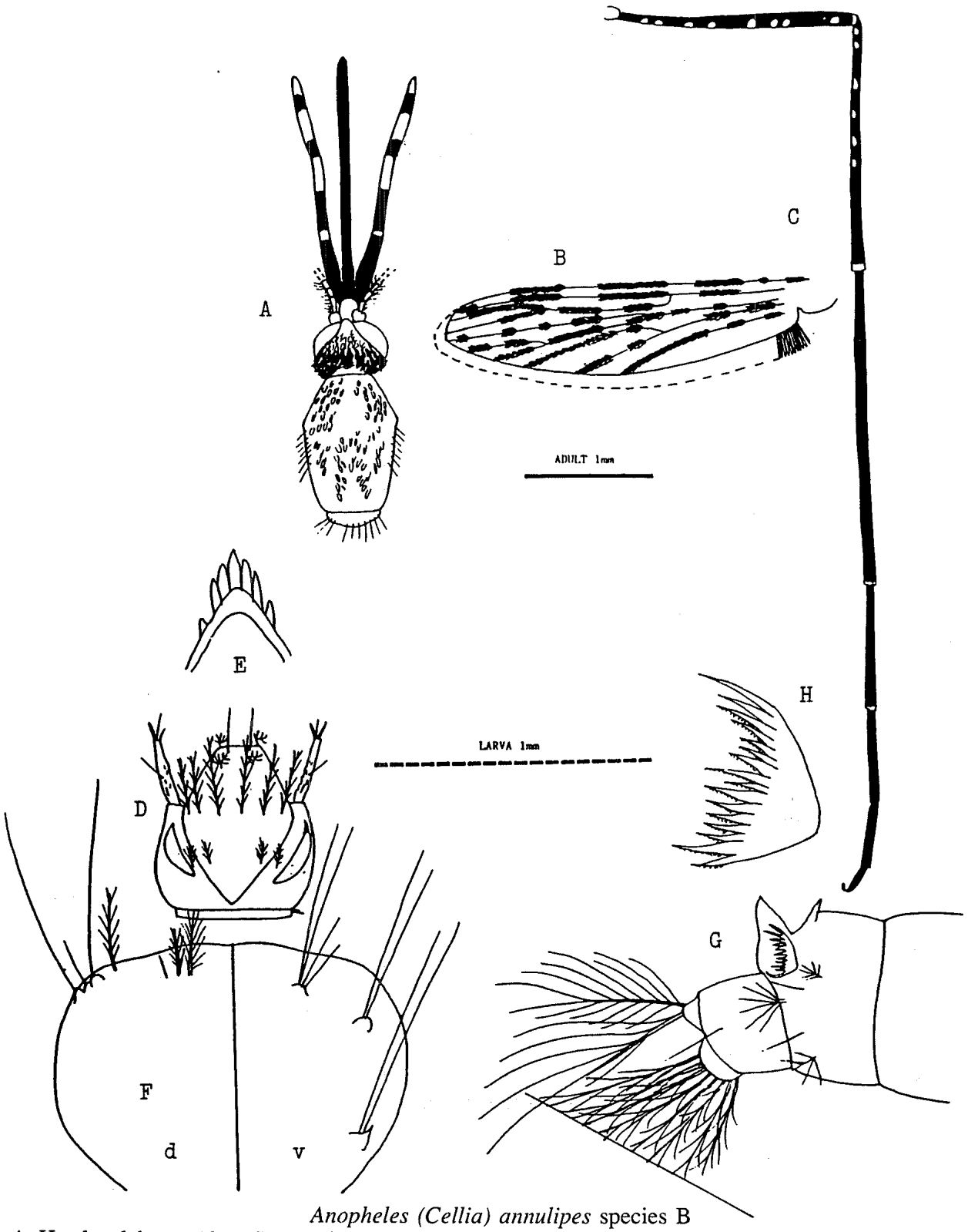
ADULT FEMALE

An annulipes B is a small to moderately sized species. Head with long pale scales on vertex and frons; dark upright forked scales on occiput and laterally. Antenna with some pale scales on basal half. Clypeus bare. Palp about 0.95x length of proboscis; dark brown scaled as follows: I dark brown; II dark with pale scales at apex; III with basal 0.6 dark, pale beyond with small dark bands at 0.75 from base and at apex; IV dark on basal half and pale on apical half. Proboscis dark scaled; about 1.4x length of forefemur. Scutal integument gingery with scattered narrow pale to gingery scales. Scutellum with narrow pale scales. Pleura with brown integument with darker streak from anterior pronotum to upper mesepimeron. Abdomen with tergites and sternites gingery, bare with fine hairs. Legs largely brown with few pale spots, which rarely form complete bands; hindfemur with narrow apical band; hindtarsi dark with narrow diffuse apical pale bands on I to IV. Wings spotted over entire length. Haltere with pale stem; dark knob.

LARVA

Antenna brown; about 0.43x length of head; seta 1-A small single, inserted on outer side of antenna about 0.43 from base. Head integument with patches of light and dark brown; seta 2-C single, long; 3-C small, dendritic with 10-11 branches; 4-C small, dendritic with about 8 branches which do not reach front of

head; 5-C to 7-C plumose and in single row, about equal in length; 8-C with 6 branches; 9-C with 9 branches. Shoulder hairs (1-P to 3-P) not on common base; 1-P with 15 branches; 2-P with 12 branches; 3-P single. Abdominal setae 1-VIII and 3-VIII with 6 branches; 2-VIII and 4-VIII with 1-2 branches; 5-VIII with 5-7 branches. Pecten on plate, teeth with dorsal fringe of denticles. Seta 1-X single, simple; 2-X plumose; 3-X dendritic; 4-X with 8 pairs of dendritic setae. Anal papillae pointed; about half length of saddle.



Anopheles (Cellia) annulipes species B

A: Head and thorax (dorsal); B: Wing (detail of scaling on some veins shown); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Larval thorax (dorsal and ventral); G: Abdominal segment VIII (lateral); H: Pecten plate (detail).

BIOLOGY

An annulipes B larvae have been found in fresh water habitats, natural and man made, open sunlit or shaded, at margins in debris, or among vegetation, and occasionally in container habitats. Adults will bite man and will enter mammal and avian baited traps, light traps and CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Ajana, May 1971, CAG; Oct 1971, CAG. Balgo, Mar 1981, AEW. Balgo, 24km W, Mar 1981, AEW. Irwin, Oct 1971, CAG. Kalbarri, Oct 1971, CAG. Newman, Mar 1979, AEW; Mar 1981, PF. Winchester, Oct 1971, CAG.

SPECIES WITH WHICH IT MAY BE CONFUSED

An annulipes B can be confused with *An annulipes A* in the southern limits of its range and is distinguished by the fact that species A is generally larger and grey coloured whilst B is gingery. In the northern parts of its range, species B overlaps broadly with *An annulipes D*. Species D can be distinguished by having the apical half of its proboscis white, and with some pale spots on hind tarsus I. It also bears superficial resemblances to *An amictus* which overlaps part of its range and can be distinguished by the absence of yellowish scales on the abdomen.

Anopheles (Cellia) annulipes species D

ADULT FEMALE

Head pale above with long pale scales extending from vertex to frons; upright forked scales pale on occiput, dark behind and laterally. Antennal segments I and II with long white scales mesially. Palp about 0.95x length of proboscis; dark on basal half with white bands on midpoint and apex of segment II; apical half pale with basal dark bands on segments III and IV. Proboscis slightly shorter than forefemur, basal half black, apical half white. Scutal integument grey, clothed in scattered white scales. Scutellum with posterior fringe of pale scales. Pleura bare of scales. Abdomen with tergites grey, bare of scales, clothed with fine hairs, tergite VIII with long yellow scales; sternites largely bare, clothed in fine hairs, basolateral white scale patches on sternites VII and VIII. Legs dark scaled, femora and tibiae covered in white spots; hindtarsus I dark with 4-5 small white spots on basal 0.6 and very narrow apical band, tarsi II to IV with narrow apical bands, tarsus V dark. Wing covered with black and white spots on all veins. Haltere with white stem and dark knob.

LARVA

Antenna light brown; 0.44x length of head; seta 1-A simple, short, outwardly projecting, inserted at 0.3 from base. Head about 0.93x longer than wide; about 0.65x width of thorax; seta 2-C single, simple; 3-C dendritic with about 10 branches; 4-C with 9 branches; 5-C to 7-C plumose in row with 13, 24, and 16 branches respectively; 8-C with 5-8 branches; 9-C with about 5 branches. Shoulder hairs (1-P to 3-P) not on fused base, 1-P slightly flattened base with 17-21 branches. Pleural groups (9-11P, 9-11M and 9-11T) all simple. Seta 1-VIII dendritic with 8 branches; 2-VIII and 4-VIII simple; 3-VIII with 6-7 branches; 5-VIII with 4-5 branches. Pecten with 15 teeth on plate. Saddle covers dorsal half of anal segment; seta 1-X simple; 2-X dendritic with 12-15 branches; 3-X dendritic with 6-7 branches; 4-X with 9 pairs of branched setae. Anal papillae long and pointed; about equal to saddle.

BIOLOGY

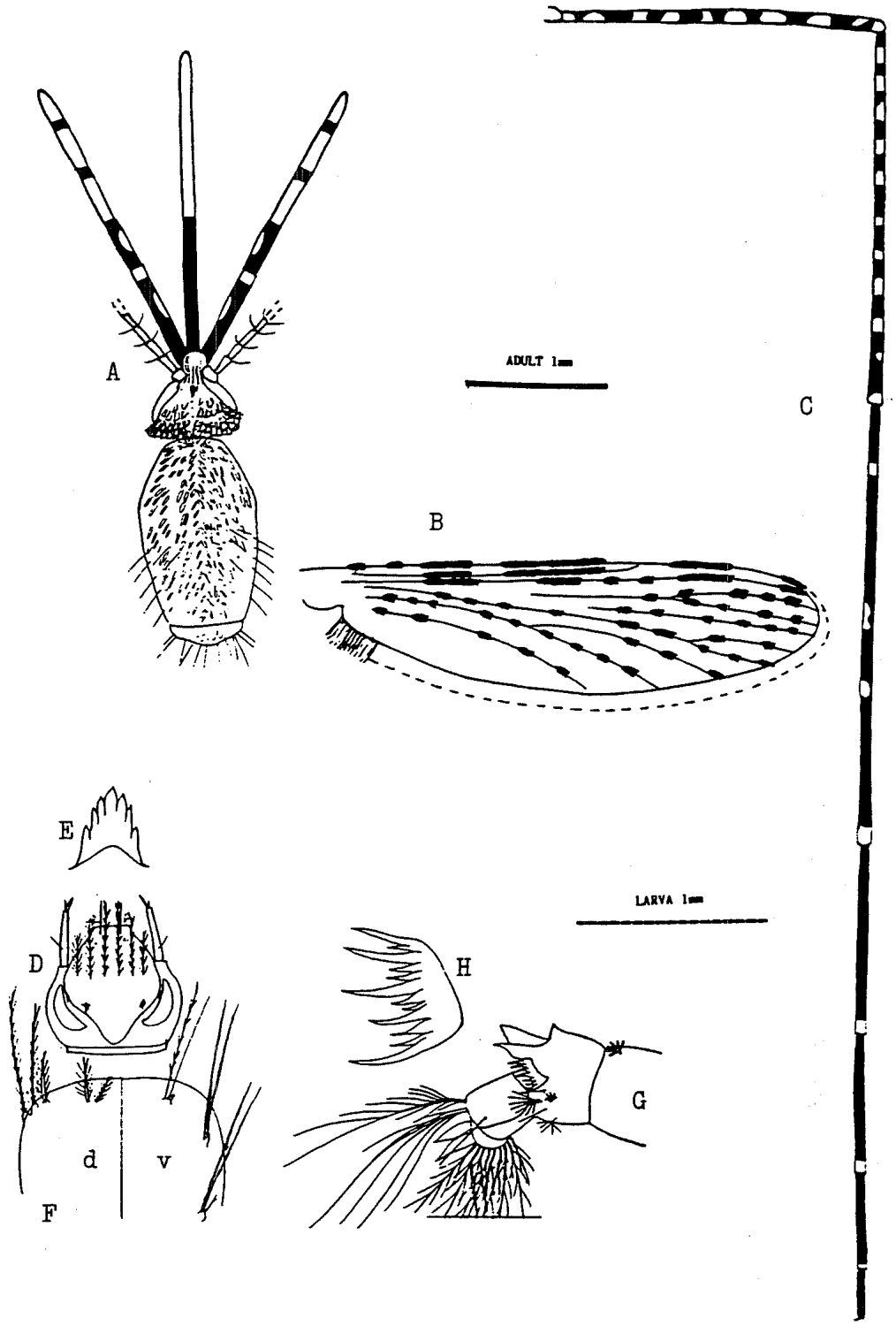
An annulipes D breed in fresh water habitats, natural and man made, open sunlit or shaded, at margins in debris, or among vegetation, and occasionally in container habitats. Adults will bite man and will enter mammal and avian baited traps, light traps and CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Balgo, Mar 1981, AEW. Balgo, 24km W, Mar 1981, AEW. Balgo, Acacia Creek, Mar 1981, AEW. Billiluna, Mar 1981, AEW. Mitchell Plateau, Jul 1981, AEW.



Anopheles (Cellia) annulipes species D

A: Head and thorax (dorsal); B: Wing (detail of scaling on some veins shown); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Larval thorax (dorsal and ventral); G: Abdominal segment VIII (lateral); H: Pecten plate (detail).

SPECIES WITH WHICH IT MAY BE CONFUSED

See *An annulipes B* above. This species also overlaps with the known distribution of *An farauti* in W.A. *An farauti* can most easily be separated by the twin black bands on the apical portion of the palp.

Anopheles (Cellia) farauti Laveran 1902

Laveran, 1902. 908.
Edwards, F.W., 1924. *Bull. Ent. Res., 14:* 351.
Type locality: Faureville, Vate (Efate), New Hebrides.
Synonymy: *Anopheles moluccensis* Swellengrebel, N.H. and Swellengrebel de Graf, F.M.H., 1919. *Meded. Burgerl. Geneesk. Diensk. Ned.-Ind., 6:* 1.

Note: *An farauti* is also recognised as a sibling species complex with at least three member species occurring on the Australian mainland. Two of the member species (numbers 1 and 3) are known from the Northern Territory. It is unclear which of the three species occurs in W.A. As yet, no reliable characters are available for separating the three species morphologically, and correct identification depends on examination of emzyme polymorphisms as determined by electrophoresis, or by examination of larval polytene chromosome banding patterns. *An farauti* is very rare in W.A., having been collected in only one locality (Kununurra) during two years of a 12 year intensive investigation of arboviral disease ecology.

ADULT FEMALE

A small to medium species. Head pale on vertex extending onto frons; upright forked scales pale behind vertex, dark on occiput and to sides. Antenna with long pale scales on basal segments; torus bare. Clypeus bare. Palp about 0.95x length of proboscis; segment I dark, II dark with pale tip, III with median pale band (0.3-0.6) followed by alternating pale and dark bands, VI white with narrow median black band. Proboscis dark, labella pale; about 1.3x length of forefemur. Scutal integument grey; clothed with narrow pale scales, with larger scale tufts on anterior margin. Scutellum with narrow pale scales. Pleura bare, integument with transverse darker band. Abdomen with tergites bare, clothed in fine hairs, tergite VIII with some yellowish scales; sternites bare, clothed in fine hairs. Hindfemur, tibia and tarsus I black with numerous white spots and bands; hindtarsi I to IV with narrow apical pale bands; V dark. Wings spotted black and white over whole length. Haltere pale stem and dark club.

LARVA

Antenna brown; seta 1-A inconspicuous, inserted at about 0.3 from base. Head setae 2-C and 3-C single; 4-C bifid; 5-C to 7-C in row, plumose, with 13, 9 and 14 branches respectively; 8-C bifid; 9-C with 5 branches. Prothoracic seta 1-P broadly flattened, not on common plate. Abdominal segments all with seta 1 always palmate; seta 1-VIII with 4 branches; 2-VIII single; 3-VIII with 8 branches; 4-VIII and 5-VIII both with 4 branches. Pecten on plate. Anal segment with seta 1-X single, simple; 2-X and 3-X plumose, irregularly branched; 4-X with 8 pairs of branched setae. Anal papillae short, rather globular.

BIOLOGY

An farauti breeds in all kinds of permanent to moderately temporary sites. Species 1 of the complex breeds in brackish coastal sites whilst species 2 and 3 are found predominantly in fresh water. The adults readily bite man, mammals and birds. Adults do not disperse far from breeding sites, generally less than 2km. Adults are readily captured in light and CO_2 baited traps. It should be noted that the biology as indicated above is very general, and that differences in behaviour may be elucidated as the different members of the complex are analysed in more detail. In general, the species of the *An farauti* complex are collected in greatest numbers during the March to May period following the wet season.

RELATION TO DISEASE

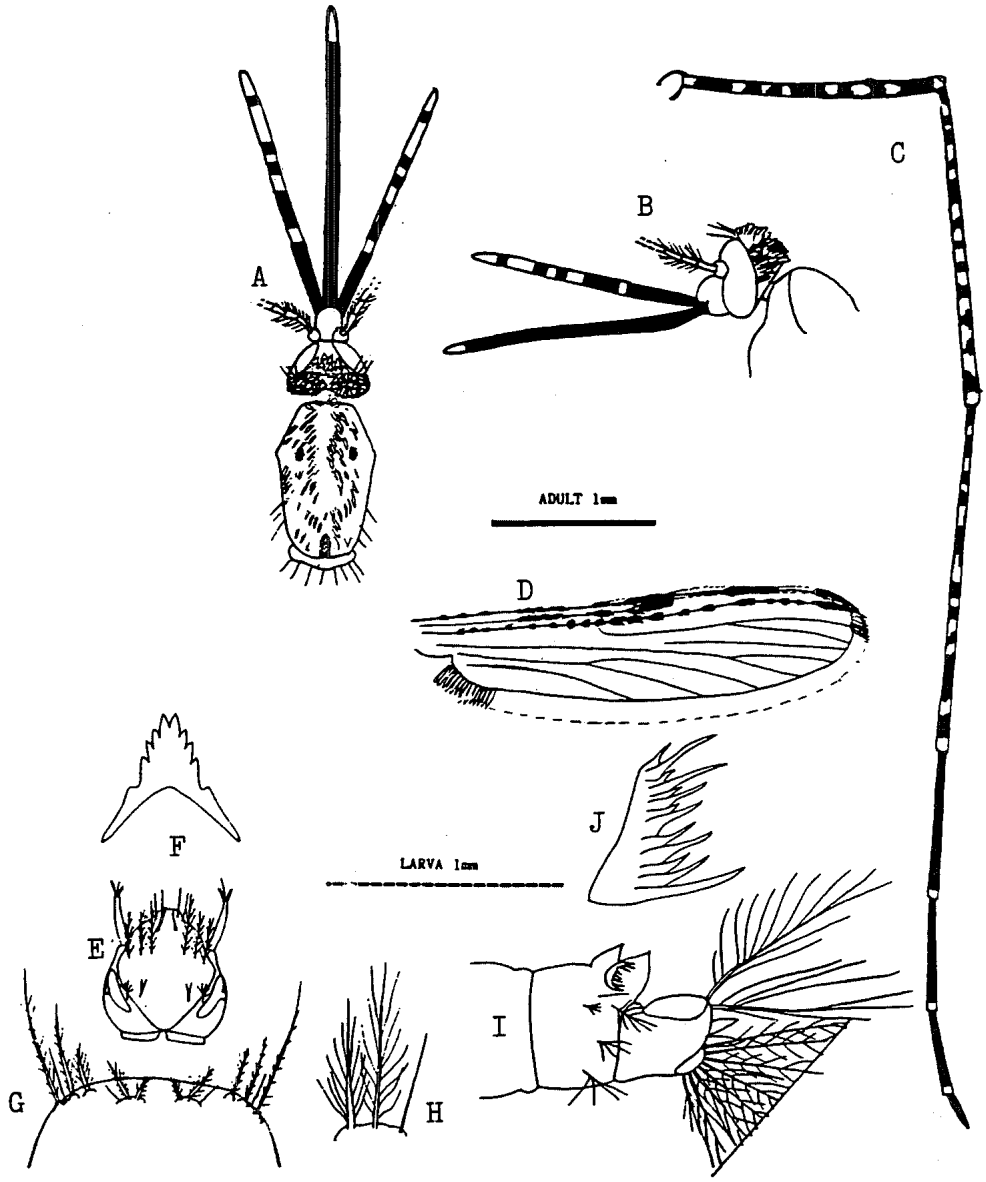
An farauti 1 is a major vector of malaria in New Guinea and elsewhere. The vector capacity of the other two species *(An farauti 2* and *An farauti 3)* is uncertain. *An farauti 1* can also carry filariasis.

DISTRIBUTION

Kununurra, Apr 1975, PFSL; 1984, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

An farauti is most easily confused with *An annulipes. An farauti* is most easily distinguished by the characteristic paired narrow black bands on the apical part of the palp.



Anopheles (Cellia) farauti

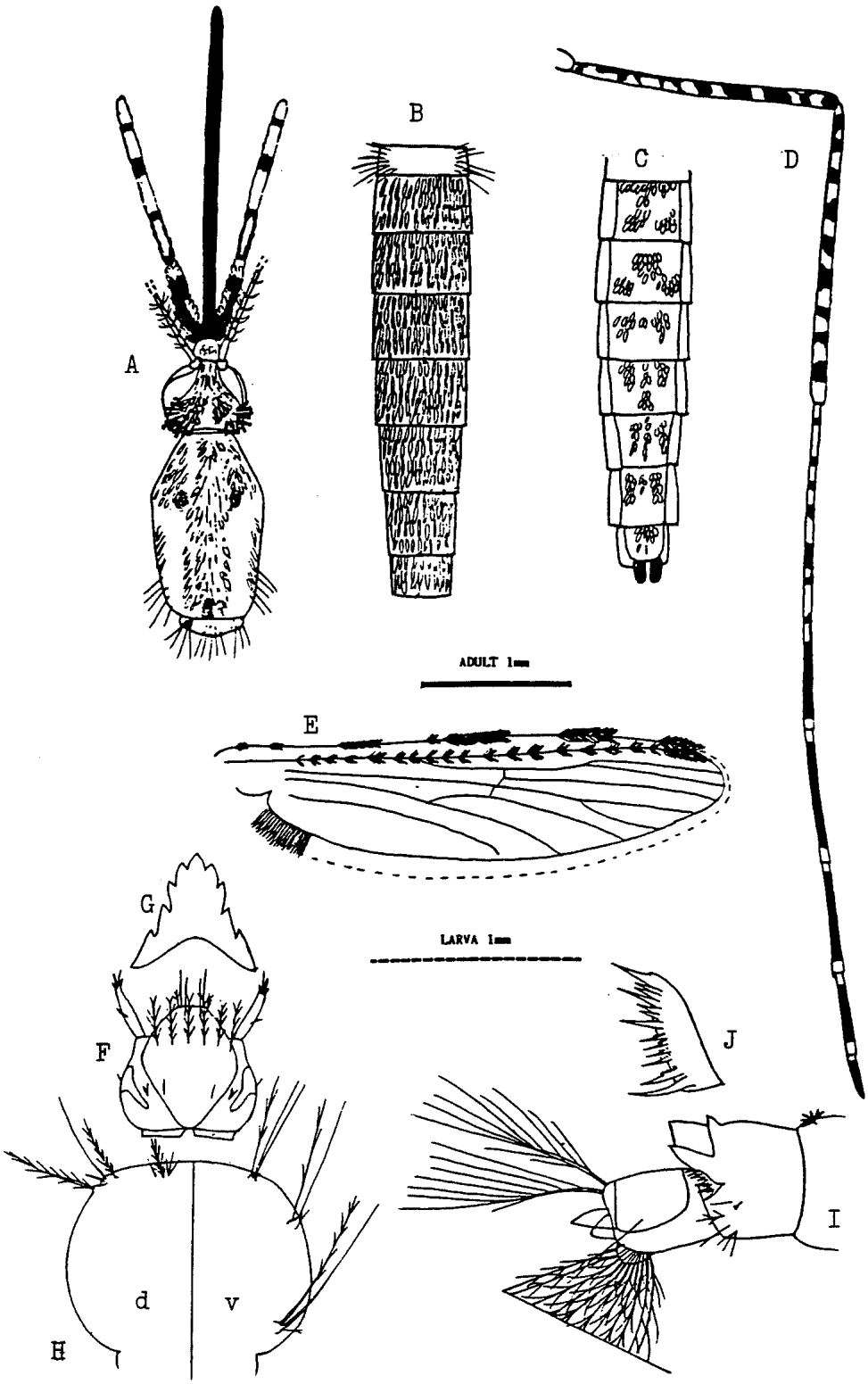
A: Head and thorax (dorsal); B: Head (lateral); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Larval thorax (dorsal); H: Prothoracic setae 1-P to 3-P (shoulder hairs); I: Abdominal segment VIII (lateral); J: Pecten plate (detail).

Anopheles (Cellia) hilli Woodhill and Lee 1944

Woodhill, A.R. and Lee, D.J., 1944. Proc. Linn. Soc. N.S.W., 69: 63. Type locality: Adelaide River, Northern Territory. Synonymy: None.

ADULT FEMALE

A moderately large species. Head pale above with long pale scales extending from vertex to frons; upright forked scales dark on occiput and to sides. Long pale scales on basal antennal segments. Palp about 0.95x length of proboscis, shaggy; dark at base with two narrow pale spots, with four broad pale bands separated by narrow black bands apically. Proboscis dark scaled; about 1.3x length of forefemur. Scutal integument grey; scattered broad white scales and tufts of long white scales on anterior margin. Scutellum with fringe of broad pale scales. Pleura largely bare with some appressed pale scales on lower and upper sternopleuron. Abdomen with tergites covered in long yellowish scales; sternites covered with scattered yellowish and white scales, with large diffuse basolateral pale patches. Hindfemur, tibia and tarsus I black with numerous narrow white bands; hindtarsus I with apical white band; hindtarsi II to IV black with basal and apical white bands, hind tarsus V black with basal pale band; gives the appearance that the white bands at each tarsal joint are broad and extend on either side of the joint. Wings covered in alternating black and white patches. Haltere with pale stem and dark club.



Anopheles (Cellia) hilli

A: Head and thorax (dorsal); B: abdomen (dorsal); C: Abdomen (ventral); D: Hindleg; E: Wing (detail of scaling on some veins shown); F: Larval head (dorsal); G: Mentum; H: Larval thorax (dorsal and ventral); I: Abdominal segment VIII (lateral); J: Pecten plate (detail).

LARVA

Antenna light brown; 0.3x length of head; seta 1-A single, simple, outward projecting, inserted at about 0.3 from base. Head oval in shape, about equal in length and width; about 0.5x width of thorax; seta 2-C simple; 3-C with 4 terminal forks; 4-C simple; 5-C to 7-C in row, plumose with 15, 13 and 15 branches respectively; 8-C simple; 9-C bifid. Thoracic hairs 1-P with 3-4 branches; all pleural groups (9-11P, 9-11M

and 9-11T) with plumose hairs. Abdominal setae 1-VIII, 3-VIII and 5-VIII with 3 branches; 2-VIII and 4-VIII simple. Pecten on plate with 13 teeth. Saddle covers dorsal half of anal segment; seta 1-X simple; 2-X and 3-X plumose, irregularly branched; 4-X with about 7 pairs of irregularly branched setae. Anal papillae short, bluntly pointed; about 0.2x length of saddle.

BIOLOGY

An hilli breeds primarily in coastal brackish water sites. Adults bite man, mammals and birds after sunset. Adults are captured readily in light and CO_2 baited traps, and in animal baited traps. The adults disperse up to 4km from breeding sites. The species is most common in the March to May period when the coastal brackish swamp breeding sites are filled and relatively stable.

RELATION TO DISEASE

None known.

DISTRIBUTION

Derby, Aug-Sep 1978; Oct 1978, AEW; Mar 1985, AEW. Fitzroy Crossing, Oct 1950, EJB; May 1954, EPH. Forrest River Mission, Jul 1954, RKC. Kalumburu, Jul 1978, AEW. Kimberley Research Station, Mar 1953, EPH/EJB; Apr 1953; Mar 1954, EPH. Kununurra, Apr 1975, PFSL; Jul 1976, AEW; Apr 1977, AEW; May 1977, AEW; Jul 1978, PFSL/AEW. La Grange, Oct 1978, AEW. Noonkanbah. Ord River, CSIRO, Apr 1953, AKO. Parrys Creek, Apr 1977, AEW. Wyndham, May 1926; Apr 1953, AKO; Apr 1953, RL; Jul 1978, PFSL/AEW. Wyndham/Kimberley Research Station, Mar 1953, NG; Apr 1953, RL.

SPECIES WITH WHICH IT MAY BE CONFUSED

An hilli is most often confused with *An amictus* and can be distinguished by the pale bands on tarsal joints extending on either side of the join between adjacent tarsi.

Anopheles (Cellia) meraukensis Venhuis 1932

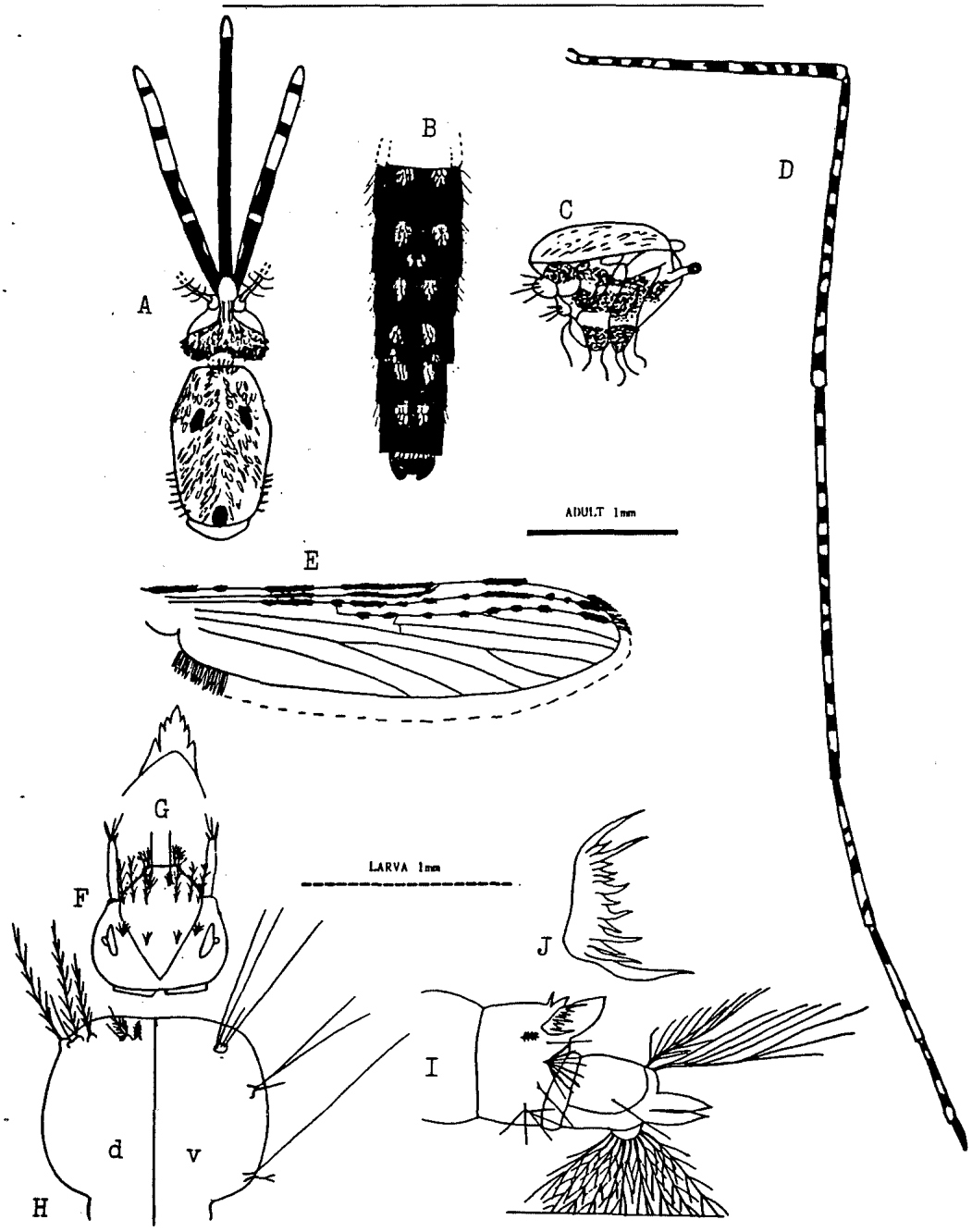
Venhuis, W.G., 1932. *Geneesk, Tijdschr. Ned.-Ind., 72:* 1040.
Type locality: Merauke, Western New Guinea.
Synonymy: None.

ADULT FEMALE

A medium sized species. Pale decumbent scales on vertex entending to frons; upright forked scales behind on vertex, with dark on occiput and laterally. Antenna with some pale scales on basal segments; torus bare. Clypeus bare. Palp about equal to proboscis; black on basal half with two small white spots, white on apical half with two narrow dark bands, white tip. Proboscis dark scaled; 0.9x length of forefemur. Scutal integument grey/brown with dark spots on fossa and prescutellar space; scattered pale scales. Scutellum with fringe of pale scales. Pleural integument dark with two pale grey transverse bands; largely bare but with a few very small pale scales on grey band on lower and upper sternopleuron. Abdomen with tergites densely clothed in broad long yellowish scales; sternites dark scaled with vivid white basal sublateral patches; some scattered median white scales on sternites III to VI and small apicolateral white patches on sternites V to VII. Forecoxa with mixture of pale and dark scales; midcoxa and hindcoxa with small patch of pale scales. Femora, tibiae and tarsal segments I and II on all three legs dark with white spots; hindtarsi I-IV with at least some white spots, V dark. Wing spotted on all veins. Haltere with pale stem, club dark.

LARVA

Antenna brown, spiculate; about 0.5 length of head; seta 1-A simple, outwardly directed, inserted at 0.3 from base. Head about as long as broad; about 0.57x width of thorax; seta 2-C simple; 3-C densely branched (about 50); 4-C small with 6 branches; 5-C to 7-C plumose, in row, with 7, 13 and 13 branches respectively; 8-C with 3 branches; 9-C with 5 branches. Prothoracic seta 1-P markedly flattened with 10-17 branches. Pleural groups (9-11P, 9-11M and 9- 11T) all simple. Abdominal seta 1 palmate; seta 1-VIII with 11 branches; 2- VIII and 4-VIII simple; 3-VIII with 8 branches; 5-VIII with 5 branches. Pecten with 11 teeth on plate. Saddle covers dorsal half of anal segment; seta 1-X simple; 2-X and 3-X plumose with irregular branching, with 10 and 6- 10 branches respectively; 4-X with 10 pairs of branched setae. Anal papillae long and pointed; 0.6x length of saddle.



Anopheles (Cellia) meraukensis

A: Head and thorax (dorsal); B: Abdomen (ventral); C: Thorax (lateral); D: Hindleg; E: Wing (detail of scaling on some veins shown); F: Larval head (dorsal); G: Mentum; H: Larval thorax (dorsal and ventral); I: Abdominal segment VIII (lateral); J: Pecten plate (detail).

BIOLOGY

Breeding sites are a variety of freshwater to brackish habitats; open grassy swamplands, sunlit to shaded, with algae or emergent vegetation, creek margins, and hoof prints. Females bite man freely at dusk and are readily captured in light traps, CO_2 traps, and in animal baited traps. Females are most common in the early to mid dry season (March to May) just after the end of the wet season.

RELATION TO DISEASE

Not implicated in natural transmission of malaria, but is known to be susceptible to experimental infection.

DISTRIBUTION

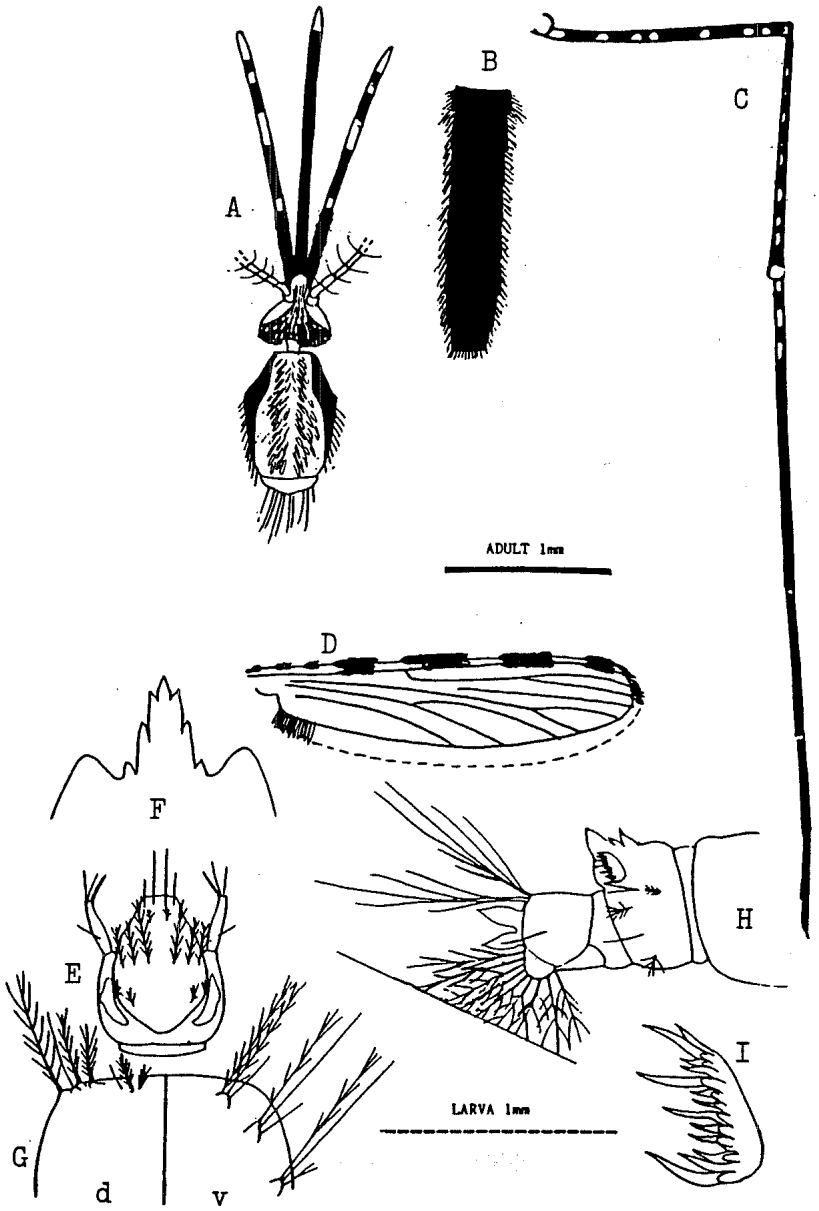
Derby, Aug-Sep 1978, AEW. Kalumburu, Mar 1953, EPH/EJB; Mar 1954; Jul 1978, AEW. Kalumburu, Carson R., Mar 1954, EPH. Kimberley Research Station, Mar 1953, EPH/EJB. Kununurra, Apr 1975, PFSL. Mitchell Plateau, Jul 1981, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

An meraukensis may be confused with most other anophelines in the north: *An annulipes D* and *An farauti* have bare tergites; *An amictus* has no pale patches on sternites; and *An hilli* and *An amictus* both lack white patches on hind tarsus II to IV.

Anopheles (Cellia) novaguinensis Venhuis 1933

Venhuis, W.G., 1933. *Geneesk. Tijdschr. Ned.-Ind., 73:* 203.
Type locality: Kakajoe and Donggeap on Merauke River, Western New Guinea.
Synonymy: *Anopheles breinli* Taylor, F.H., 1943. *Proc. Linn. Soc. N.S.W., 68:* 156.



Anopheles (Cellia) novaguinensis
A: Head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Larval thorax (dorsal and ventral); H: Abdominal segment VIII (lateral); I: Pecten plate (detail).

ADULT FEMALE

A small to medium slender species, with a distinctive black colour. Head clothed in narrow white decumbent scales on vertex extending onto frons; upright forked scales pale on vertex, dark on occiput and laterally. Torus and basal antennal segment with patch of white scales mesially. Clypeus bare. Palps long and slender, about 0.83x length of proboscis; very dark black with segments I and II with narrow apical bands; III with apical 0.3 white; IV with apical 0.5 white. Proboscis dark black, slender; about 1.38x length of forefemur. Scutum with striking dark lateral margins; integument black, bare on lateral margins and prescutellar space; pale scales on medial half of scutum. Scutellum with posterior fringe of white scales and long bristles. Pleura bare, black. Abdomen with tergites and sternites bare, black, clothed with fine hairs; sternite VIII with small submedian basal white patches. Hindfemora, tibia black with lines of white spots; hind tarsus I with 1-2 medial white spots and an apical white spot, II with white apical spot, III-V dark. Wings spotted along whole length, very distinct dark black on wings. Haltere with pale stem and dark club.

LARVA

Antenna brown, about 0.35x length of head, seta 1-A simple, inserted 0.2 from base, projecting outwards. Head with length 1.15x width; about 0.59x width of thorax, setae 2-C and 3-C simple; 4-C short with 3-4 branches; 5-C to 7-C plumose, in row; 8-C with 4-5 branches; 9-C with 7 branches. Pleural groups (9-11P, 9-11M, 9-11T) all simple. Abdominal segments with all seta 1 generally palmate; seta 1-VIII with 8-11 branches; 2-VIII with 1-3 branches; 3-VIII with 7-9 branches; 4-VIII simple; 5-VIII with 4-5 branches. Pecten on plate with about 11 teeth. Saddle covers dorsal 0.8 of anal segment; seta 1-X simple; 2-X and 3-X plumose with irregular branching; 4-X with 9 pairs of branched setae. Anal papillae pointed; about 0.6x length of saddle.

BIOLOGY

Breeding is generally in clear, fresh, sunlit, shallow water with abundant algal growth and in grassy swamplands. Adults will bite man at sunset. Adults are captured occasionally in light and CO_2 baited traps. Generally an uncommon species, found in greatest numbers in the March to May period.

RELATION TO DISEASE

None known.

DISTRIBUTION

Derby, Aug-Sep 1978. Drysdale R., Aug 1979, AEW. Kalumburu, Mar 1953, EPH/EJB; Mar 1954, EPH. Kalumburu, Longonye Creek, Mar 1954, EPH. Kimberley Research Station, Mar 1954, EPH/EJB. Lake Argyle, May 1972, PFSL. Lake Argyle, Upper Smoke Creek, Mar 1982, AEW. Mitchell Plateau, Jul 1981, AEW. Ord River, Jul 1978, PFSL/AEW. Pago Mission, Mar 1954, EPH. Wyndham, Jul 1953, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

CHAPTER 19: genus *COQUILLETTIDIA*

Two species of *Coquillettidia* are known from W.A. They have discontinuous distributions, one *(Cq xanthogaster)* being restricted to tropical areas and the other *(Cq nr. linealis* ['Ben Lomond' species]) to the south west. The genus *Coquillettidia* is very closely related to the genus *Mansonia*, and is considered to be a subgenus of *Mansonia* by some authors. However, the new world species *(Coquillettidia)* can be readily distinguished from the old world species *(Mansonia)* in all stages, and are thought by most authors to form a distinct genus.

GENERIC CHARACTERS

Adult: Proboscis never swollen at tip. Palps in female not more than 0.25x length of proboscis. Vertex with numerous upright forked scales and clothed in narrow decumbent scales. Postspiracular bristles absent. Lower mesepimeral bristles present. All claws in female simple; pulvilli absent. Wing scales generally narrow.

Larva: Antennae long; seta 1-A being large and branched, arising less than 0.5 from base; 2-A and 3-A inserted well before tip, around midpoint; distal part of antenna longer than basal segment. Mentum generally small. Thorax contains large paired tracheal dilatations. Lateral comb teeth form single row of a few simple spines. Siphon is short; seta 1-S single pair of setae; pecten absent; valves modified for piercing plant stems. Saddle is complete ring; precratal tufts absent.

KEY TO ADULT FEMALES OF *COQUILLETTIDIA* IN WESTERN AUSTRALIA

1. – Integument brown; scutum with narrow lines of brown, golden and bronze scales; southern species ..... *Cq* 'Ben Lomond' sp.
   – Integument orange; scutum with 3 rows of scales and bristles; legs dark; northern species ..... *Cq xanthogaster*

KEYS: LARVAE: see key to genera (Chapter 15, page 93).

DESCRIPTIONS OF SPECIES

Coquillettidia 'Ben Lomond' species

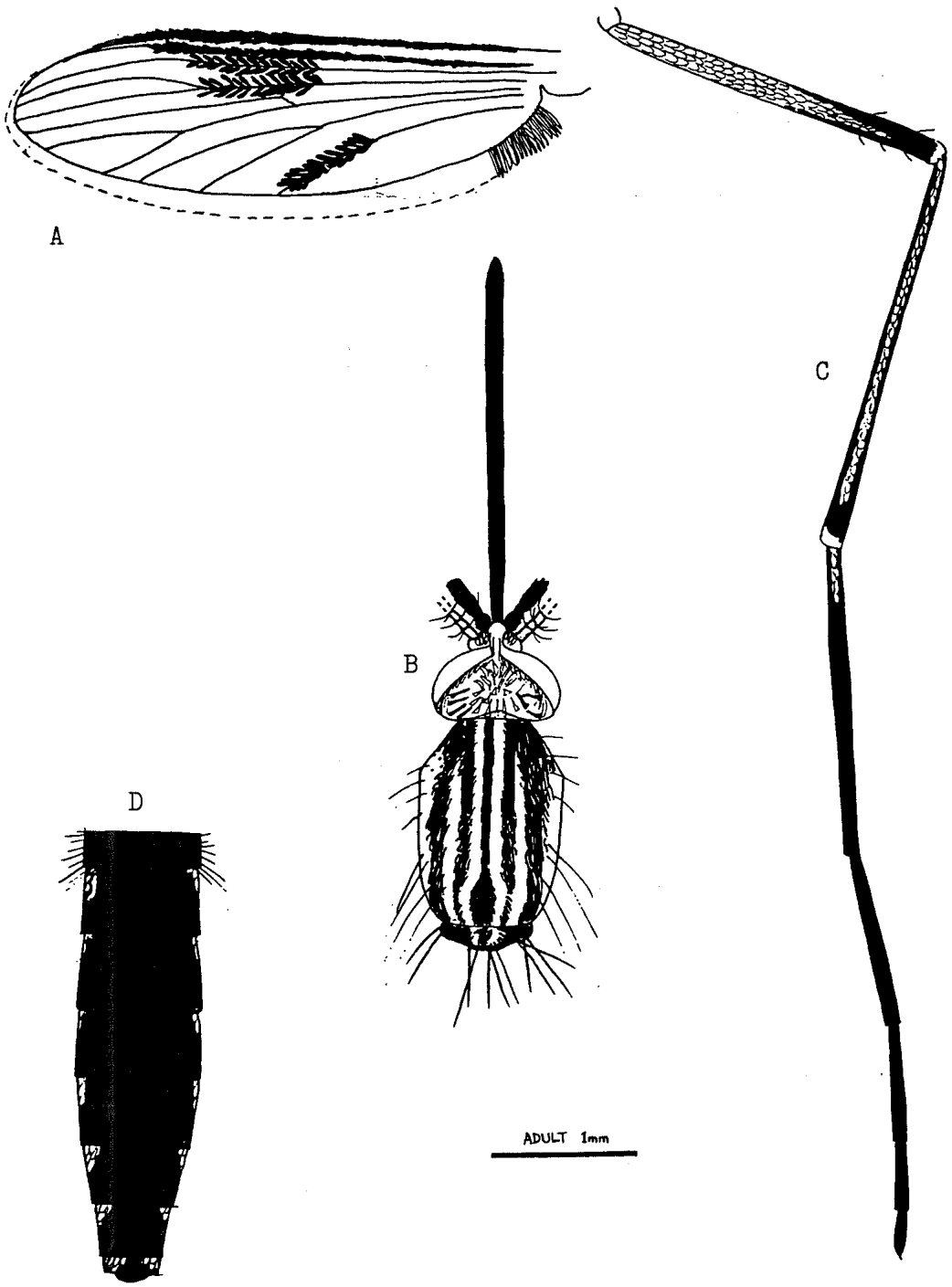
Dr E.N. Marks recognises two very closely related species in southern Australia: *Cq linealis* and an undescribed species, *Cq species near linealis* also referred to as *Cq* 'Ben Lomond' species. Dr Marks considers that the W.A. species is the undescribed 'Ben Lomond' species. The two species are very similar morphologically, and the following description is taken from W.A. specimens. It is included here as this species is a major pest in some areas, and has been described and illustrated, at least in part, previously. Note: this species is called *Cq species near linealis* in the Monograph series 'The Culicidae of the Australasian Region'.

ADULT FEMALE

A small to medium sized species. Vertex with narrow golden curved scales with pale eye border; darker scales laterally; upright forked scales numerous. Palp is dark scaled; 0.16x length of proboscis. Proboscis is dark scaled; about 1.1x length of forefemur. Scutum clothed in dark to bronze scales, with a pattern of longitudinal lines of pale green/golden scales; some white scales in front of wing root. Scutellum with patch of narrow golden/green scales on midlobe, lateral lobes bare. Pleural integument dark brown; patches of narrow pale scales on anterior pronotum and posterior pronotum; patches of broad flat white scales on propleuron, sternopleuron and mesepimeron; 3 lower mesepimeral bristles present. Abdomen with tergites dark scaled with small basolateral white triangular patches; sternites are white with medial dark black patches, and apical black bands, sometimes forming a broad apical dark triangle. Hindfemur pale anteriorly on basal 0.75 extending to median stripe reaching almost to knee; hindtibia and tarsus I dark with median anterior pale stripe; hindtarsi II-V dark. Wing scales narrow, dark. Haltere pale scaled.

LARVA

Unknown.



Coquillettidia 'Ben Lomond' species
A: Wing (detail of scaling); B: Adult head and thorax (dorsal); C: Hindleg; D: Abdomen (dorsal).

BIOLOGY

Cq sp. nr. linealis readily bites man through the day and at night, and can be a significant pest in some areas. Adults will disperse for some distance in search of blood meals. Populations of this species are often associated with more permanent water bodies characterised by the presence of large stands of cumbungi (*Typha* species) and *Juncus* species. Adult females will readily enter light and CO_2 baited traps, and will also enter avian baited traps. Males can occasionally be taken in CO_2 baited traps set near to breeding sites. The main seasonal prevalence of the species is from October to January.

RELATION TO DISEASE

None known.

DISTRIBUTION

Bald Hills, Apr 1940, Wa. Bunbury, Jan-Apr 1985, MEC; Oct-Dec 1985, MEC; Nov 1985, Ed. Canning R., Apr 1975, RH; Mar 1979, PFSL; Jun 1979, PFSL. Canning R., Canning, Mar-Apr 1975, PFSL. Canning R., Ferndale, Mar 1975, PFSL; Feb- Mar 1977, AB. Canning R., Kent St Weir, Mar-Apr 1975, PFSL. Canning R., Riverton Bridge, Mar 1975, PFSL. Jandakot, Nov-Dec 1971, SJM; Jan-Apr 1972, JCT; Jan-Apr 1972, SJM; Oct-Dec 1972, SJM; Dec 1972, JCT; Jan-Feb 1973, SJM; Mar 1974, PFSL; Mar 1975; Nov 1985, ALD. Jandakot, Russell Swamp, Mar-Apr 1974. Joondalup, Jan-Mar 1978, AB; Nov-Dec 1977, AB. Lake Goollelal, Jan-Mar 1978, AB; Jan 1982, PFSL. Lake Gwelup, Nov 1983, JCT. Lake Joondalup, Jan 1982, PFSL. Porongurups, Mar 1973, PFSL. Perth, Oct 1942; Dec 1942, FNR. Perth, Canning, Mar 1980, FWH. Perth, Careniup, Nov 1983, JCT. Perth, Kings Park, Jan 1935; Feb 1935, CFHJ; Oct 1953, DLM/FNR; Jan 1954, DLM; Feb 1972, PFSL. Perth, Leederville, Feb 1955, DLM. Perth, Nedlands, HEP; Jan 1952, EPH; Nov 1971, SJM; Oct 1973, PFSL; Mar-Apr 1974, WJB. Perth, Shenton Park, Sep 1977, AEW. Perth, Subiaco, HMC; Mar 1985, MEC. Perth, Wallburnup Swamp, Jan 1982, PFSL. Yanchep, Dec 1954, BM.

SPECIES WITH WHICH IT MAY BE CONFUSED

There are no species in southern W.A. which could be confused with *Cq* 'Ben Lomond' sp.

Coquillettidia xanthogaster (Edwards) 1924

Edwards, F.W., 1924. *Bull. Ent. Res., 14:* 351.
Type locality: Burpengary, Queensland.
Synonymy: None.

ADULT FEMALE

A medium sized species. The most striking feature of the species is the orange integument of the head, thorax and abdomen. Vertex clothed in narrow decumbent orange scales; broad flat decumbent scales laterally on head with slightly darker colour, orange/grey; upright forked scales numerous on occiput and laterally, darker in colour. Torus and clypeus bare. Palps dark scaled; 0.25x length of proboscis. Proboscis is black; 1.1x length of forefemur. Scutum bright orange with 3 rows of dorsocentral bristles associated with very fine golden/orange scales; supraalar bristles strong. Scutellum bare with posterior row of very strong dark bristles. Pleura largely bare with patches of appressed white scales on upper mesepimeron and lower posterior sternopleuron. Abdomen with tergites clothed in pale yellowish scales, with darker purplish colours posteriorly on each segment; sternites similarly scaled, sternite VIII large and prominant, encloses cerci. Femora dark with pale scales on basal 0.33; tibiae and tarsi all dark; claws equal. Wing predominantly clothed in narrow dark scales. Haltere pale orange/yellow.

LARVA

Antenna slightly darker at base, about 2.1x length of head; seta 1-A multibranched, inserted 0.27 from base; flagellar segment long and flexible. Head 0.73x as long as broad; about 0.6x the width of the thorax; seta 4-C with two branches; 5-C and 6-C with 6 branches; 7-C with 8 branches and 8-C with 5 branches. Lateral comb consists of a row of seven stout simple spines; seta 3-VIII single and prominant. Saddle forms complete ring; precratal tufts absent; seta 1-X with 5 branches; 2-X with 11 branches; 3-X with 8 branches; 4-X with 3 pairs of multibranched tufts. Anal papillae are long and pointed; approximately 0.6x length of saddle.

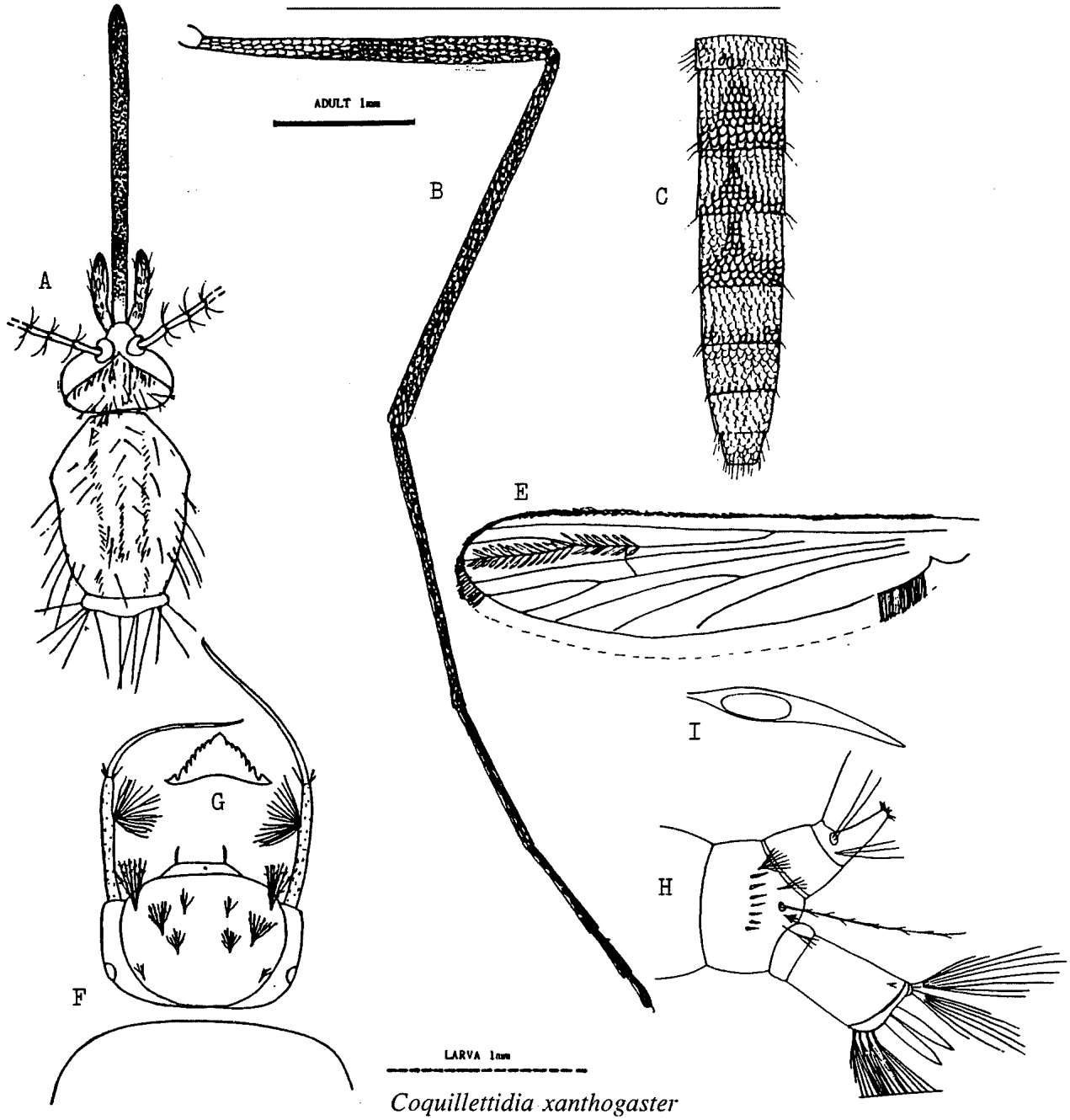
BIOLOGY

Cq xanthogaster breeds in permanent to semipermanent fresh water sites in the tropics, characterised by the presence of large stands of emergent vegetation, particularly reeds such as Cumbungi *(Typha* species), rushes *(Eleocharis* species), and water lilies or water hyacinths. Eggs are laid in small rafts on the water surface. The larvae are cryptic and are very difficult to locate. They attach to the roots of plants at or very near the mud substrate.

The adults will disperse away from the breeding site for several kilometers, and readily enter both animal and bird baited traps, and are readily taken in light and CO_2 baited traps. Males are taken in CO_2 baited traps set near to breeding areas. The adults can be a significant pest in some circumstances. Adults are most prevalent in the mid to late dry season (June to November).

RELATION TO DISEASE

The vector status of this species remains unclear, but it is not considered to be a major vector of disease. Dengue-4 virus was isolated from *Cq xanthogaster* in New Caledonia. Experimental data shows that *Cq xanthogaster* will support replication of RRv, but its role in transmission of the virus remains unclear.



Coquillettidia xanthogaster

A: Adult head and thorax (dorsal); B: Hindleg; C: Abdomen (dorsal); D: Wing (detail of scaling on some veins shown); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail).

DISTRIBUTION

Billiluna, Mar 1981, AEW. Derby, Myalls Bore, Sep-Oct 1978, AEW. Derby, Prison Boab, Mar-Apr 1977, AEW. Drysdale R., Aug 1979, AEW. Kalumburu, Aug 1979, AEW. Kununurra, Dec 1972, PFSL; Apr-May 1973, PFSL; Nov-Dec 1973, PFSL; Apr 1974, PFSL; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Oct-Nov 1975, PFSL; Oct- Nov 1976, AEW; Apr-May 1977, AEW; Nov-Dec 1977, AEW; Jun-Jul 1978, PFSL/AEW; Dec 1979, OA; Mar-Dec 1980, OA; Feb-Jul 1981, OA. Parrys Creek, May 1973, PFSL; Apr 1977, AEW. Wyndham, Jun 1981, OA.

SPECIES WITH WHICH IT MAY BE CONFUSED

Cq xanthogaster is the only medium sized species with a full orange integument found in the Kimberleys. Two other species have at least the thorax and/or head with orange integument *(Ae britteni* and *Tr magnesianus)* but these species are larger and smaller respectively, and both are characterised by having metallic silver or gold scaling on the pleura. A closely related species *(Cq crassipes)* is found in Queensland and it is very difficult to separate the females of the two species.

CHAPTER 20: genus *CULEX*

The genus *Culex* is represented by 21 species in W.A. Of these, 3 are undescribed, though all the life stages are known for each. Five subgenera are represented, *Culex, Culiciomyia, Lophoceraomyia, Lutzia* and *Neoculex*. Separation of some species, particularly in the *Culex (Culex)*, can be difficult. The status of the species in *Cx (Lophoceraomyia)* is confusing as the subgenus is currently being reviewed, and many historical records refer to species (for example *Cx (Lop) fraudatrix)* not considered to occur in W.A.

GENERIC CHARACTERS

Adult: Head with decumbent scales narrow, and upright forked scales on vertex, Palps shorter than proboscis. Spiracular bristles absent. Lower mesepimeral bristles absent or few in number. Pleura largely bare, with a few small patches of scales. Abdomen with segment VIII short and broad, cerci short. Tarsal claws simple, pulvilli present.

Larva: Antennal seta 1-A inserted beyond midpoint of antenna. Prothoracic setae 1P to 7P usually long and branched; 1P to 3P set on distinct sclerotised plate. Saddle completely rings anal segment. Siphon long; pecten well developed; seta 1-S with several pairs of setae. Anal segment with seta 3-X usually long and simple.

KEY TO SUBGENERA OF *CULEX* IN WESTERN AUSTRALIA ADULT FEMALES

1.	– 4-6 lower mesepimeral bristles; all femora strongly speckled with light scales	LUTZIA *Cx (Lut) halifaxii*
	– Usually 0-2 lower mesepimeral bristles, not more than 3	2
2.	– Proboscis with pale band near midpoint	CULEX (part)
	– Proboscis without pale band	3
3.	– Bristles on midline of scutum (acrostichal bristles) poorly developed except at extreme anterior, and weakly near prescutellar space	4
	– Bristles on midline of scutum (acrostichal bristles) well developed	5
4.	– Scutal scaling dense, smooth in appearance; proboscis relatively thick (pleural integument pale with paired distinct transverse brown bands)	CULICIOMYIA *Cx (Cui) pullus*
	– Scutal scaling sparse, rough in appearance; proboscis relatively thin	LOPHOCERAOMYIA
5.	– Tergites with apical bands	NEOCULEX *Cx (Ncx) latus*
	– Tergites with basal pale bands	CULEX (part)

KEY TO SUBGENERA OF *CULEX* IN WESTERN AUSTRALIA 4TH INSTAR LARVAE

1.	– Mouth brushes modified for predation; Saddle as long as siphon	LUTZIA *Cx (Lut) halifaxii*
	– Mouth brushes not modified for predation; saddle shorter than siphon	2
2.	– Precratal tufts present	NEOCULEX *Cx (Ncx) latus*
	– Precratal tufts absent	3
3.	– Ventral brush (4-X) with 4 pairs of hairs; siphon with weakly sclerotized band at about 0.67 length	CULICIOMYIA *Cx (Cui) pullus*
	– Ventral brush (4-X) with 5-7 pairs of hairs	4
4.	– Prothoracic hair 3-P of the same order of magnitude and thickness as 1-P, usually at least 0.67 as long	CULEX
	– Prothoracic hair 3-P much thinner than 1-P and usually less than 0.5 of its length and head hairs 5,6-C near middle of dorsal surface	LOPHOCERAOMYIA

DESCRIPTIONS OF SPECIES

Subgenus : *Culex*

The subgenus *Culex* has several subgroups which can be recognised fairly simply. The most discrete subgroup is the 'pipiens' group which is represented by four species in W.A. The other main subgroup in W.A. is the 'sitiens' group which contains the major vector species *Cx (Cux) annulirostris*. The species are listed in alphabetical order, but the 'pipiens' group is clearly indicated in the keys.

The 'pipiens' group is recognised by having uniformly dark antennae in the larvae, and a dark unbanded proboscis in the adult. All the species in the group were originally considered to be subspecies of the European species *Culex (Culex) pipiens*, but work carried out at the University of W.A. and elsewhere has shown that the four Australian members were reproductively isolated, and therefore were good species. Some members of this group are difficult to separate.

SUBGENERIC CHARACTERS

Adult: The separation of the subgenera are largely based on male characters. Acrostichal bristles well developed, lower mesepimeral bristles present or absent.

Larva: The distinctive larval characters of the subgenus are indicated in the key to the subgenera.

KEY TO ADULT FEMALES OF *CULEX (CULEX)* IN WESTERN AUSTRALIA

(based in part on key prepared by Dr E.N. MARKS)

1.	– Proboscis all dark; tarsi all dark ..... [pipiens group]	2
	– Proboscis with distinct pale band at about midpoint; tarsi generally with distinct bands	5
2.	– Tergites dark with basal bands constricted sublaterally	3
	– Tergites dark with basal bands not constricted	4
3.	– Sternites pale with median and lateral apical patches of black scales; post spiracular area with a few scales; darker species	*Cx (Cux) australicus*
	– Sternites generally without median or apical lateral patches of black scales, but may be present as small inconspicuous patches (there is a large overlap with Cx australicus particularly in northern populations); post spiracular area bare; lighter species	*Cx (Cux) quinquefasciatus*
4.	– Tergites almost black, strongly contrasted with broad creamy bands; ventral surface of proboscis with pale scales over whole length	*Cx (Cux) globocoxitus*
	– Tergites brown, poorly contrasted with creamy bands; ventral proboscis with dark scales on apical 0.25	*Cx (Cux) molestus*
5.	– Scutum with patch of broad, elongate blunt-ended scales in front of wing root	6
	– Scutum without prealar patch of broad scales	8
6.	– Wings mottled with pale scales (femora and tibiae mottled; tarsi with basal and apical pale scaled bands; tergal bands indented in midline)	*Cx (Cux) squamosus*
	– Wings not mottled	7
7.	– Tibiae with anterior and posterior line of pale scales; scutum broadly clothed in creamy scales on anterior half	*Cx (Cux) starkiae*
	– Tibiae without lines of pale scales; scutum white on anterior half ...	*Cx (Cux) vicinus*
8.	– Tergites with apical creamy brown bands	*Cx (Cux) bitaeniorhynchus*
	– Abdominal tergites with basal pale scaling or all dark	9
9.	– Femora unmottled	10
	– Femora mottled (tergites with pale basal bands)	11
10.	– Scutum scaled with dark bronze scales (very small species)	*Cx (Cux)* ENM's sp. No.92
	– Scutum with extensive pale scaling. Anterior scutum pale scaled with small dark patches on fossae; hind tarsi I and II with small basal pale bands, sometimes III with small patch; proboscis with narrow pale band	*Cx (Cux) crinicauda*

11. – Anterior half of scutum with pale broad lyre- pattern with median dark stripe and submedian whitish stripe (small species) ..... *Cx (Cux) palpalis*
– Scutum without broad lyre pattern, or if present then pale scaling in midline (larger species)..... 12

12. – Tergites with pale basal bands extended in midline; bases of forked cells equidistant from base of wing; proboscis with pale band extending from 0.3-0.6 from base; sternites usually with apical dark band often terrupted in midline..... *Cx (Cux) annulirostris*
– Tergites with straight pale basal bands; base of second forked cell nearer the base of wing; proboscis with pale band extending from 0.45-0.6 of length; sternites with apical dark band complete ..... *Cx (Cux) sitiens*

KEY TO 4TH INSTAR LARVAE OF *CULEX (CULEX)* IN WESTERN AUSTRALIA

(based in part on key prepared by Dr E.N. MARKS)

1. – Head about the same width as thorax; antennal tuft arising at about 0.67 from base 2
– Head about 0.5 width of thorax; antennal tuft arising at 0.5 or less from base 9

2. – Antenna entirely grey or brown ..... [pipiens group]..... 3
– Antenna with basal 0.67 milky white, tip usually darker..... 5

3. – Anal seta 2-X with 3 branches; anal papillae about 0.33-0.5 length saddle ..... *Cx (Cux) globocoxitus*
– Seta 2-X single or bifid; anal papillae at least as long as saddle..... 4

4. – Antenna dark brown, long (about 0.75 length of head); siphon index 4.5-6.5 (usually more than 5.0); seta 1-S with four pairs of tufts..... *Cx (Cux) australicus*
– Antenna grey, rather short (about 0.55 length of head); siphon index less than 4.8 (usually 3.5- 4.5); 3-4 pairs of setae in 1-S ..... *Cx (Cux) quinquefasciatus*
Cx (Cux) molestus

5. – Lateral comb teeth with fairly even fringe of fine denticles at apex. 6
– Lateral comb teeth (at least distal row) with central denticle at apex produced into a distinct spine 7

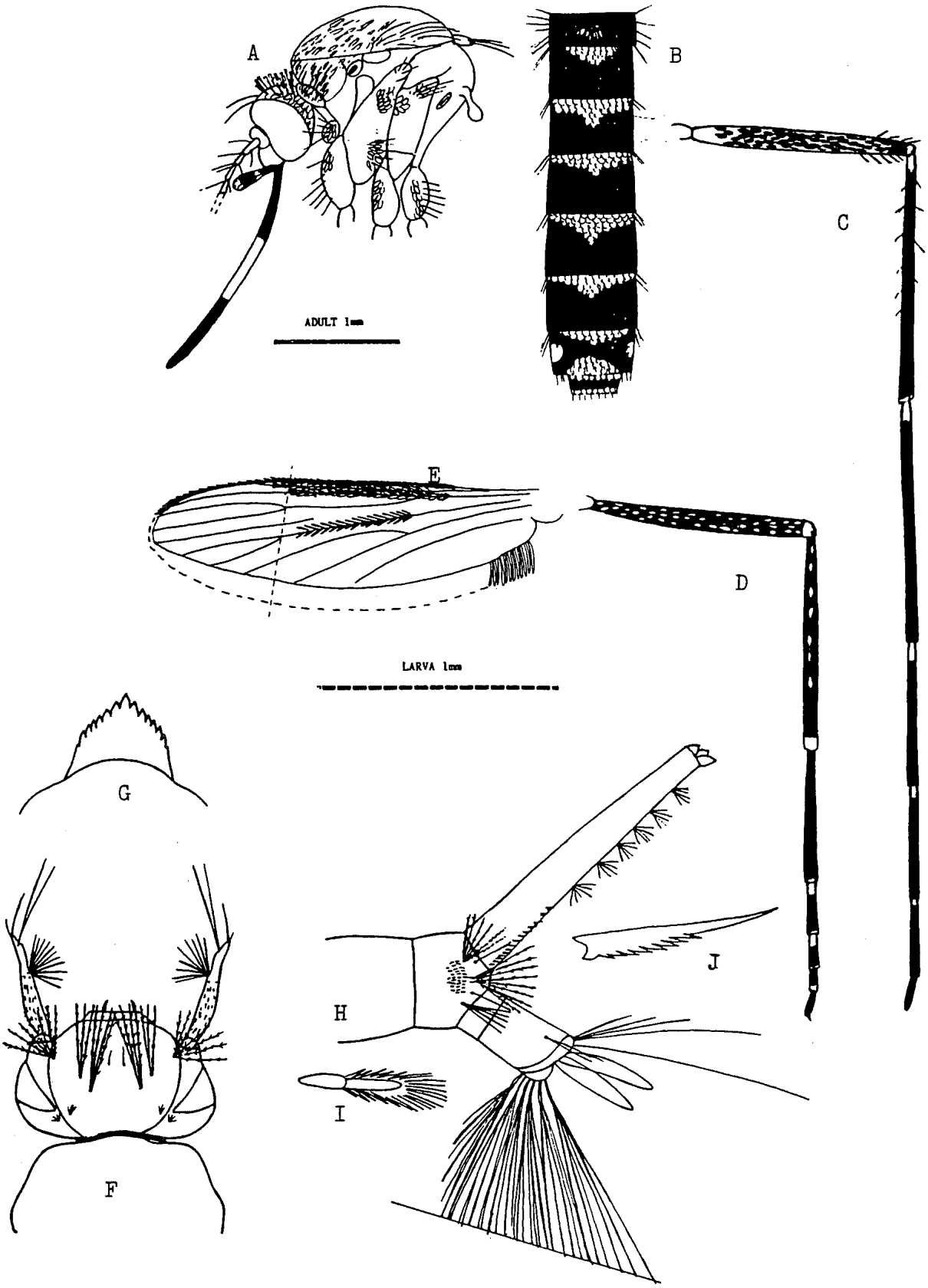
6. – Clypeal spines very stout; saddle cut away posteroventrally to half it's length (papillae short rounded; siphonal index about 5.0; 5-6 pairs subventral siphonal tufts, 3-6 branched)..... *Cx (Cux) sitiens*
– Clypeal spines and saddle not so; Hair 1-X with more than 2 branches. Seta 6-C 3-4 branched; 5-C 4-5 branched; Siphonal index 6.0 to 7.0; 5-6 pairs of subventral siphonal tufts, 2-5 branched ..... *Cx (Cux) annulirostris*

7. – Siphonal index about 5.0 (6 pairs of subventral siphonal tufts, about 6 branched; 6-C 3 branched; 5-C 3-5 branched; tip of siphon curved dorsally; central spine of comb teeth extends beyond the apex of fringe denticles by about 0.33 the length of the tooth) ..... *Cx (Cux) palpalis*
– Siphonal index about 6.0 to 10.0..... 8

8. – 6-C 1-2 branched; 5-C 2 branched, distinctly weaker than 6-C; siphonal index 8.0; 5-6 pairs of subventral siphonal tufts, 4-branched; central spine of comb tooth extends beyond the apex of fringe denticles by about 0.25 of length of tooth..... *Cx (Cux)* ENM's sp. No.92
– 6-C 2-3 branched; 5-C 2-5 branched, as stout as 6- C. Comb teeth of proximal and distal rows similar with slender spine extending beyond fringe denticles by about 0.33-0.5 length of tooth..... *Cx (Cux) crinicauda*

9. – Lateral comb of about 5-7 strong spines; siphon index about 7.0..... *Cx (Cux) bitaeniorhynchus*
– Lateral comb of about 20 spines..... 10

10. – Dorsal valve hairs not modified; siphon index about 7.0..... *Cx (Cux) squamosus*
– Dorsal valve hairs stout, modified as curved hooks; siphon index about 4.5 ..... *Cx (Cux) starkeae*
Cx (Cux) vicinus



Culex (Culex) annulirostris

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Foreleg; D: Wing (detail of scaling on some veins shown); F: Larval head (dorsal); G: Mentum; H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail of basal and apical teeth).

Culex (Culex) annulirostris Skuse 1889

Skuse, F., 1889. *Proc. Linn. Soc. N.S.W., 3:* 1737.
Type locality: Blue Mountains and Berowra, New South Wales.
Synonymy: *Culex bancroftii* Theobald, F.V., 1901. *Mon. Cul., 1:* 367.
Culex jepsoni Bahr, P.H., 1912. *J. Lond. Sch. Trop. Med., 1:* 18.
Culex somerseti Taylor, F.H., 1912. *Rept. Commis. Publ. Hlth. Qld.*, p28.
Culex consimilis Taylor, F.H., 1913. *Aust. Inst. Trop. Med. Rept.* p8.
Culex simplex Taylor, F.H., 1914. *Trans. Ent. Soc.*, p698.
Culex palmi Baisas, F.E., 1938. *Mon. Bull. Bur. Hlth. Philip. Manila 18(1):* 207.

ADULT FEMALE

A widely distributed, medium sized species with a banded proboscis. Head with narrow fawn decumbent scales dorsally with some pale scales in midline; lateral head clothed in flat white and dark scales; upright forked scales numerous, brown. Torus with some scaling mesially. Clypeus bare. Palp dark scaled with a few pale scales at tip; about 0.21x length of proboscis. Proboscis black with broad pale band extending from 0.3-0.6 from base; about 0.88x length of forefemur. Scutal integument dark brown; clothed with admixture of narrow bronze, cream and white scales; pale areas behind fossa and around prescutellar space. Scutellum with narrow white scales on all three lobes. Pleural integument brown; anterior and posterior pronotum with narrow palish scales; patches of appressed broad white scales on lower and upper sternopleuron, and on mesepimeron. Abdomen with tergites dark scaled with white basal bands which are extended into points on segments II-VI; sternites variable, generally pale scaled with apical black band, broken in midline, but may be complete in some specimens. All coxae with patch of light and dark scales. Foretibia with row of pale spots associated with row of spines on anterior surface. Hindleg with femur mottled; tibia dark; tarsi I-IV dark with narrow basal band, V dark. Pulvilli present, tarsal claws simple. Wing dark scaled. Haltere with pale stem and dark club.

LARVA

Antenna milky white at base with small spicules and tip dark beyond insertion of seta 1-A; about 0.9x length of head; seta 1-A a broad fan of 20+ branches inserted at 0.625 from base. Head about 1.6x as long as wide; about 0.64x width of thorax; seta 4-C with 1-2 small branches; 5-C with 4 pectinate branches; 6-C with 3-4 pectinate branches; 7-C with 7-10 plumose branches; 8-C and 9-C with single short hair. Prothoracic setae with 1-P to 3-P single, long on common basal boss; 4-P with 2 branches, about 0.75x length of 1-P; 5-P and 6-P single, long; 7-P with 3 long branches. Abdominal segment VIII with lateral comb of 30-40+ fringed scales in a triangular patch; seta 1-VIII with 5-7 pectinate branches; 2-VIII and 4-VIII short and single; 3-VIII with 8-9 pectinate branches; 5-VIII with 5-6 pectinate branches. Siphon index about 4.5; about 2.6x length of saddle; acus well developed; seta 1-S with 6 pairs of tufts with 6-8 branches on apical 0.6 of siphon; pecten with 11-15 fringed spines, apical spines may be slightly more widely spaced. Anal segment with saddle complete, with numerous small spicules; seta 1-X single; 2-X with 3-4 branches; 3-X single, very long; 4-X with 6 pairs of tufts on grid. Anal papillae long and pointed, about same length as saddle.

BIOLOGY

The biology of this species needs to be reevaluated following the recent validation of *Cx palpalis* as a valid species. *Cx palpalis* has been referred to in recent literature as *Cx ENM's 'Normanton' species*. Our knowledge of the biology of *Cx annulirostris* is based on data drawn, in some cases, from a mixture of *Cx annulirostris* and *Cx palpalis* and possibly other species in the complex. Adults of *Cx annulirostris* are generalist feeders, attacking a wide variety of mammals and birds. Man is readily bitten, occasionally in the day but predominantly in the evening, just after sunset. This species is the most common and widely distributed pest species in Australia, generally a non- domestic species, though it has been widely collected from domestic container habitats in northern areas. Adults have a mean dispersal range of about 10km. Adults may be collected throughout the year in northern areas, with maximum populations in the late dry season (July to October). In southern areas, the species may be captured at any time of the year, but is very scarce in the winter. The highest populations of adults are seen in the December to April period. Studies in Victoria and New South Wales have indicated that the species overwinters as adults resting in flood debris, animal burrows and scree slopes, and breeding is not observed until the mean temperature rises above 17.5 degrees centigrade.

The eggs of *Cx annulirostris* are not resistant to desiccation, and are laid in rafts on the water surface. Larval breeding areas are generally in shallow fresh water sites, open and sunlit with emergent vegetation.

Generally, it is found breeding in more permanent sites, but is also able to colonise new sites rapidly and can often be found breeding prolifically in ground pools which are relatively short lived (2-3 weeks). It is often found breeding in drains or outfall areas, in sewage farms or effluent overflows, and in container habitats. In the south, this species is often found breeding with *Cx australicus* and *An annulipes*. In the north it has been found breeding with a wide variety of species.

RELATION TO DISEASE

Cx annulirostris is the major vector of arboviral diseases in Australia. It is implicated as the dominant vector during epidemics of Australian Encephalitis (MVEv and Kunjin virus) and Epidemic Polyarthritis (RRv). Numerous other arboviruses have been isolated from this species in W.A. and elsewhere in Australia (for a full review see : Lee, D.J et.al. The Culicidae of the Australasian Region Volume 7 (1989)). *Cx annulirostris* is also a vector of periodic filariasis *(Wuchereria bancrofti)* outside Australia, and is a major vector of dog heart worm *(Dirofilaria immitis)* throughout Australia.

DISTRIBUTION

Ashburton, Jun 1955, EJB. Balgo, Jun-Jul 1978, AEW; Mar 1981, AEW. Balgo, 12km W, Mar 1981, AEW. Balgo, 24km W, Mar 1981, AEW. Balgo, Darbai R., Mar 1981, AEW. Balgo, The Pound, Jun-Jul 1978, AEW. Balline Stn, May 1985, MEC. Barradale Crossing, Jun 1955, EJB. Beagle Bay, Aug 1953, EJB. Beebingarra Creek, Jun 1978, AEW; Mar 1979, AEW. Beverley Springs Stn, Sep 1984, MEC. Billiluna, Mar 1981, AEW. Blina Stn, Oct 1984, MEC. Boddington, Apr 1973, SJM. Brickhouse Stn, Apr-May 1985, MEC. Bridgetown, May 1956, EJB. Broome, Sep 1978, AEW; Feb-May 1984, MEC; Jul-Oct 1985, SH; Apr-May 1985, MEC. Bunbury, Jan-Feb 1985, MEC. Camballin, May 1979, AEW; Jul-Aug 1979, AEW. Canning R., Mar-May 1975, RH; Mar 1979, PFSL. Canning R., Canning, Mar-Apr 1975, PFSL. Canning R., Cannington, May 1963, JBF. Canning R., Castledare, Mar 1975, PFSL. Canning R., Clontarf, May 1963, JBF. Canning R., Ferndale, Feb-Mar 1977, AB. Canning R., Kelmscott, Mar 1971, PFSL. Canning R., Kent St Weir, Oct 1973, PFSL; Feb 1974, PFSL; Mar-Apr 1975, PFSL. Canning R., Riverton Bridge, Mar 1975, PFSL. Cape Lambert, May 1984. Carnarvon, Jul 1964, LEK; Apr 1979, AEW; Dec 1979, AH/CS; Feb-Mar 1980, AH/CS; Feb 1984, MEC; May 1984, WJOB; Jun-Sep 1984, MEC; Jan 1985, MEC; Apr 1985, MEC; Jun 1985, MEC. Carnarvon, Babbage Island, Dec 1979, AH/CS; Mar 1980, AH/CS. Carnarvon, Bilbawarra Bore, May 1985, MEC. Cherrabun, May 1979, AEW. Christmas Creek Community, Oct 1984, MEC. Clackline, 3km S, Apr 1955, DLM. Dale River, Jan 1952, KRN. Dale River, Beverley, Apr 1955, DLM. Dampier, Aug 1973, ENM; Mar 1979, AEW; May-Jun 1984, MEC; Aug-Oct, MEC; Jan 1985, MEC. Darkan, Nov 1952, DG. De Grey R. crossing, Jun 1978, AEW; Mar 1979, AEW. De Grey R., Welburn Pool, Jul 1979, AEW. De Grey Station, Jun 1978, AEW; Mar 1979, AEW. Derby, WWD; Mar 1953, EPH/EJB; Apr 1953, AKO; Mar-Apr 1977, AEW; Aug-Sep 1978; Sep- Oct 1978, AEW; Mar-Apr 1980, RN/JR; Aug 1980, RN/JR; Jan-Feb 1981, RN/JR; Apr- May 1981, RN/JR; Feb-Mar 1984, MEC; Aug 1984; Mar 1985, AEW; Mar 1985, MEC. Derby, 7km E, Apr 1977, AEW. Derby, 24km E, Apr 1977, AEW. Derby, 30km S, Mar-Apr 1977, AEW. Derby, 40km S, Mar-Apr 1977, AEW. Derby, Langie crossing, Mar 1954, EPH. Derby, E, Millards Soak, Apr 1977, AEW. Derby, Myalls Bore, Mar 1954, EPH; Sep-Oct 1978, AEW; Apr-May 1980, RN/JR; Jan-Feb 1981, RN/JR; Apr-May 1981, RN/JR. Derby, Prison Boab, Mar-Apr 1977, AEW. Dogger Gorge, Jan 1975, PFSL. Doorawarrah Stn, May 1985, MEC. Drakesbrook, Mar 1955, EJB. Drysdale R., Aug 1979, AEW. Edajee Stn, May 1985, MEC. Esperence, Sep 1951. Exmouth, Feb 1980, PS; Apr-Sep 1980, PS; Nov-Dec 1980, PS; Jan-Feb 1981, PS; Aug 1984, MEC; Mar 1985, MEC. Exmouth, US Navy Base, Jan 1980, PS; Jul 1980, PS; Nov-Dec 1980, PS; Jan 1981, PS; Apr 1981, PS. Fitzroy Crossing, Oct 1950, EJB; Jul-Sep 1984, MEC; Apr 1985, MEC; Jul 1985, MEC. Forrest R. Mission, Apr 1953, RL; Jun 1954, EPH; Jun 1954, RKC; Apr 1955, RKC. Fortesque, Jan 1985, MEC. Gascoyne R. Crossing, Apr 1979, AEW. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Glengary, Ma. Goomalling, Jul 1955, EJB. Goomalling, 15km W, Aug 1968. Guildford, Jan 1943, FNR; Oct 1943, FNR. Halls Creek, Jul 1984, MEC; Apr 1985, MEC. Harvey, Apr 1955, EJB. Helena R., Midland, May 1963, JBF. Irwin, May 1955, EJB. Ivanhoe Homestead, Mar 1954, EPH. Jandakot, Nov-Dec 1971, SJM; Jan-May 1972, JCT; Jan-May 1972, SJM; Dec 1972, JCT; Dec 1972, SJM; Mar 1974, AEW; Mar 1975. Jandakot, Russell Swamp, Mar-Apr 1974. Joondalup, Dec 1977, AB; Jan-Mar 1978, AB. Kalumburu, Jul 1953, EJB; Mar 1954, EPH; Mar 1955, EPH/EJB; Jul 1978, PFSL/AEW; Aug 1979, AEW. Kalumburu, Longonye Creek, Mar 1954, EPH. Karratha, Mar 1979, AEW; Jan-Dec 1980, MW/TH; Jan-Feb 1981, MW/TH; Apr-Jun 1981, MW/TH; Feb-Mar 1984, MEC; May-Oct 1984, MEC; Dec 1984, MEC; Jan 1985, MEC; Jul 1985, MEC. Kimberley Downs, Mar 1953, EPH/EJB; Mar 1954, EPH/EJB; May 1979, AEW. Kimberley Downs, 34km E, Mar 1954, EPH. Kimberley Research Station, Mar 1954, EPH; Mar 1955, EPH/EJB; Oct 1961, KTR; Jan 1962, KTR. Kodup, Nov 1951, Ma. Kununurra, Apr-Jun 1972,

PFSL; Nov-Dec 1972, PFSL; Jan 1973, PFSL; Apr-May 1973, PFSL; Nov-Dec 1973, PFSL; Apr 1974, PFSL; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Oct-Nov 1975, PFSL; Jun-Jul 1976, AEW; Oct-Nov 1976, AEW; Apr 1977, AEW; Nov-Dec 1977, AEW; Jun-Jul 1978, PFSL/AEW; Dec 1979, OA; Feb-Sep 1980, OA; Nov 1980, OA; Feb-Jun 1981, OA; Feb-Mar 1984, MEC. La Grange, Oct 1978, AEW; Sep 1984, MEC. Lake Argyle, Apr-Jun 1972, PFSL; Dec 1972, PFSL; Nov-Dec 1977, AEW. Lake Argyle NE, Jul 1978, AEW. Lake Argyle SW, Jul 1978, PFSL/AEW. Lake Chandala, Aug-Sep 1980, AEW; Oct 1980, PFSL. Lake Claremont, Mar 1979, PFSL. Lake Daley, Nov 1979, AEW. Lake Goollelal, Jan-Mar 1978, AB. Lake Gregory Community, Aug 1984, MEC. Lake Gwelup, Nov 1983, JCT. Lake Joondalup N, Mar 1978, AB. Lissa Down Stn, Nov 1984, MEC. Lissadel, Jul 1978, PFSL/AEW. Liveringa, Apr 1953, AKO. Lockyer Gap, Nov 1984, MEC. Louisa Downs, May 1979, AEW. Ludlow, Jan 1943, PNF. Mabel Down Stn, Nov 1984, MEC. Manjimup, May 1956, EJB. Marble Bar, Mar 1979, AEW; Dec 1984, MEC. May River crossing, Apr 1977, AEW. Meda, Apr 1977, AEW. Miaree Pools, Jun 1984, MEC; Oct 1984, MEC. Millstream, Jun 1953, EPH/EJB; Mar 1954, EPH; Jun 1954, EPH; Mar 1955, EPH; Oct 1970, DHC; Apr 1971, DHC; Jan 1975, PFSL; Oct 1978, AEW; Apr 1979, AEW; Nov 1984, MEC. Millstream, Dawsons Springs, Jun 1954, EPH. Millstream, Deep Reach Pool, Jan 1975, PFSL. Millstream, Palm Pool Crossing, Jan 1975, PFSL. Millstream, Palm Pool, 10km E, Jan 1975, PFSL. Millstream, Palm Pool, 17km E, Jan 1975, PFSL. Millstream, Palm Pool, 17km W, Jan 1975, PFSL. Millstream/Roebourne, Jun 1954, EPH. Minnie R., Mar-Apr 1977, AEW. Mitchell Plateau, Jul 1981, AEW. Mooka, May 1985, MEC. Moola Bulla, Oct 1949, RHB/Be. Moora, Jun 1955, EJB. Mowanjum, Sep-Oct 1978, AEW. Mullewa, Jun 1955, EJB. Munkayarra Pool, Mar-Apr 1977, AEW. Murray, May 1956, EJB. Murray R., Apr 1971, CAG. Nanutarra, Ashburton R., Apr 1980, AEW. Narrogin, Mar 1955, EJB. Neale Junction, 128km S, Jul 1974, KTR. Newman, Oct 1978, AEW; Mar 1979, AEW; Mar 1981, PF. Newman, Fortescue R., Mar 1979, AEW. Newman, Gingianna Billabong, Mar 1979, AEW. Nichol, No 3 Bore, Sep 1949. Nicholson, Sep 1949, RHB/Be. Northampton, May 1955, EJB. Nyang Stn, May 1985, MEC. Ord River, CSIRO, Apr 1953, AKO. Palm Garden, Sep 1943, RHB/Be. Parry's Creek, Dec 1972, PFSL; Apr-May 1973, PFSL; Jun-Jul 1976, AEW; Oct-Nov 1976, AEW; Apr 1977, AEW. Perenjori, May 1955, EJB. Perth, FNR; Jun 1955, EJB; Feb 1971, HEP. Perth, Belmont, Jun 1955, EJB. Perth, Canning, Mar 1980, FWH. Perth, Careniup, Nov 1983, JCT. Perth, Ferndale, Mar-Apr 1975, PFSL. Perth, Kelmscott, Aug 1972, PFSL. Perth, Nedlands, Mar-Apr 1974, WJB. Perth, Morley, Oct 1974, PFSL. Perth, Subiaco, Mar 1985, MEC. Perth, Wallburnup Swamp, Jan 1982, PFSL. Perth, Welshpool, Jul 1974, PFSL. Petermarer Creek, Jun 1978, AEW. Port Hedland, Jul 1973, EJB; Jun 1978, AEW; Sep 1978, AEW; Mar 1979, AEW/WJ; Jan-Apr 1980, BB; Feb-Mar 1984, MEC; May-Jun 1984, MEC; Aug-Oct 1984, MEC. Quanbun Stn, Oct 1984, MEC. Ringers Soak, Apr 1985, MEC. Roebourne, Feb-Mar 1953, EPH/EJB; Feb-Mar 1954, EPH; Jun 1954, EPH; Apr 1979, AEW; May-Jun 1984, MEC; Aug-Oct 1984, MEC; Jan 1985, MEC. Roleystone/Araluen, Feb 1971, PFSL. Shay Gap, Nov 1980, NC/CM. Spring Valley Stn, Nov 1984, MEC. Strelley R., Jun 1978, AEW; Mar 1979, AEW. Sturt Creek Station, Oct 1978, AEW. Swan River, Guildford, May 1963, JBF; Mar-Apr 1975, PFSL. Swan River, Hearne Hill, May 1963, JBF. Swan River, Maylands, May 1963, JBF. Tabba Tabba Creek, Jun 1978, AEW. Tom Price, Oct 1978, AEW; Mar 1979, AEW; Jun-Oct 1980, AD; Dec 1980, AD. Turkey Creek, Jul 1978, PFSL/AEW. Upper Chapman, May 1955, EJB. Wandering, Mar 1955, EJB. Westonia, Apr 1943, CFHJ. Wickham, Apr 1979, AEW; Jun 1984, MEC; Apr 1986, PFSL. Williambury Stn, Jun 1985, MEC. Williams, Mar 1955, EJB. Winning, Mar 1981, PFSL. Wittenoom, Nov 1984, MEC. Wogoola, Jun 1955, EJB. Wyndham, Nov 1924, TGC; Jan 1930, TGC; Mar 1930, TGC; Sep 1943, He; Mar 1953, RL; Apr 1953, AKO; Apr 1953, RL; Aug 1953, EJB; Apr-Jun 1972, PFSL; Dec 1972, PFSL; Jan 1973, PFSL; Nov-Dec 1977, AEW; Jul 1978, AEW; Apr-May 1980, OA; Dec 1980, OA; Apr-Jul 1981, OA; Feb 1984, MEC. Wyndham, 12 mile, Jun 1953, RL. Wyndham/Kimberley Research Station, Mar 1953, RL; Nov 1953, RL. Yanchep National Park, Nov 1985, ALD. Yeeda, Apr 1967, EJB; Mar-Apr 1977, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

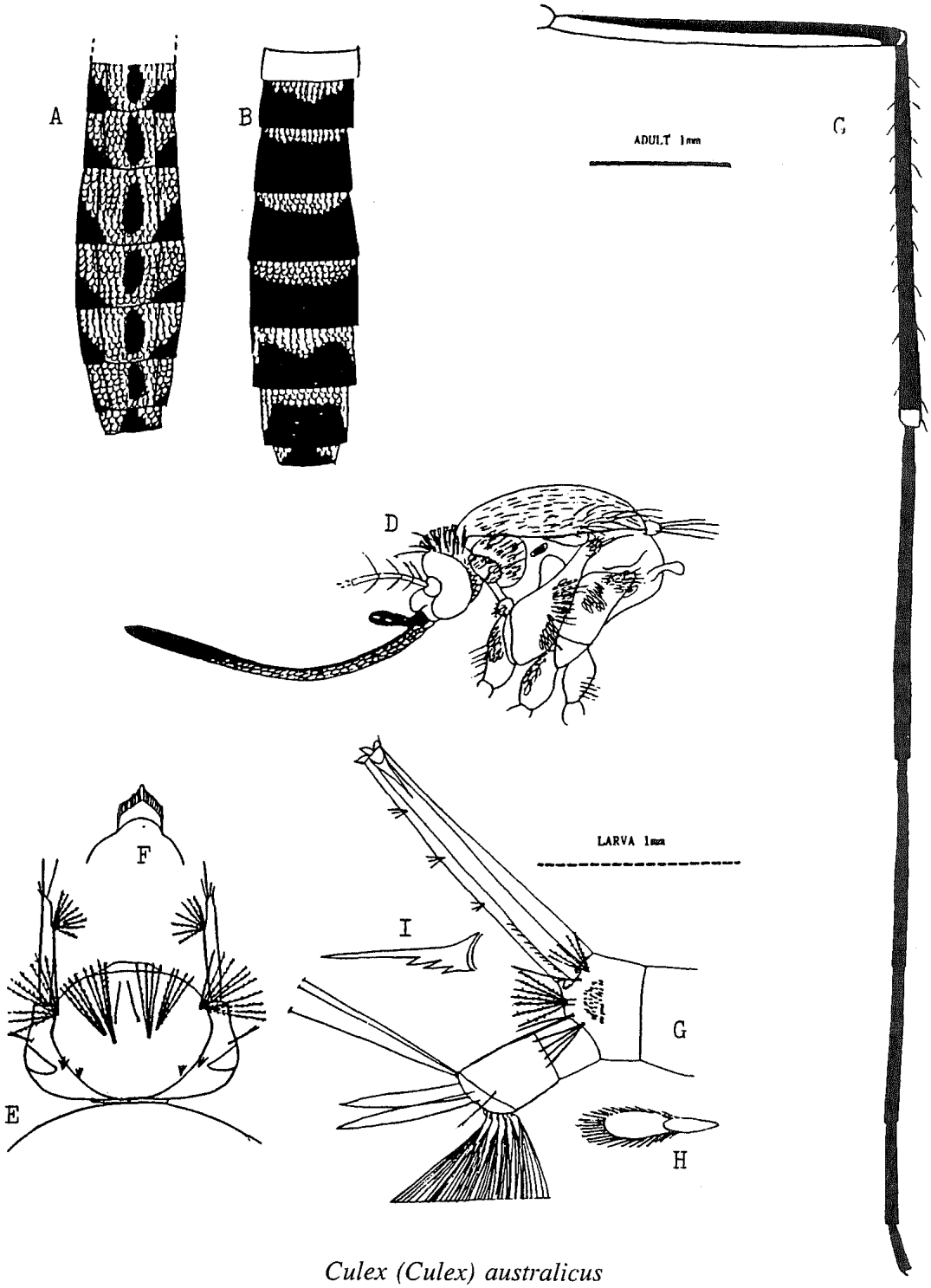
In southern W.A., *Cx annulirostris* is the only *Culex* species with a banded proboscis, and cannot be confused with any other species. In the north, there are several species which resemble *Cx annulirostris* in that they have a banded proboscis, and abdominal bands extended mesially into distinct points. These species can usually be separated by the presence of a patch of broad scales in front of the wing root, or have femora unmottled. *Cx palpalis*, though fairly uncommon in northern W.A., is the most closely related species to *Cx annulirostris*, and can be separated using the characters in the key.

Culex (Culex) australicus Dobrotworsky and Drummond 1953

Dobrotworsky, N.V. and Drummond, F.H., 1953. *Proc. Linn. Soc. N.S.W., 78 :* 143.
Type locality: Melbourne, Victoria.
Synonymy: None.

ADULT FEMALE

A medium sized, brown species with an unbanded proboscis. Head clothed with narrow elongate yellowish scales on vertex, darker behind eye border; upright forked scales not confined to occiput. Torus



Culex (Culex) australicus

A: Abdomen (ventral); B: Abdomen (dorsal); C: Hindleg; D: Adult head and thorax (lateral); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

and clypeus bare. Palp dark scaled with a few pale scales apically; about 0.17x length of proboscis. Proboscis dark above, mottled pale below on middle 0.3; about 1.18x length of forefemur. Scutal integument dark brown; clothed in fine bronze scales with pale scales above wing root and prescutellar space. Scutellum with long narrow creamy scales on all lobes. Pleural integument brown; anterior pronotum and posterior pronotum with dense elongate white and brown scales; broad flat white scales on propleuron, upper and lower sternopleuron, anterior and lower mesepimeron. Abdomen with tergites black scaled with white basal bands, constricted laterally and separated from lateral patches on II-V; sternites pale scaled with elongate black median and apicolateral patches. Forecoxae with pale appressed scales above darker scales below; midcoxae and hindcoxae with pale scales only. Hindfemur pale below and dark above with white knee spot; tibia dark with pale apical tip; tarsi all dark. Wings all dark. Haltere with pale stem; club with pale scales on dark integument.

LARVA

Antenna uniformly brown, spiculate near base, about 0.79x length of head; seta 1-A multibranched and pectinate, inserted at 0.67 from base. Head about 0.67x as long as wide, about 0.67x width of thorax; seta 4-C simple and single; 5-C pectinate with 4 branches; 6-C pectinate with 4-5 branches; 7-C pectinate with 8-10 branches; 8-C with 2 short branches; 9-C with 2-3 short branches. Abdominal segment VIII with lateral comb of 25-40 fringed scales in a triangular patch; seta 1-VIII with 5 pectinate branches; 2-VIII and 4-VIII simple and single; 3-VIII with 7 pectinate branches; 5-VIII with 4 simple branches. Siphon with acus, index about 7.0 or more, about 4.86x length of saddle; seta 1-S with 2-3 pairs of setae with 5-7 branches on apical 0.6 of siphon; pecten with 8-11 teeth with basal denticles. Anal segment with saddle complete; seta 1-X single; 2-X with 2 branches; 3-X single and long; 4-X with 6 pairs of tufts on grid. Anal papillae long and pointed, about 0.95x length of saddle.

BIOLOGY

Adults of *Cx australicus* feed predominantly on birds and small mammals. They are readily collected in bird baited traps, light traps and CO_2 baited traps. Adults may aggregate around man and may alight, but rarely, if ever, bite.

This species breeds in open fresh water sites with emergent vegetation. It is often found breeding in association with *Cx annulirostris* and *An annulipes* s.l.. *Cx australicus* may breed in slightly brackish locations, and will tolerate slightly polluted waters. It is commonly found in drains around urban areas.

RELATION TO DISEASE

Not known to transmit diseases of man. Experimental data indicates that *Cx australicus* will support MVEv for at least 10 days following artificial feeding with the virus, and a single strain of MVEv was isolated from this species during the 1974 epidemic in the Murray Valley. It has been speculated that there may be a significant role for this species in pre-epidemic amplification cycles of MVEv. Both Kunjin and Sindbis viruses have been isolated from this species, and it is implicated in the mechanical transmission of Myxomatosis in rabbits.

DISTRIBUTION

Albany, Aug 1956, EJB; Jan 1972, SJM; Aug 1972, SJM; Aug 1973, SJM. Albany, Lake Steppings, Jan 1972, SJM. Armadale. Armadale/Kelmscott, Jun 1955, EJB. Ashburton, Jun 1955, EJB. Ashburton R., Jun 1955, EJB. Augusta, Oct 1974, PFSL. Badgingarra, Jul 1985, MEC. Balgar Plains, Jul 1985, MEC. Balingup, May 1956, EJB. Balline Stn, May 1985, MEC. Barradale Crossing, Jun 1955, EJB. Beagle Bay, Aug 1953, EJB. Beverley, Aug 1973, PFSL. Blina Stn, Oct 1984, MEC. Bodallin W, Sep 1973, SJM. Boddington, Mar 1971. Boddington, Mooradung Brook, Mar 1972, PFSL. Boologooro Stn, May 1985, MEC. Boya, Jul 1973, PFSL. Brickhouse Stn, Apr 1985, MEC. Bridgetown, May 1956, EJB. Brookton, Jun 1955, EJB. Broome, Sep 1978, AEW; Feb-Mar 1984, MEC; May 1984, MEC; Aug-Sep 1984, MEC. Bullsbrook, Oct 1980, PFSL. Bullsbrook, 5km N, Sep 1980, AEW. Bullsbrook, 6km N, Aug 1973, PFSL. Bulong, Sep 1973, SJM. Bunbury, Sep 1974, PFSL; Jan-Dec 1985, MEC. Canning R., Mar-May 1975, RH; Jun 1979, AEW. Canning R., Canning, Mar-Apr 1975, PFSL. Canning R., Cannington, May 1963, JBF. Canning R., Castledare, Mar 1975, PFSL. Canning R., Clontarf, May 1963, JBF. Canning R., Kent St Weir, Oct 1973, PFSL; Mar 1975, PFSL. Canning R., Riverton Bridge, Mar-Apr 1975, PFSL. Carnamah, May 1955, EJB. Carnarvon, Apr 1979, AEW; Apr 1980, AH/CS; Jun-Dec 1980, AH/CS; Jun-Aug 1981, AH/CS; May 1984, WJOB; May-Sep 1984, MEC; Jan 1985, MEC; Mar 1985, MEC; May-Jun 1985, MEC. Carnarvon, Babbage Island, Jul-Nov 1980, AH/CS; Jan-Mar 1981, AH/CS; Jun-Aug 1981, AH/CS. Cherrabun, May 1979, AEW. Chidlow, Jun 1973, SJM. Christmas Creek Community, Oct 1984, MEC. Corrigin, Jun 1955, EJB. Dale Bridge, 9.6km E, Jan 1953, JHC. Dalwallinu, Jul 1955, EJB. Dampier, Mar 1979, AEW; Aug 1984, MEC; Oct 1984, MEC; Jan 1985, MEC. Dandaragan, Jul 1955, EJB. Dardanup,

5km NW, Nov 1952, DLM. Derby, Oct 1978, AEW; Feb 1981, RN/JR; Feb 1984, MEC; Jul-Aug 1984, MEC; Mar 1985, MEC. Derby, Myalls Bore, Jan 1981, RN/JR; Apr 1981, RN/JR. Donnybrook, May 1974. Dowerin, Jul 1956, EJB. Dundas, Aug 1956, EJB. Eaton, Oct 1974, PFSL. Esperence, Aug 1956, EJB. Exmouth, Feb-Aug 1980, PS; Nov 1980, PS; Feb 1981, PS; Aug-Sep 1984, MEC. Exmouth, US Navy Base, Jan 1980, PS; Mar-Apr 1980, PS; Jun-Jul 1980, PS; Dec 1980, PS. Fitzroy Crossing, Jul-Aug 1984, MEC. Forrest National Park, Jan 1972, PFSL; Feb 1972, SJM; Sep 1972, PFSL. Gascoyne Junction, May 1985, MEC. Gascoyne R. Crossing, Apr 1979, AEW. Geraldton, Aug 1985, MEC. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Gingin, 15km E, Sep 1973, PFSL. Glencoe, May 1971, SJM; Jul 1972, SJM; Nov 1973, SJM. Glenroy, Sep 1984, MEC. Goomalling, Jul 1955, EJB. Greenmount, Sep 1973, PFSL. Guildford, Mar 1950, PNF; Jul 1954, EPH. Halls Creek, Jul 1984, MEC. Hamilin Stn, Apr 1985, MEC. Harvey, Apr 1955, EJB. Helena R., Guildford, Jul- Sep 1973, SJM. Helena R., Helena Valley, May 1963, JBF. Helena R., Midland, May 1963, JBF. Highbury, Apr 1972, SJM. Irwin, May 1955, EJB. Irwin R., Oct 1971, SJM; Jul 1973, SJM. Jandakot, Oct-Dec 1971, SJM; Jan-Dec 1972, SJM; Jan-Mar 1972, JCT; May-Dec 1972, JCT; Jan 1973, SJM; Oct 1973, SJM; Oct 1974, PFSL. Jandawaring, Jul 1985, MEC. Jibberding/Whitewells, Sep 1967, HEP. Jurien Bay, Sep 1974, JHS; Jul 1985, MEC. Karratha, Feb-Mar 1984, MEC; May 1984, MEC; Jul-Aug 1984, MEC. Kalbarri, May 1985, MEC. Katanning, Aug 1956, EJB. Kellerberrin, Jul 1956, EJB. Kendenup, May 1971, SJM. Keysbrook, Feb 1971, SJM; Mar 1972, SJM. Kondinin, Mar 1955, EJB. Koorda, Jul 1956, EJB. Kulin, Mar 1955, EJB. Kununoppin/Trayning, Jul 1956, EJB. Kununurra, Apr-Jun 1972, PFSL; Mar 1973, PFSL; Mar 1984, MEC. La Grange, Oct 1978, AEW; Sep 1984, MEC. Lake Chandala, Aug-Oct 1980, AEW. Lake Clifton, Aug 1980, AEW. Lake Gregory Community, Aug 1984, MEC. Laverton, Aug 1956, EJB. Leonora, Jun 1956, EJB. Lissa Down Stn, Nov 1984, MEC. Lockyer Gap, Nov 1984, MEC. Lynton Stn, May 1985, MEC. Manjimup, May 1956, EJB. Marble Bar, Aug 1944, Mo; Mar 1979, AEW. Marradong, Mar 1972, SJM. Mayanup, Sep 1974, PFSL. Meekatharra, Jun 1985, MEC. Merridin, Jul 1956, EJB. Millars Well, Nov 1984, MEC. Millstream, Jun 1953, EPH/EJB; Jun 1954, EPH; Jan 1975, PFSL; Oct 1978, AEW; Apr 1979, AEW. Millstream, Kanjieangie, Jun 1954, EPH. Millstream/Roebourne, Jun 1954, EPH. Minderoo, Jun 1955, EJB. Mingulla Village, May 1985, MEC. Minilya Roadhouse, May 1985, MEC. Mooka, May 1985, MEC. Moora, Jun 1955, EJB. Mowanjum, Sep-Oct 1978, AEW. Mt Magnet, Apr 1985, MEC. Mt Marshall, Jul 1956, EJB. Muchea, 5km N, Sep 1980, AEW. Mukinbudin, Jul 1956, EJB. Mullewa, Jun 1955, EJB; Apr 1985, MEC. Mumballup, Sep 1974, PFSL. Mumballup, 21km E, Sep 1974, PFSL. Murray, May 1956, EJB. Narembeen, Jul 1956, EJB. Narrogin, Mar 1955, EJB. New Cherrabun Stn, Oct 1984, MEC. Newman, Oct 1978, AEW; Mar 1979, AEW. Northam, Jun 1955, EJB. Northampton, May 1955, EJB; Apr 1985, MEC. North Dandalup R., Jan 1984, PFSL. Nungarin, Jul 1956, EJB. Ord River Stn, Nov 1984, MEC. Peedamulla Creek, Jun 1955, EJB. Perenjori, May 1955, EJB. Perth, HEP; Apr 1948, WMO; Mar 1951, ATK; Jun 1953, DLM; Jun 1955, EJB. Perth, Belmont, Jun 1955, EJB. Perth, Canning, Mar 1980, FWH. Perth, Ferndale, Mar-Apr 1975, PFSL. Perth, Maylands, Oct 1974, PFSL. Perth, Morley, Oct 1974, PFSL. Perth, Mt Lawley, Sep 1974, PFSL. Perth, Nedlands, Oct-Dec 1971, SJM; Sep-Nov 1972, SJM; Sep 1980, AEW. Perth, Riverdale, May 1967. Phillips R., Aug 1956, EJB. Pingelly, Apr 1972, SJM. Plantagenet, 1956, EJB. Popanyinning, Apr 1972, SJM. Port Hedland, Sep 1978, AEW; Mar 1979, AEW; Jan-Mar 1980, BB; May-Nov 1984, MEC. Preston, Jun 1955, EJB. Rockingham, Jun 1955, EJB. Roebourne, Jun 1954, EJB; Sep-Nov 1984, MEC; Jan 1985, MEC. Serpentine/Jarrahdale, Jun 1955, EJB. Shay Gap, Oct-Dec 1980, NC/CM. Southern Cross, Jun 1973, SJM. Spring Creek Stn, Nov 1984, MEC. Sturt Creek Station, Oct 1978, AEW. Swan, Jun 1955, EJB. Swan River, Caversham, May 1963, JBF. Swan River, Hearne Hill, May 1963, JBF. Swan River, Guildford, May 1963, JBF. Swan River, South Perth, May 1963, JBF. Tableland Stn, Sep 1984, MEC. Tambellup, Aug 1956, EJB. Tammin, Jul 1956, EJB. Three Springs, May 1955, EJB. Tom Price, Oct 1978, AEW; Mar 1979, AEW. Toodyay, Jun 1955, EJB. Upper Blackwood, May 1956, EJB. Upper Chapman, May 1955, EJB. Victoria Plains, Jul 1955, EJB. Wagin, Aug 1955, EJB. Wandering, Mar 1955, EJB. Wanneroo, Jun 1955, EJB. Warramboo Creek, Jun 1955, EJB. Welcome Soak, Nov 1968, HEP. Williambury Stn, Jun 1985, MEC. Williams, Mar 1955, EJB. Wogoola, Jun 1955, EJB. Wittenoom, Nov 1984, MEC. Wongan/Ballidu, Jul 1955, EJB. Woodanilling, 3km S, Apr 1972, SJM. Wyalkatchem, Jul 1974, PFSL. Wyalkatchen, 13km S, Jul 1974, PFSL. Yanchep. Yanrey, Jun 1955, EJB. Yarraloola, Jun 1955, EJB. York, Jun 1955, EJB. York R., May 1978, PFSL.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is very similar to *Cx quinquefasciatus*. Northern populations of *Cx quinquefasciatus* have sternal markings similar to *Cx australicus*. The characters in the key will separate most specimens, but absolute confirmation requires further analysis of male genetalia, or possibly enzyme mobility polymorphisms in electrophoretic tests.

Culex (Culex) bitaeniorhynchus Giles 1901

Giles, G.M., *1901. J. Bombay Soc., 13:607.*
Type locality: Travancore, India.
Synonymy: *Culex ager* Giles, G.M., 1901. *Entomologist, 34:*196.
Culex infula Theobald, F.V., 1901. *Mon. Cul., 1:*370.
Culex tenax Theobald, F.V., *1901. Mon. Cul., 1:198.*
Culex ambiguus Theobald, F.V., 1903. *Mon. Cul., 3:*248.
Culex taeniarostris Theobald, F.V., 1907. *Mon. Cul., 4:*299.
Culex ocellata Theobald, F.V., 1907. *Mon. Cul., 4:*488.
Culex sarawaki Theobald, F.V., 1907. *Mon. Cul., 4:*514.
Culex domesticus Leicester, G.F.,1908. *Stud. Inst. Med. Res. F.M.S., 3:*169.
Culex abdominalis Taylor, F.H., 1913. *Rep. Aust. Inst. Trop. Med. 1911* p53.

Culex karatsuensis Mochizuki, D., 1913. *Fukuoka Acta Med., 7:*28

ADULT FEMALE

Robust species with banded proboscis, dark with yellow/orange tinge to some scales. Head with long narrow bronze and dark scales above; upright forked scales dark, numerous; broad flat dark and creamy scales laterally. Torus and clypeus bare. Palp dark scaled; about 0.19x length of proboscis. Proboscis dark with creamy band extending from 0.4-0.7 from base; proboscis about 0.85x length of forefemur. Scutal integument black; clothed with fine black to dark bronze scales. Scutellum with narrow black scales on all three lobes. Pleural integument blotchy with pale to dark reddish/brown areas; admixture of cream and black narrow scales on anterior pronotum; black only on posterior pronotum; small patches of elongate white scales on upper and posterior sternopleuron. Abdomen with tergites black with mottling of orange/cream scales and apical transverse band of orange/cream scales; sternites creamy scaled with large dark apicolateral patches. Hindfemur dark with a few yellowish scales; tibia dark; tarsi with narrow basal orange/yellow bands. Wing dark with some mottling of pale scales. Haltere with pale stem, dark club.

LARVA

Antenna about 0.75x length of head, seta 1-A inserted about 0.45 from base. Head about 0.79x as long as wide, about 0.5x width of thorax; seta 4-C small, with 3 branches; 5-C with 3 branches; 6-C bifid; 7-C with 5-6 branches; 8-C and 9-C with 4 branches. Abdominal segment VIII with lateral comb of 5-10 scales in an irregular line, each scale being a strong spine with basal fringe; setae 1-VIII and 3-VIII with 6 pectinate branches; 2-VIII with 3 branches; 4-VIII with 3-4 branches; 5-VIII with 4 branches. Siphon index is about 10.75; siphon about 5x length saddle; acus present; seta 1-S consisting of 3 pairs of very small bifid setae; pecten inconspicuous, 4-5 denticulate teeth at very base of siphon. Anal segment with saddle complete, slightly cut away posterioventrally; seta 1-X with 1-3 branches; 2-X with 3-5 branches; 3-X single; 4-X with 6 pairs of branched setae. Anal papillae long and pointed; about 1.5x length of saddle.

BIOLOGY

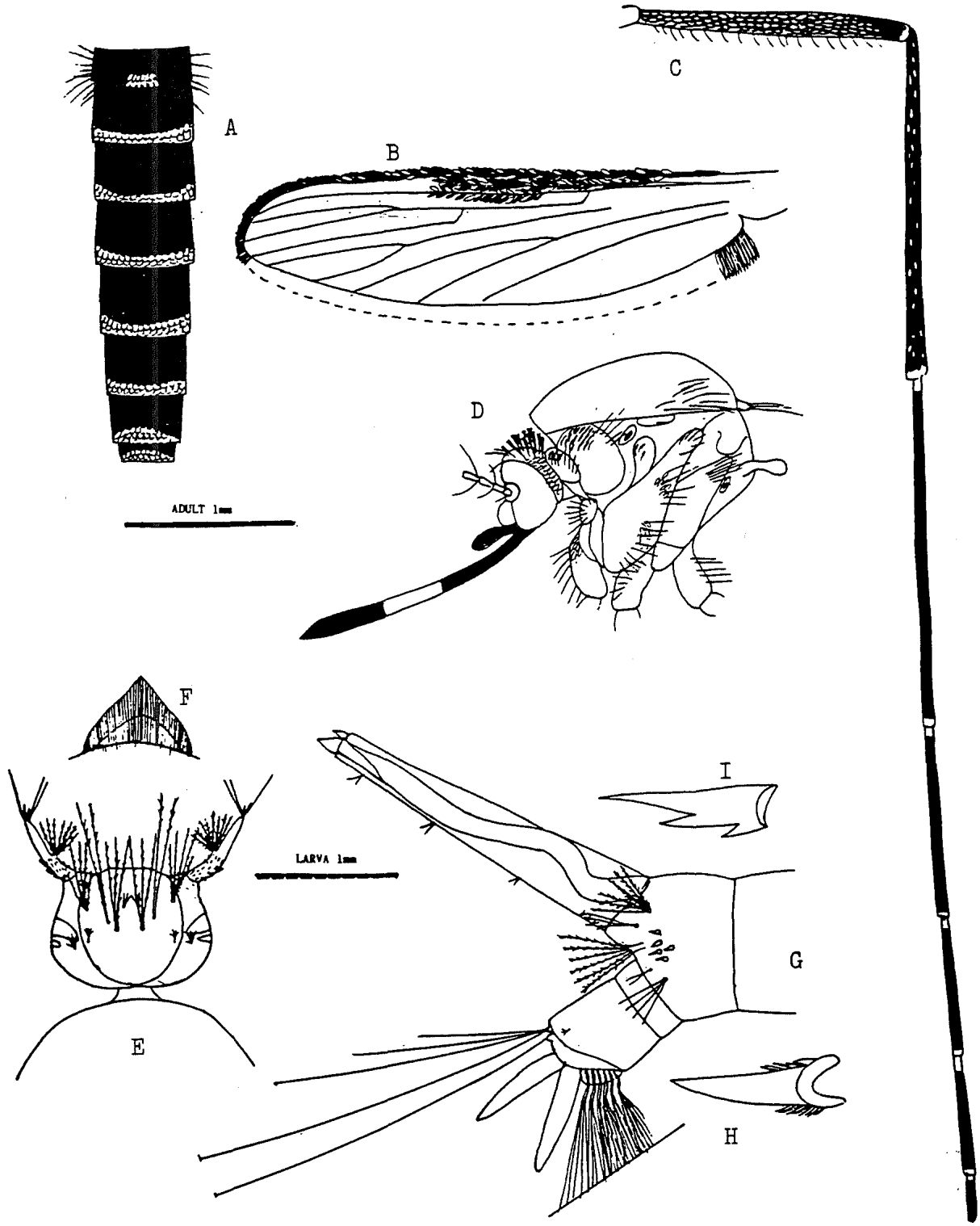
Cx bitaeniorhynchus breeds in fresh ground waters and is associated with the presence of filamentous algae. The species has a generally northern distribution, and is most common in the period following the wet season, when ground waters are relatively stable, and filamentous algae growth is greatest. The adults feed on large mammals including man, but will also feed on avian baits. The adults are taken in mammal and avian baited traps, light and CO_2 baited traps. The species is never very common and is rarely a dominant element in the fauna.

RELATION TO DISEASE

In Asia, this species is recognised as a capable vector of filariasis (both *Wuchereria bancrofti* and *Brugia malayi).* In Australia, MVEv and Getah viruses have been isolated from this species, but its vector status remains unclear. Experimental infection with RRv shows that *Cx bitaeniorhynchus* does not support replication of this virus.

DISTRIBUTION

De Grey, 10km S, Jun 1978, AEW. De Grey R., Jun 1978, AEW. Drysdale R., Aug 1979, AEW. Kalumburu, Aug 1979, AEW. Karratha, Mar 1979, AEW. Kimberley Downs, May 1979, AEW. Kununurra, Dec 1972, PFSL; Jan 1983, PFSL; Apr 1973, PFSL; Apr 1975, PFSL; Apr 1977, AEW; Nov-Dec 1977, AEW. Marble Bar, Mar 1979, AEW. Millstream, Jun 1953, EPH/EJB; Mar 1954, EPH; Jun 1954, EPH; Jan 1975, PFSL; Apr 1979, AEW. Millstream, Dawsons Spring, Jun 1954, EPH. Millstream/Roebourne, Jun 1954, EJB. Roebourne, Aug 1984, MEC. Wittenoom, Yampire Gorge, Sep 1974, JHS.



Culex (Culex) bitaeniorhynchus

A: Abdomen (dorsal); B: Wing (detail of scaling on some veins shown): C: Hindleg; D: Head and thorax (lateral); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

SPECIES WITH WHICH IT MAY BE CONFUSED

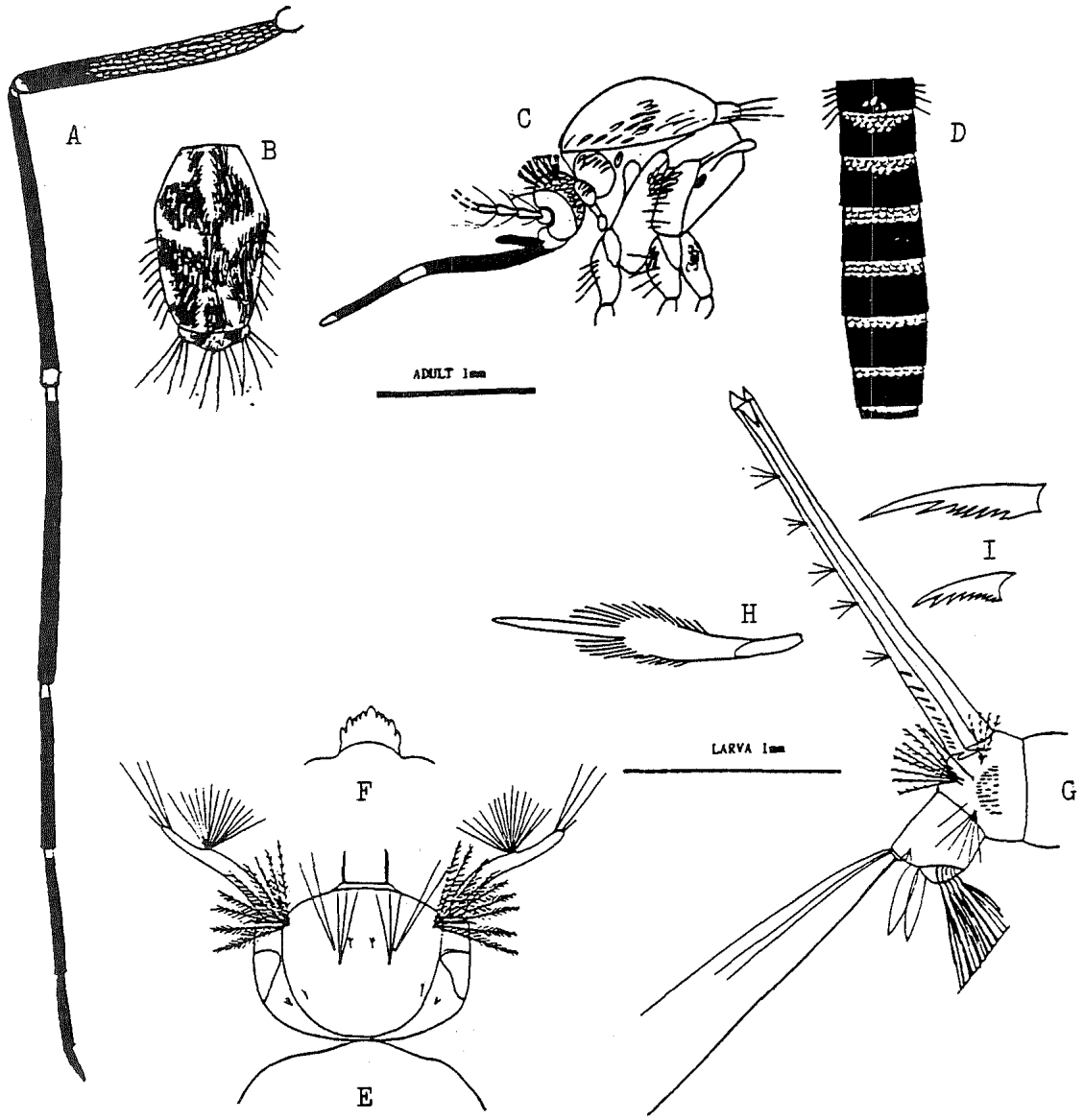
Cx bitaeniorhynchus is the only *Culex* species which has a banded proboscis and apical tergal bands.

Culex (Culex) crinicauda Edwards 1921

Edwards, F.W., 1921. *Bull. Ent. Res., 12*:77.
(Nom. Nov. for *Culex parvus* Taylor).
Type locality: Umbrawarra Creek, Northern Territory.
Synonymy: *Culex parvus* Taylor, F.H., 1912. *Bull. N. Terr. Aust., 1a*:27.

ADULT FEMALE

A small to medium palish species with a banded proboscis. Head with narrow creamy scales on vertex, darker laterally; broad flat pale scales on side of head; upright forked scales numerous. Clypeus and torus bare. Palps black; about 0.15x length of proboscis. Proboscis black with narrow white band extending from 0.5-0.65 from base. Scutal integument brown; clothed in narrow brown/bronze scales with marked areas of elongate pale scales in midline, around fossa, on anterior lateral margins of scutum extending into midline behind fossa, and above wing root. Scutellum with pale scales on all three lobes. Pleural integument cream to brown; with elongate cream scales on anterior pronotum and posterior pronotum; broad flat white scale patches on upper and posterior sternopleuron, anterior mesepimeron and a few on the upper mesepimeron. Abdomen with tergites black scaled with straight creamy white basal bands; sternites pale scaled with apical half of VII and VIII dark. Forecoxa with small patch of scales white above, dark below; midcoxa and



Culex (Culex) crinicauda
A: Adult Hindleg; B: Thorax (dorsal); C: Head and thorax (lateral); D: Abdomen (dorsal); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail of basal and apical teeth).

hindcoxa with pale scales. Hindfemur unmottled with narrow basal band and apical knee spot; tibia dark with a few apical pale scales; tarsi I-III with narrow basal bands, IV-V dark. Wing dark scaled. Haltere all pale.

LARVA

Antenna pale at base, dark at tip, spiculate; about same length as head; seta 1-A multibranched, inserted about 0.67 from base. Head about same width as thorax; seta 4-C with 1-2 small branches; 5-C with 3 pectinate branches; 6-C with 2-3 pectinate branches; 7-C with 9 plumose branches; 8-C and 9-C with 1-3 very small fine branches. Abdominal segment VIII with lateral comb of about 26 scales (each a strong spine with long basal fringe) in an irregular patch; seta 1-VIII with 4-6 pectinate branches; 2-VIII and 4-VIII simple, single; 3- VIII with 8 pectinate branches; 5-VIII with 3-5 branches. Siphon index about 7.5; siphon about 5x length of saddle; strong acus present; seta 1-S with 5-6 pairs of tufts, each with 3-4 branches; pecten with 11 denticulate teeth on basal 0.28 of siphon. Anal segment with saddle complete, with small apical spines; seta 1-X small, with 3 branches; 2-X with 3 branches; 3-X single; 4-X with 6 pairs of branched setae; precratal tufts absent. Anal papillae long and pointed; about 1.3x length of saddle.

BIOLOGY

Cx crinicauda breeds in fresh clear ground waters, but has also been found breeding in large container habitats (e.g. drums). Adults have been collected in light and CO_2 baited traps, and in avian baited traps. The biology of this species is poorly known.

RELATION TO DISEASE

None known.

DISTRIBUTION

Gregorys Gorge, Jan 1975, PFSL. House Roof Hill, Mar 1954, EPH. Kalumburu, Mar 1953, EPH/EJB; Mar 1954, EPH; Jul 1978, AEW. Kalumburu, Longonye Creek, Mar 1954, EPH. Karratha, Jun-Jul 1984, MEC. Kimberley Research Station, Mar 1953, EPH/EJB; Mar 1954, EPH. Kimberley Research Station, The Grotto, Mar 1954, EPH. Kimberley Research Station, Middle Spring, Mar 1954, EPH. Miaree Pools, Jun 1984, MEC. Marble Bar, Sep 1974, JHS. Millstream, Jan 1975, PFSL. Millstream, Palm Pool, Jan 1975, PFSL. Millstream, Creek Summit, Jan 1975, PFSL. Roebourne, Aug 1984, MEC. Wittenoom Gorge, Mar 1953, EPH/EJB; Nov 1984, MEC. Yeeda, Apr 1967, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species can be confused with other *Culex* species with banded proboscis, but can be separated using the characters in the keys.

Culex (Culex) globocoxitus Dobrotworsky 1953

Dobrotworsky, N.V., 1953. *Proc. Linn. Soc. N.S.W., 77*:357.
Type locality: Williamstown, Victoria.
Synonymy: none

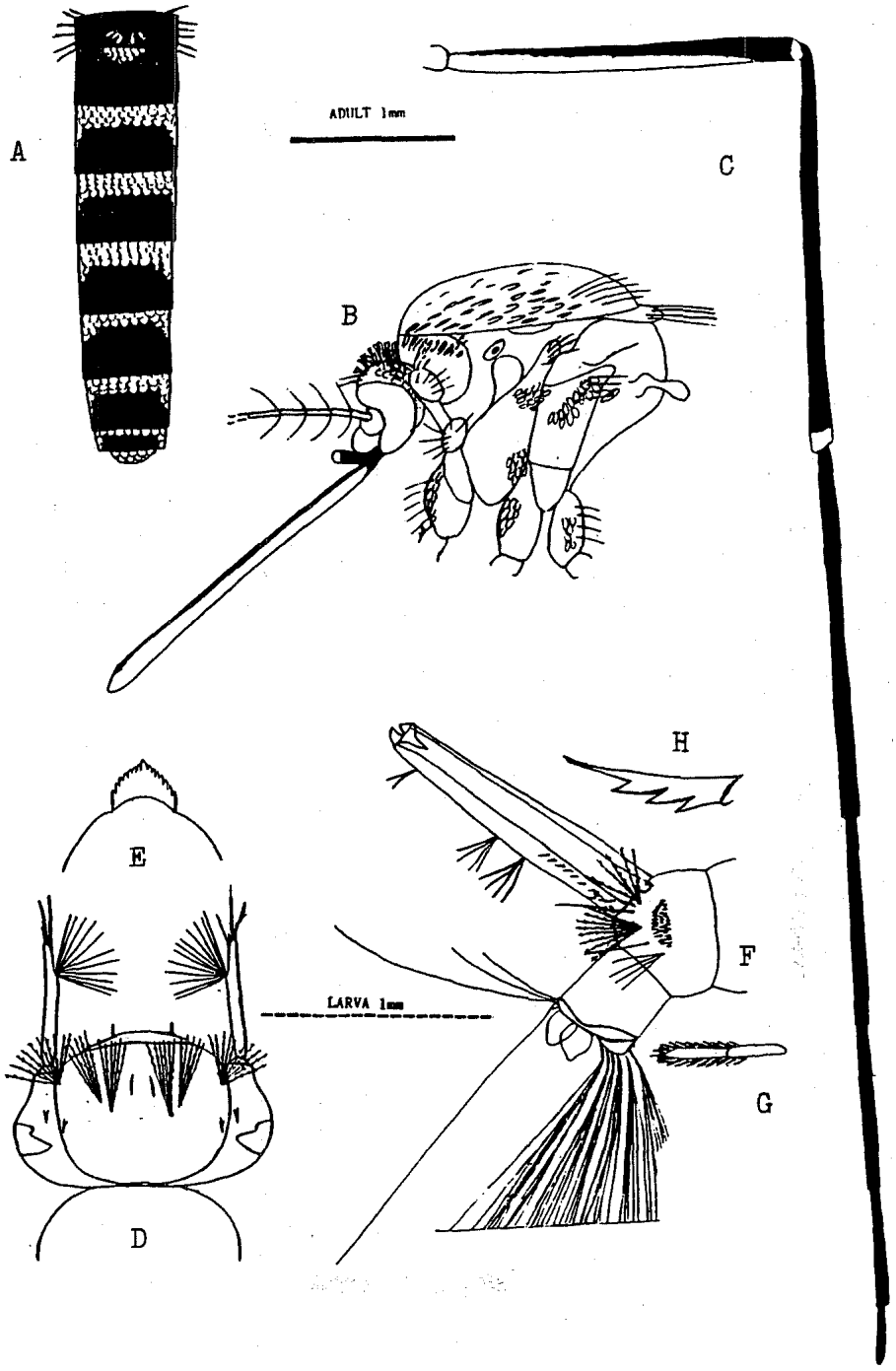
ADULT FEMALE

A medium sized species, with unbanded proboscis. Head clothed with narrow pale scales on vertex; broad flat scales on side of head; upright forked scales numerous. Torus and clypeus bare. Palp dark scaled with some pale scales at tip; about 0.125x length of proboscis. Proboscis dark above, pale below almost to tip; about 1.1x length of forefemur. Scutal integument light brown; densely clothed in light brown and cream scales with creamy lateral margins and around prescutellar space. Scutellum with narrow pale scales on all three lobes. Pleural integument light brown; narrow pale to brown scales on anterior pronotum and posterior pronotum; flat white scales on propleuron, upper and posterior sternopleuron, anterior and upper mesepimeron; 1 lower mesepimeral bristle present. Abdominal tergites black with broad creamy basal bands, not constricted laterally; sternites white to cream, sometimes with dark medial and apicolateral patches. Forecoxa with patch of scales, pale above and dark below; midcoxa and hindcoxa all pale scales. Hindfemur pale ventrally, dark dorsally for almost whole length, dark at tip; tibia dark with white apical patch; tarsi all dark. Wing all dark scaled. Haltere with pale stem, dark club.

LARVA

Antenna dark brown over whole length; small spicules on basal 0.6; about 0.7x length of head; seta 1-A with more than 10 branches, inserted at 0.7 from base of antenna. Head about 0.8x as long as wide; about 0.9x width of thorax; seta 4-C single, small; 5-C and 6-C with 3-4 pectinate branches; 7-C with 7-9 pectinate branches. Prothoracic setae 1-P to 3-P single, long, on common basal tubercle; 4-P with 2 shorter branches;

5-P and 6-P single, long; 7-P with 2 long branches. Abdominal segment VIII with lateral comb of 30+ fringed scales in a triangular patch; seta 1-VIII with 7 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 6-8 pectinate branches; 5-VIII with 5-7 pectinate branches. Siphon index about 5.4; siphon about 4x as long as saddle; seta 1-S with 3 pairs of tufts with 3-4 branches on dorsal 0.7 of siphon; pecten with 10-14 denticulate spines on basal 0.3 of siphon. Anal segment with saddle complete but cut away slightly posterioventrally above grid; seta 1-X and 3-X single; 2-X with 3 branches; 4-X with 6 pairs of tufts on grid. Anal papillae short, bluntly pointed; about 0.5x length of saddle or less.



Culex (Culex) globocoxitus

A: Abdomen (dorsal); B: Adult head and thorax (lateral); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

BIOLOGY

Cx globocoxitus breeds in open swamps, and is often collected in brackish waters. It is common in coastal areas in south west W.A. and is also common in inland salt affected areas. The species is active throughout most of the year, but the peak season is July to November. The adults generally do not bite man. Adults are readily taken with avian baited traps, and in CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Ajana, Oct 1971, SJM; Jul 1973, SJM. Albany, Jan 1972, SJM; Aug 1972, SJM; Aug 1973, SJM. Binnu, May 1985, MEC. Bodallin W, Sep 1973, SJM. Boddington, Mar 1971, HEP. Brickhouse Stn, Apr 1985, MEC. Bunbury, Jan-Dec 1985, MEC. Canning R., Apr 1975, RH. Canning R., Canning, Apr 1975, PFSL. Canning R., Clontarf, May 1963, JBF. Canning R., Kent St Weir, Apr 1975, PFSL. Carnarvon, Jul 1973, SJM; May 1984, WJOB; Mar 1985, MEC. Carnarvon, Bilbawarra Bore, May 1985, MEC. Cuballing, Nov 1973, SJM. Dale River, Apr 1974, SJM. Doorawarrah, May 1985, MEC. Doorawarrah, 10km W, Jul 1973, SJM. Gascoyne Junction, May 1985, MEC. Geraldton, Aug 1985, MEC. Gidgegannup W, May 1973, SJM. Glencoe, Jul 1972, SJM; Nov 1973, SJM. Glencoe, 6km W of Popanyinning, May 1971, SJM. Helena R., Guildford, Jul-Sep 1973, SJM. Hutt River, May 1985, MEC. Irwin, Oct 1952, DLM. Irwin R., Oct 1971, SJM; Jun 1972, SJM; Jul 1973, SJM. Irwin R., Mountain Bridge, Nov 1973, PFSL. Jandakot, Oct-Dec 1971, SJM; Jan-Feb 1972, JCT; Jan-Feb 1972, SJM; May-Dec 1972, JCT; May-Dec 1972, SJM; Jan-Feb 1973, SJM. Kalbarri, Oct 1971, SJM; May 1985, MEC. Kalbarri, Lucky Bay, May 1985, MEC. Kendenup, May 1971, SJM; Apr 1974, SJM. Keysbrook, Feb 1971, SJM; Mar 1972, SJM. Kojonup, Apr 1972, SJM. Koorda, Jul 1974, PFSL. Lake Clifton, Aug 1980, NFS. Marradong, Mar 1972, SJM. Mobrup, May 1973, SJM. Mooka, May 1985, MEC.Mt Magnet, Apr 1985, MEC. Narrogin, Apr 1973, SJM. Narrogin, 5km N, Apr 1973, SJM. Narrogin, 8km N, Apr 1973, SJM. Northampton, Oct 1971, SJM. Perth, Nedlands, Oct-Nov 1971, SJM; Sep-Dec 1972, SJM. Perth, Subiaco, Mar 1985, MEC. Port Hedland, Oct 1984, MEC*. Quindanning, 10km W, Apr 1973, SJM. Swan River, Hearne Hill, May 1963, JBF. Useless Loop, 1973, SJM. Winchester, Oct 1971, SJM. Woodanilling, Apr 1972, SJM. York, May 1973, SJM.
* specimen not seen or verified by an experienced medical entomologist.

SPECIES WITH WHICH IT MAY BE CONFUSED

Cx globocoxitus may be difficult to separate from *Cx molestus* and the other members of the 'pipiens' group. See keys for characters.

Culex (Culex) molestus Forksal 1775

Forksal, P., 1775. *Descr. Animalium.*, p85.
Type locality: Rosetta, Kahira and Alexandria, Egypt.
Synonymy: *Culex domesticus* Germar, E.F., 1817. *Reise nach Dalmatien und in das Gebiet von Ragusa.* p290.
Culex haematophagus Ficalbi, E., 1893. *Boll. Soc. Ent. Ital., 25:*143.
Culex quasimodestus Theobald, F.V.,1905. *Ann. Hist.-Nat. Mus. Hung., 3:*88.
Culex autogenicus Roubaud, M.E., 1935. *Bull. Soc. Pat. Exot., 27:*444.
Culex berbericus Roubaud, M.E., 1935. *Bull. Soc. Pat. Exot., 27:*445.
Culex sternopallidus Roubaud, M.E., 1945. *Bull. Soc. Pat. Exot., 38:*54.
Culex sternopunctatus Roubaud, M.E., 1945. *Bull. Soc. Pat. Exot., 38:*54.

This species is often considered to be a subspecies of *Cx pipiens*. Studies at the University of W.A. by Dr. S.J. Miles have shown that it is reproductively isolated from other members of the pipiens group and should be considered a good species.

ADULT FEMALE

A relatively uncommon medium sized species with an unbanded proboscis. Head with narrow white to yellow scales dorsally on vertex; flat white scales on sides of head; upright forked scales numerous, pale and dark. Torus with some small white scales medially. Clypeus bare. Palp dark scaled with scattered pale scales dorsally near apex; about 0.2x length of proboscis. Proboscis dark above, pale on basal 0.67 below with dark tip; about 0.96x length of forefemur. Scutal integument light brown, clothed in fine brown to yellow scales.

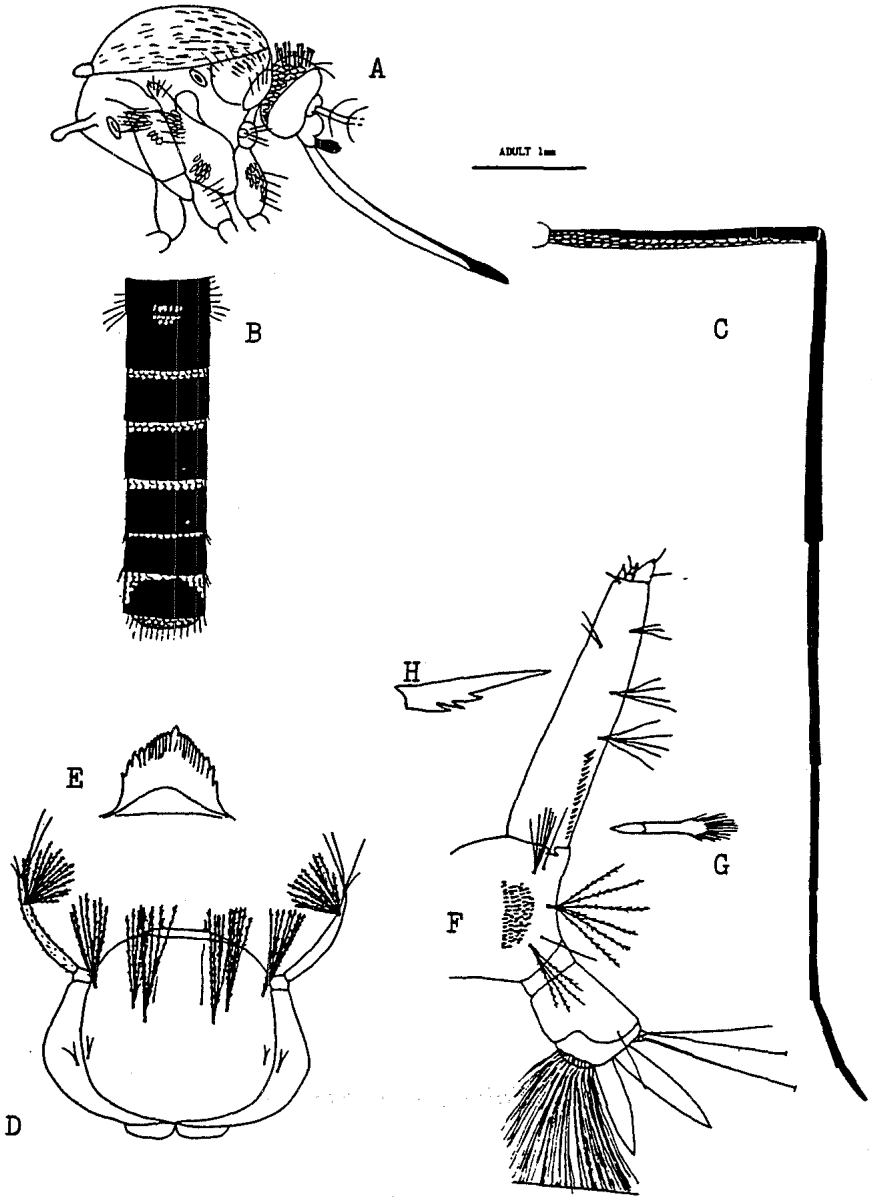
Scutellum with narrow pale scales on all lobes. Pleural integument light brown; with small patch of pale scales on posterior sternopleuron and anterior mesepimeron. Abdomen with tergites brown scaled with broad creamy bands, not constricted laterally but with large lateral patches; sternites all pale scaled. Hindfemur pale ventrally, dark dorsally almost to knee, tip dark; tibia brown; tarsi all brown. Wing dark scaled. Haltere all pale.

LARVA

The larva is almost identical with that of *Cx quinquefasciatus*, and no reliable characters are known which can be used to separate the two species. See description of larva of *Cx quinquefasciatus*.

BIOLOGY

Cx molestus breeds in heavily polluted sites such as septic tanks. The species is autogenous, and will often survive within sealed septic tanks. Other sites where the species may be found include polluted waters in rubbish tips. *Cx molestus* bites man readily. It may be taken in light and CO_2 traps in urban areas in the south western portion of the State in almost all months of the year.



Culex (Culex) molestus

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

RELATION TO DISEASE

Barmah Forest virus has been isolated from a mixed pool containing *Cx molestus*, and MVEv has been shown to survive for at least 10 days following feeding in the laboratory. However, the vector potential of this species is suspect.

DISTRIBUTION

Albany, Jan 1972, SJM. Bullsbrook, Sep 1980, AEW; Oct 1980, PFSL. Cranbrook, Apr 1972, SJM. Forrest National Park, May 1973, SJM. Fremantle, Jan 1951, DC. Geraldton, Jul 1973, SJM. Kalgoorlie, Jul 1973, SJM. Lake Chandala, Aug-Sep 1980, AEW; Oct 1980, PFSL. Lake Clifton, Aug 1980, AEW. Mandurah, Mar 1973, SJM. Manjimup, Mar 1973, SJM. Murray R., Apr 1971, CAG. Muchea, 7km N, Sep 1980, AEW. Narrogin, 5km N, Apr 1973, SJM. Perth, Cannington, Jun 1973, SJM. Perth, Clontarf, Mar 1971, SJM. Perth, Jolimont, Feb 1972, PFSL. Perth, Mt Lawley, Sep 1974, PFSL. Perth, Nedlands, Nov-Dec 1971, SJM; Feb-Apr 1972, SJM. Perth, Welshpool, Sep 1973, PFSL. Popanyinning, Apr 1972, SJM. Rottnest, Jun 1979, AEW. Williams, Apr 1972, SJM; Apr 1973, SJM.

SPECIES WITH WHICH IT MAY BE CONFUSED

See notes on *Cx globocoxitus*, *Cx australicus* and *Cx quinquefasciatus*, the other members of the 'pipiens' group.

Culex (Culex) palpalis (Taylor) 1912

Taylor, F.H., 1912. *Appendix II Bull. Nth. Terr. Aust., 1a:* 29.
Type locality: Umbrawarra Creek, Northern Territory, Australia.
Synonymy: None.

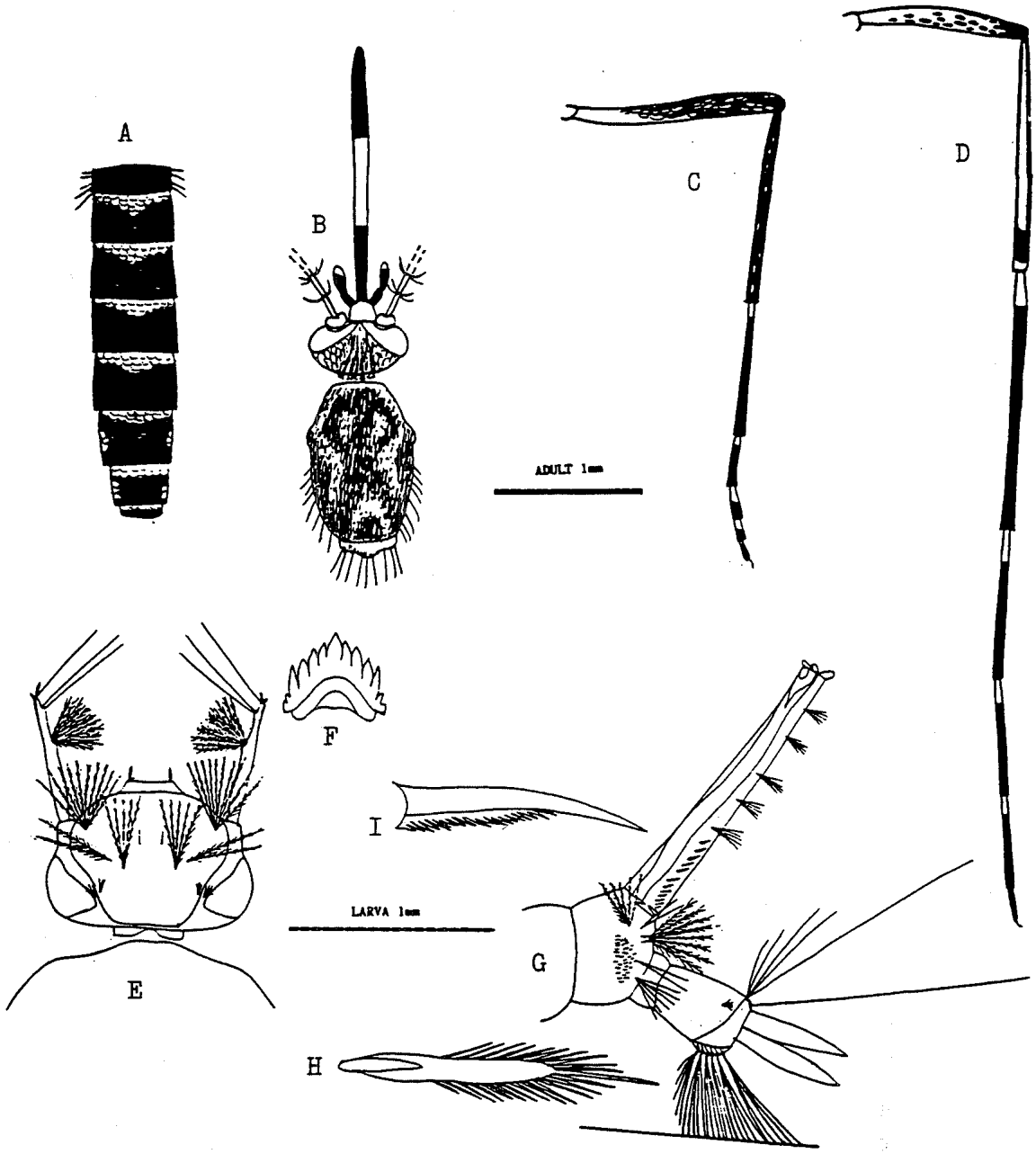
This species has only recently been resurrected from synonymy with *Cx annulirostris*. It has been referred to in the recent literature and correspondence variously as *Cx* 'species near annulirostris', *Cx* ENM's 'Normanton' species, or similar combinations. The species is closely related to, and very similar in appearance to *Cx annulirostris*, but it is a tropical species with few records in W.A.

ADULT FEMALE

Cx palpalis is a medium sized species with banded proboscis, similar in appearance to *Cx annulirostris*. Head with narrow white scales dorsally, broad white and brown laterally; upright forked scales brown and white, numerous. Clypeus bare. Torus with some pale scales mediodorsally. Palp dark scaled with a few white scales at tip; about 0.17x length of proboscis. Proboscis dark with pale band extending from 0.3-0.62 from base; slightly shorter than forefemur. Scutum with brown integument, clothed in a mixture of white, yellow and bronze scales, forming a diffuse lyre pattern in many specimens. Scutellum with narrow white scales on all three lobes. Pleura with brown integument; narrow white scales on both anterior pronotum and posterior pronotum; broad white scales on propleuron, upper and lower sternopleuron and upper mesepimeron. Abdomen with tergites dark scaled with basal white bands with lateral patches, some of the tergal bands may be extended into points in the midline on occasion; sternites pale scaled with apical dark band, sometimes broken in midline by pale scales. Foretibia with a distinct row of pale patches along dorsal surface. Hindfemur pale at base, increasing mottling apically and dark apically to knee; tibia dark with median pale streak and white apical narrow band; tarsi I-IV dark with narrow basal bands, V dark. Wing dark scaled. Haltere with pale stem and club.

LARVA

Antenna about 0.87x length of head, pale at base with dark tip; set 1-A with 25 strongly plumose dark branches, inserted at 0.64 from base. Head about 0.62x as long as wide; about same width as thorax; seta 4-C short single; 5-C with 3-4 plumose branches; 6-C with 2-3 plumose branches; 7-C with about 10 plumose branches; 8-C with 3 short branches; 9-C with 5 short branches. Pleural setae 1-P to 3-P single; 4-P with 2 branches 5-P and 6-P single; 7-P with 3 branches. Abdominal segment VIII with lateral comb of 28-36 fringed scales with a strong central spine; seta 1-VIII with 2-5 plumose branches; 2- VIII and 4-VIII with 2 simple branches; 3-VIII with 8-9 plumose branches; 5- VIII with 6 simple branches. Siphon slightly curved dorsally at tip; small acus present; index about 5.0; siphon about 2.75x length of saddle; seta 1-S with 5-6 pairs of ventral tufts, each with 5-7 branches and distributed over dorsal 0.67 of siphon; pecten with 12-18 fringed spines over the basal 0.36 of siphon. Anal segment with saddle complete; seta 1-X with 5 branches; 2-X with 3-5 branches; 3-X single and long; 4-X with 6 pairs of tufts on grid. Anal papillae long and pointed; about same length as saddle.



Culex (Culex) palpalis

A: Adult abdomen (dorsal); B: Head and thorax (dorsal); C: Foreleg; D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

BIOLOGY

This species breeds in more permanent, stable fresh water sites with emergent vegetation, lodged reeds, and some algal growth. Breeding appears to be associated with surface aquatic plants or lodged emergent vegetation. The species is locally quite common in parts of its range, and is collected at the end of the wet season. Adults are captured readily in CO_2 baited traps.

RELATION TO DISEASE

None known. The difficulty in the separation of the adult from *Cx annulirostris* (see above) could mean that pools of 'annulirostris' from which viruses have been isolated may have contained *Cx* ENM's 'Normanton' species. A full evaluation of the vector status of this species must await further analysis. Two isolates of Kunjin virus have been made from *Cx sp near annulirostris* from Queensland, and these may refer to *Cx palpalis*.

DISTRIBUTION

Carnarvon, May 1984, JWOB*. Camballin, Aug 1979, AEW. Drysdale R., Aug 1979, AEW. Kalumburu, Aug 1979, AEW. Kimberley Downs, May 1979, AEW. Mitchell Plateau, Jul 1981, AEW. (*: This is a published record and has not been seen by the author.)

SPECIES WITH WHICH IT MAY BE CONFUSED

Cx palpalis closely resembles *Cx annulirostris,* and the characters in the key are the most reliable characters to separate the two species. It is generally slightly smaller than *Cx annulirostris* and the diffuse lyre pattern on the scutum is fairly reliable for initial separation, though other characters will need to be checked. The species is difficult to separate from *Cx annulirostris.* Typical specimens of both species are fairly readily distinguished. There are, however, significant overlaps in morphology between the two species in some populations, and specimens within the overlap range can be exceedingly difficult to assign to one species or the other.

Culex (Culex) quinquefasciatus Say 1823

Say, T., 1823. *J. Acad. Sci. Philad., 3:*10.
Type locality: Mississippi River, United States.
Synonymy: *Culex pungens* Weidemann, C.R.G., 1828. *Aussereuropaische Zweiflugelige Insecten.* Vol.1 p.9.

Culex fatigans Weidemann, C.R.G., 1828. *Aussereuropaische Zweiflugelige Insecten.* Vol.1 p.10.
Culex aestuans Weidemann, C.R.G., 1828. *Aussereuropaische Zweiflugelige Insecten.* Vol.1 p.11.
Culex acer Walker, F., 1848. List of the Specimens of Dipterous insects in the collection of the British Museum, Part 1. p.8.
Culex cingulatus Doleschall,C.L.,1856. *Natuurk. Tijdschr. Ned.-ind., 10:* 405.
Culex cubensis Bigot, J.M.F., 1857. *in:* Sagra, R. de la, Historia Fisica, politica y natural de la Isla de Cuba. Vol.7 p.329.
Culex anxifer Bigot, J.M.F., 1859. *Ann. Soc. ent. Fr., (3)7:*117.
Culex serotinus Phillipi, R.A., 1865. *Verh. zool.-bot. Ges. Wein., 15:*595.
Culex autumnalis Weyenburgh, S.H., 1882. Los habitantes del Rio Primero, por el doctor H. Weyenburgh... Montevideo, Imprenta y encuadernacion de Ruis y Brecchi. p.23.
Culex penafieli Sanchez, J., 1885. *La Naturalenza, Mexico, 7:*213.
Culex macleayi Skuse, F.A.A., 1889. *Proc. Linn. Soc. N.S.W., 3:*1746.
Culex skusii Giles, G.M., 1900. *A Handbook of Gnats or Mosquitoes...* p.292.
Culex doleschallii Giles, G.M., 1900. *A Handbook of Gnats or Mosquitoes...* p.338.
Culex albolineatus Giles, G.M., 1901. *J. Bombay Soc., 13:*609.
Culex quasipipiens Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.136.
Culex fouchowensis Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.137.
Culex reesi Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.145.
Culex sericus Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.147.
Culex luteoannulatus Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.159.
Culex trilineatus Theobald, F.V., 1901. *Mon. Cul.,* Vol.2 p.159.
Culex pallidocephala Theobald, F.V., 1904. *First Rept. Welcome Labs., Gordon Coll., Khartoum, 1:*73.
Culex cartroni Ventrillon, E., 1905. *Bull. Mus. Hist. nat., Paris, 11:*429.
Culex barbarus Dyar, H.G. and Knab, F., 1906. *J. N. Y. ent. Soc., 14:*210.
Culex didieri Neveu-Lemaire, M., 1906. *Arch. Parasit., Paris, 10:*257.
Culex pygmaeus Neveu-Lemaire, M., 1906. *Arch. Parasit., Paris, 10:*256.
Culex quasilinealis Theobald, F.V., 1907. *Mon. Cul.,* Vol.4 p.415.
Culex stoehri Theobald, F.V., 1907. *Mon. Cul.,* Vol.4 p.419.
Culex christophersii Theobald, F.V., 1907. *Mon. Cul.,* Vol.4 p.453.
Culex raymondii Tamayo, 1907. *in:* Tamayo, M.O. and Gargia, C.A., 1907. *Mem. Municip. Lima 1906.* p.36.
Culex aikenii Dyar, H.G. and Knab, F., 1908. *Proc. U. S. Nat. Mus., 35(1632):*61.
Culex minor Theobald, F.V., 1908. *Rec. Indian Mus., 2:*298.
Culex revocator Dyar, H.G. and Knab, F., 1909. *Smithson. misc. Coll., 52(1822):*256.
Culex lachrimans Dyar, H.G. and Knab, F.,1909. *Smithson. misc. Coll., 52(1822):*259.
Culex goughii Theobald, F.V., 1911. *South Africa Veterin. Div. Rept., 1:*268.

Culex fuscus Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond., 1914*:699.
Culex aseyehae Dyar, H.G. and Knab, F., 1915. *Insec. Inscit. menst., 3*:112.
Culex townsvillensis Taylor, F.H., 1919. *Proc. Linn. Soc. N.S.W., 43*:836.
Culex hensemaeon Dyar, H.G., 1920. *Insec. Inscit. menst., 8*:178.
Culex nigrirostris Enderlein, G., 1920. *Wein. ent. Ztg., 38*:51.

ADULT FEMALE

Cx quinquefasciatus is the common brown house mosquito with a dark proboscis and is perhaps the most commonly encountered species in urban and peridomestic situations throughout W.A. Head with narrow elongate pale scales on vertex; broad flat brown and dark scales on sides of head; upright forked scales numerous, pale to brown. Torus and clypeus bare. Palp dark scaled with a few pale scales near tip; about 0.22x length of proboscis. Proboscis equal to forefemur; dark scaled above and below over the entire length; sometimes with pale scaling below about middle 0.3 or extending to base, always dark apically. Scutal integument brown, clothed in narrow creamy to bronze scales. Scutellum with long narrow creamy scales on all lobes. Pleural integument pale yellow/brown; narrow pale scales on anterior pronotum and posterior pronotum; broad flat appressed white scales on propleuron, upper and lower sternopleuron, and on anterior and upper mesepimeron. Abdomen with tergites black with basal white bands, constricted laterally and separated from lateral patch on tergites II-V, VII with apical row of white scales, V largely white; sternites pale scaled with a few scattered dark scales in midline in southern populations, but may have marked median dark patches, particularly in northern populations. Forecoxa with patch of appressed scales, white above and black below; midcoxa and hindcoxa with white scales only. Hindfemur pale anteriorly to apex, dark above; tibia and tarsi dark. Wings dark scaled. Haltere pale with creamy pale scales on knob.

LARVA

Antenna uniformly brown; with small spicules on basal 0.6; antenna about 0.55x length of head; seta 1-A multibranched, inserted at 0.7 from base. Head about 0.77x as long as wide; about 0.65x width of thorax; seta 4-C single; 5-C with 4-5 branches; 6-C with 3-4 branches; 7-C with 7-9 branches; 5-C to 7-C pectinate. Prothoracic setae 1-P to 3-P single, long, on common basal tubercle; 4-P with 2 shorter branches; 5-P and 6-P single, long; 7-P with 2 long branches. Abdominal segment VIII with lateral comb of 30-40+ fringed scales in a triangular patch; seta 1-VIII with 4-7 pectinate branches; 2-VIII and 4-VIII short and single; 3-VIII with 6-7 pectinate branches; 5-VIII with 3-5 pectinate branches. Siphon slightly swollen on basal 0.3, forming a slight bottle shape and curving slightly dorsally near apex; strong acus present; index about 5.0; siphon about 3x length of saddle; seta 1-S with 3 pairs of tufts with 5-7 branches over apical 0.65 of siphon; pecten with 8-12 spines with basal denticles in row over basal 0.3 of siphon. Anal segment with saddle complete; seta 1-X and 3-X single; 2-X with 2-3 branches; 4-X with 6 pairs of tufts on grid. Anal papillae long and pointed, as long as saddle.

BIOLOGY

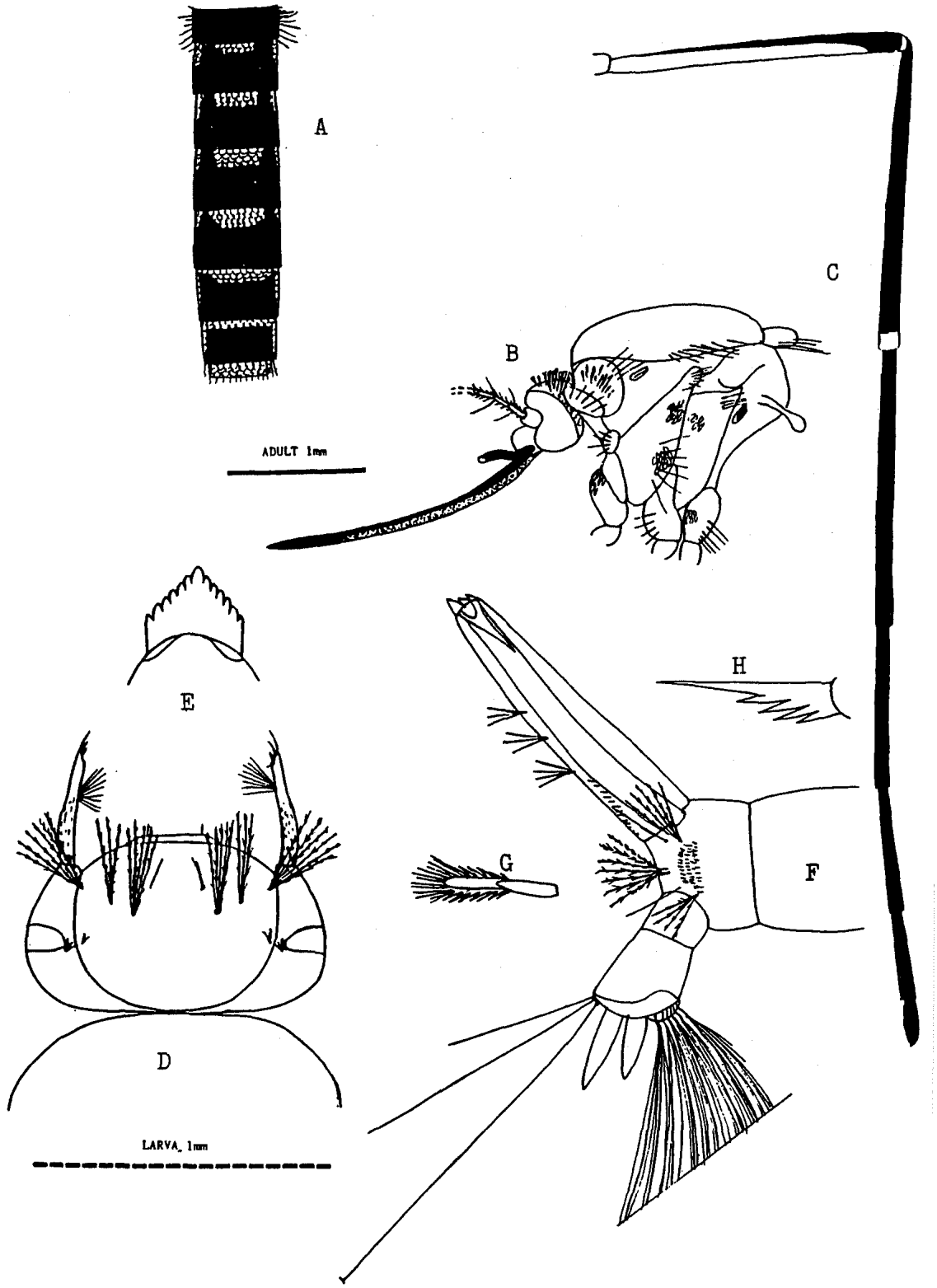
Cx quinquefasciatus breeds in fresh to polluted domestic waters, drains, containers and septic tanks. It is often found in sewage treatment effluent, or in the holding basins themselves. It is also commonly collected in drains and ground waters near urban development. The species is not autogenous and the females must take a blood meal to mature an egg batch. However, the species is readily colonised, and has been widely used as an experimental tool as a result. *Cx quinquefasciatus* feeds mainly at night, biting man, mammals and birds. This species is the most commonly encountered urban pest, and can be a significant nuisance when seeking blood feeds indoors at night. Swarming occurs 30 minutes before sunset, and is generally located amongst the branches of small eucalypt trees. The adults do not disperse far from the breeding site. The species may be collected at any time during the year. In southern areas, the peak season is March to August. In the north, peak numbers are seen in the June to August period, with a second smaller peak in December/January.

RELATION TO DISEASE

Cx quinquefasciatus is a vector of periodic filariasis, and of dog heart worm *(Dirofilaria immitis)*. It is generally a poor laboratory vector of arboviruses, though there has been a single isolate of MVEv from this species in Kununurra, but experimental data suggests that it is a poor vector. Similarly, it appears to be poor vector of RRv. The species has been extensively analysed to determine whether it supports the replication of a large number of Australian arboviruses, generally with an indication that replication was supported following intrathoracic inoculation. However, it is considered that the species is a poor vector.

DISTRIBUTION

Albany, Aug 1956, EJB; Jan 1972, SJM; Aug 1972, SJM; Dec 1972, SJM. Augusta, May 1956, EJB. Augusta/Margaret R. Badgingarra, Jul 1985, MEC. Balgar Plains, Jul 1985, MEC. Balgo, Jun-Jul 1978, AEW; Mar 1981, AEW. Bedford Downs Stn, Nov 1984, MEC. Bedfordale, Aug 1951, DGS. Beebinbarra Creek, Jun 1978, AEW. Beverley, Oct 1943, PNF; Mar 1952, KRN. Beverley Springs Stn, Sep 1984, MEC.



Culex (Culex) quinquefasciatus

A: Abdomen (dorsal); B: Head and thorax (lateral); C: Hindleg; D: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

Billiluna, Mar 1981, AEW. Black Box Hill, May 1943, PNF. Blina Stn, Oct 1984, MEC. Brickhouse Mill, Jun 1985, MEC. Brickhouse Stn, Apr 1985, MEC. Brookton, Jun 1955, EJB. Broome, Sep 1978, AEW; Feb-May 1984, MEC; Apr-May 1985, MEC; Jul-Oct 1985, SH. Broken Spring Stn, Oct 1984, MEC. Bruce Rock, Jul 1956, EJB. Bunbury, Jan-Dec 1985, MEC. Canning R., Apr 1975, RH; Jun 1979, AEW. Canning R., Cannington, May 1963, JBF. Canning R., Kent St Weir, Mar 1975, PFSL. Canning R., Manning, Jun 1979, AEW. Canning R., Riverton Bridge, Mar 1975, PFSL. Carbarup, Nov 1952, Ev. Carlorup, Oct 1952, TGC. Carnamah, May 1955, EJB. Carnarvon, Jun-Jul 1954, EPH; Jun 1972, SJM; Jul 1973, SJM; Aug 1973, ENM; Apr 1979, AEW; Feb-Mar 1984, MEC; May 1984, WJOB; May-Oct 1984, MEC; Jan 1985, MEC; Jun 1985, MEC. Cherrabun, May 1979, AEW. Cockatoo Is., Sep 1984, MEC. Corrigin, Jun 1955, EJB. Cranbrook, Apr 1972, SJM. Dale R., Jan-Feb 1952, KRN. Dalwallinu, Jul 1955, EJB. Dampier, Mar 1979, AEW; Jun 1984, MEC; Oct 1984, MEC; Jan 1985, MEC. Dampier Downs, Oct 1984, MEC. De Grey Station, Jun 1978, AEW; Mar 1979, AEW. De Grey R., Jun 1978, AEW. Derby, LEC; Apr 1951, EJB; Mar 1953, EPH/EJB; Mar 1954, EPH; Mar 1954, EJB; Mar-Apr 1967, EJB; Mar-Apr 1977, AEW; Sep-Oct 1978, AEW; Feb-Mar 1984, MEC; Jul-Aug 1984, MEC; Mar 1985, AEW. Derby, Myalls Bore, Sep-Oct 1978, AEW. Doorawarrah, Jul 1973, SJM; May 1985, MEC. Dowerin, Jul 1956, EJB. Drakesbrook, Mar 1955, EJB. Dundas, Aug 1956, EJB. Edajee Stn, May 1985, MEC. Esperance, Aug 1956, EJB. Exmouth, Aug-Sep 1984, MEC; Mar 1985, MEC. Fitzroy Crossing, Jul- Sep 1984, MEC; Jul 1985, MEC. Forrest National Park, Jan-Feb 1972, PFSL; Feb 1972, SJM; May 1973, PFSL; May 1973, SJM. Fossil Downs Stn, Oct 1984, MEC. Geraldton, Jul 1973, SJM; Jul-Aug 1985, MEC. Geraldton/Greenough, May 1955, EJB. Gingin, Jul 1955, EJB. Gnowangerup, Jul 1956, EJB. Goomalling, Jul 1955, EJB. Gosnells, Oct 1967, HEP. Greenmount, Sep 1973, PFSL. Guildford, Mar 1950, PNF. Halls Creek, Jul 1984, MEC; Apr 1985, MEC. Harvey, Feb 1943, PNF; Sep 1943, PNF; Feb 1953, PNF; Apr 1955, EJB. Helena R., Guildford, May 1963, JBF; Jul-Sep 1973, SJM. Helena R., Midland, May 1963, JBF. Highbury, Apr 1972, SJM. Hill River Creek, Jul 1985, MEC. Irwin, May 1955, EJB. Jandakot, Oct 1974, PFSL. Jandawaring, Jul 1985, MEC. Joondalup, Jan-Mar 1978, AB. Jubilee Stn, Oct 1984, MEC. Jurien Bay, Jul 1985, MEC. Kalbarri, Apr-May 1985, MEC. Kalgoorlie, Aug 1956, EJB; Jul 1973, SJM. Karratha, Feb-Mar 1984, MEC; May-Oct 1984, MEC; Jan 1985, MEC; Jul 1985, MEC. Katanning, Nov 1952, DG. Kellerberrin, Jul 1956, EJB. Kelmscott, Mar 1972, PFSL. Kimberley Research Station, Sep 1961, KTR; Sep 1962, KTR. Kondinin, Mar 1955, EJB. Koolan Is., Sep 1984, MEC. Kulin, Mar 1955, EJB. Kununurra, Apr-Jun 1972, PFSL; Dec 1972, PFSL; Mar-May 1973, PFSL; Aug 1973, ENM; Nov-Dec 1973, PFSL; Apr 1974, PFSL; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Oct-Nov 1975, PFSL; Jun-Jul 1976, AEW; Oct-Nov 1976, AEW; Apr 1977, AEW; Nov-Dec 1977, AEW; Jun-Jul 1978, PFSL/AEW; Jun 1981, OA; Feb-Mar 1984, MEC; May 1984, MEC. La Grange, Oct 1978, AEW; Sep 1984, MEC. Lake Goollelal, Jan-Mar 1978, AB; Jan 1982, PFSL. Lake Grace, Mar 1955, EJB. Lake Gregory Community, Aug 1984, MEC. Lake Joondalup, Jan 1982, PFSL. Lake Monger, Jun 1954, EPH. Laverton, Aug 1956, EJB. Leonora, Jun 1956, EJB; Jul 1973, SJM. Leopold Stn, Oct 1984, MEC. Mabel Down Stn, Nov 1984, MEC. Manjimup, May 1956, EJB. Marble Bar, Mar 1979, AEW. Meekatharra, Jun 1985, MEC. Menzies, Jun 1956, EJB; Jun 1973, SJM. Merredin, Jul 1956, EJB; Jun 1973, SJM. Miaree Pools, Jun 1984, MEC. Midland, Oct 1953, JAB; Oct 1958, JAB. Millars Well, Nov 1984, MEC. Millstream, Jan 1975, PFSL; Oct 1978, AEW. Millstream, Palm Pool, Jan 1975, PFSL. Mingulla Village, May 1985, MEC. Minilya Roadhouse, May 1985, MEC. Minnivale. Mistake Creek Stn, Nov 1984, MEC. Miudja Community, Oct 1984, MEC. Moonijim Centre, Oct 1952, DG. Moora, Jun 1955, EJB. Morowa, Jun 1955, EJB. Mowanjum, Sep-Oct 1978, AEW. Mt Magnet, Apr 1985, MEC. Mt Marshall, Jul 1956, EJB. Mullewa, Jun 1955, EJB; Apr 1985, MEC. Mulubula Stn, Sep 1984, MEC. Murray R., Apr 1971, CAG. Nanutarra, Ashburton R., Apr 1980, AEW. Narembeen, Jul 1956, EJB. Narrogin, Mar 1955, EJB; Feb 1972, SJM; Apr 1973, SJM. New Cherrabun Stn, Oct 1984, MEC. Newman, Oct 1978, AEW; Mar 1979, AEW; Mar 1981, PF. Nicholson Stn, Nov 1984, MEC. Nookanbah Stn, Oct 1984, MEC. Northam, Jun 1955, EJB. Northampton, May 1955, EJB; Apr 1985, MEC. Onslow, Nov 1984, MEC; May 1985, MEC. Ord River Stn, Nov 1984, MEC. Paraburdoo, Aug 1973, ENM. Perenjori, May 1955, EJB. Perth, Jun-Jul 1948, WMO; Jun 1953, DLM; Jun 1955, EJB; Apr 1959, LEK; Mar 1962, LEK; Oct 1976, AEW. Perth, Applecross, Oct 1963, GMR. Perth, Belmont, Jun 1955, EJB. Perth, Canning, Mar 1980, FWH. Perth, Careniup, Nov 1983, JCT. Perth, Ferndale, Mar 1975, PFSL. Perth, Inglewood, Mar 1951, JFa. Perth, Jolimont, Feb 1972, PFSL. Perth, Lake Monger, Jun 1954, EPH. Perth, Maylands, Oct 1974, PFSL. Perth, Mt Hawthorn, Jun 1956, JHC. Perth, Mt Lawley, Mar 1979, PFSL. Perth, Nedlands, Mar 1969, LEK; Oct-Dec 1971, SJM; Jan-Jul 1972, SJM; Sep-Dec 1972, SJM; Jan-Feb 1973, SJM; Oct 1973, PFSL; Sep 1980, AEW; Mar 1985, MEC. Perth, Shenton Park, Sep 1977, PFSL. Perth, South Perth, Jan 1922, DLH; Apr 1959, LEK; Jul 1961, JS. Perth, Subiaco, Mar 1985, MEC. Perth, Wallburnup Swamp, Jan 1982, PFSL. Pingelly, Apr 1972, SJM. Port Hedland, HEP; Jun 1970, HEP; Jul 1973, EJB; Jun 1978, AEW; Sep 1978, AEW; Mar 1979, AEW; Feb- Nov 1984, MEC. Port Hedland, McGregors Swamp, Jun 1978, AEW.

Quanbun Stn, Oct 1984, MEC. Redcliffe, Aug 1961, JF. Roebourne, Feb-Mar 1953, EPH/EJB; Feb 1954, MMC; Jun 1984, MEC; Aug-Sep 1984, MEC; Nov 1984, MEC; Jan 1985, MEC. Rosewood Stn, Nov 1984, MEC. Rottnest, Jun 1979, AEW. Sandfire Roadhouse, Sep 1984, MEC. Spring Creek Stn, Nov 1984, MEC. Spring Valley Stn, Nov 1984, MEC. Sturt Creek Stn, Oct 1978, AEW; Nov 1984, MEC. Swan R., JC. Swan R., Caversham, May 1963, JBF. Swan R., Hearne Hill, May 1963, JBF. Swan R., Maylands, May 1963, JBF. Swan R., South Perth, May 1963, JBF. Three Springs, May 1955, EJB. Tom Price, Oct 1978, AEW; Mar 1979, AEW. Toodyay, Jun 1955, EJB. Turkey Creek, Nov 1984, MEC. Upper Blackwood, May 1956, EJB. Upper Chapman, May 1955, EJB. Victoria Plains, Jul 1955, EJB. Wagin, Aug 1955, EJB; Apr 1972, SJM. Wanneroo, Jun 1955, EJB. Wickham, Jun 1984, MEC; Sep-Oct 1984, MEC; Apr 1986, PFSL. Williams, Apr 1972, SJM; Apr 1973, SJM. Wiluna, Jun 1956, EJB. Wittenoom, Nov 1984, MEC. Wongan/Ballidu, Jul 1955, EJB. Wyalkatchem, Jul 1956, EJB. Wyndham, LEC; May 1926, MM; Dec 1972, PFSL; Nov-Dec 1977, AEW; Jul 1978, AEW; May-Oct 1980, OA; Jan 1981, OA; Apr-Jul 1981, OA; Feb 1984, MEC; May 1984, MEC. Yallingup, May 1952, CFHJ. Yeeda, Apr 1977, AEW. Yilgarn, Aug 1956, EJB. York, Jun 1955, EJB; Oct 1972, PFSL.

SPECIES WITH WHICH IT MAY BE CONFUSED

See *Cx australicus* and the other members of the 'pipiens' group.

Culex (Culex) sitiens Weidemann 1828

Weidemann, C.R.G., 1828. *Aussereuropaische zweiflugelige insecten.* Vol.1. p.542.
Type locality: Sumatra.
Synonymy: *Culex impellens* Walker, F., 1859. *J. Proc. Linn. Soc. Lond. Zool., 4* :91.
Culex microannulatus Theobald, F.V., 1901. *Mon. Cul., 1*:353.
Culex gnophodes Theobald, F.V., 1903. *Mem. Lpool. Sch. Trop. Med., 10*:163.
Culex somaliensis Neveu-Lemaire, M., 1906. *Arch. Parasit., Paris, 10*:254.
Culex nigricephala Leicester, G.F., 1908. *Stud. Inst. Med. Res.F.M.S., 3*:149.
Culex salus Theobald, F.V., 1908. *Rept. Wellcome Lab., Gordon Coll., Khartoum., 3*:256.
Culex jepsoni Theobald, F.V., 1910. *Entomologist, 43*:158.
Culex saibaii Taylor, F.H., 1912. *Rep. Comm. Publ. Hlth. Qd.* p.28.
Culex paludis Taylor, F.H., 1913. *Rep. Aust. Inst. Trop. Med. 1911.* p.56.
Culex annulata Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond. 1914*:689.
Culex milni Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond. 1914*:196.
Culex salinus Baisas, F.E., 1938. *Mon. Bull. Bur. Phillip., Manila, 18*:204.

ADULT FEMALE

A medium sized species with a narrow pale band on the proboscis and straight tergal bands. Head clothed with narrow curved white scales dorsally, darker laterally; broad white scales on side of head; upright forked scales numerous. Torus and clypeus bare. Palp dark scaled with a few white scales at tip; about 0.18x length of proboscis. Proboscis dark with narrow white band about 0.45-0.6 from base; about 0.84x length of forefemur. Scutal integument brown; clothed in bronze to black scales, with pale scales on anterior margin, above wing root, and around prescutellar space. Scutellum with narrow scales on all three lobes. Pleural integument brown with creamy narrow scale patches on anterior pronotum and posterior pronotum; broad creamy white scales on propleuron, upper and posterior sternopleuron, and anterior mesepimeron. Abdomen with tergites black scaled with straight basal white bands; sternites pale scaled with complete subapical black bands. Forecoxa with broad flat white and black scales, midcoxa and hindcoxa with pale scales only. Hindfemora mottled, pale below and dark above, dark at apex; tibia with lightish median anterior streak on mid third, with white knee spot; tarsi dark with narrow pale basal bands on I-III, IV and V dark. Wing dark scaled; base of second forked cell closer to base of wing than base of first forked cell. Haltere all pale.

LARVA

Antenna pale at base, darker beyond insert of seta 1-A; about 0.72x length of head; seta 1-A multibranched, inserted about 0.6 from base. Head about 0.63x as long as wide; seta 1-C short and stout; 4-C small, with 1-2 branches; 5-C with 5-6 branches; 6-C with 4 branches; 7-C with 8-9 pectinate branches; 8-C small, with 4 branches; 9-C small, with 3 branches. Abdominal segment VIII with lateral comb with 30-35 fringed scales in triangular patch; seta 1-VIII with 9 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 8-10 pectinate branches; 5-VIII with 4 simple branches. Siphon index about 3.0; about 3.8x length of

saddle; seta 1-S with 5-6 pairs of tufts with 7-8 branches; pecten with 13 basally fringed teeth on basal 0.3 of siphon. Saddle complete, cut away posterioventrally; with spicules on posterior apex of saddle; seta 1- X with 1-2 branches; 2-X with 4 branches; 3-X single; 4-X with 6 pairs of branched tufts on grid; precratal tufts absent. Anal papillae short and globular.

BIOLOGY

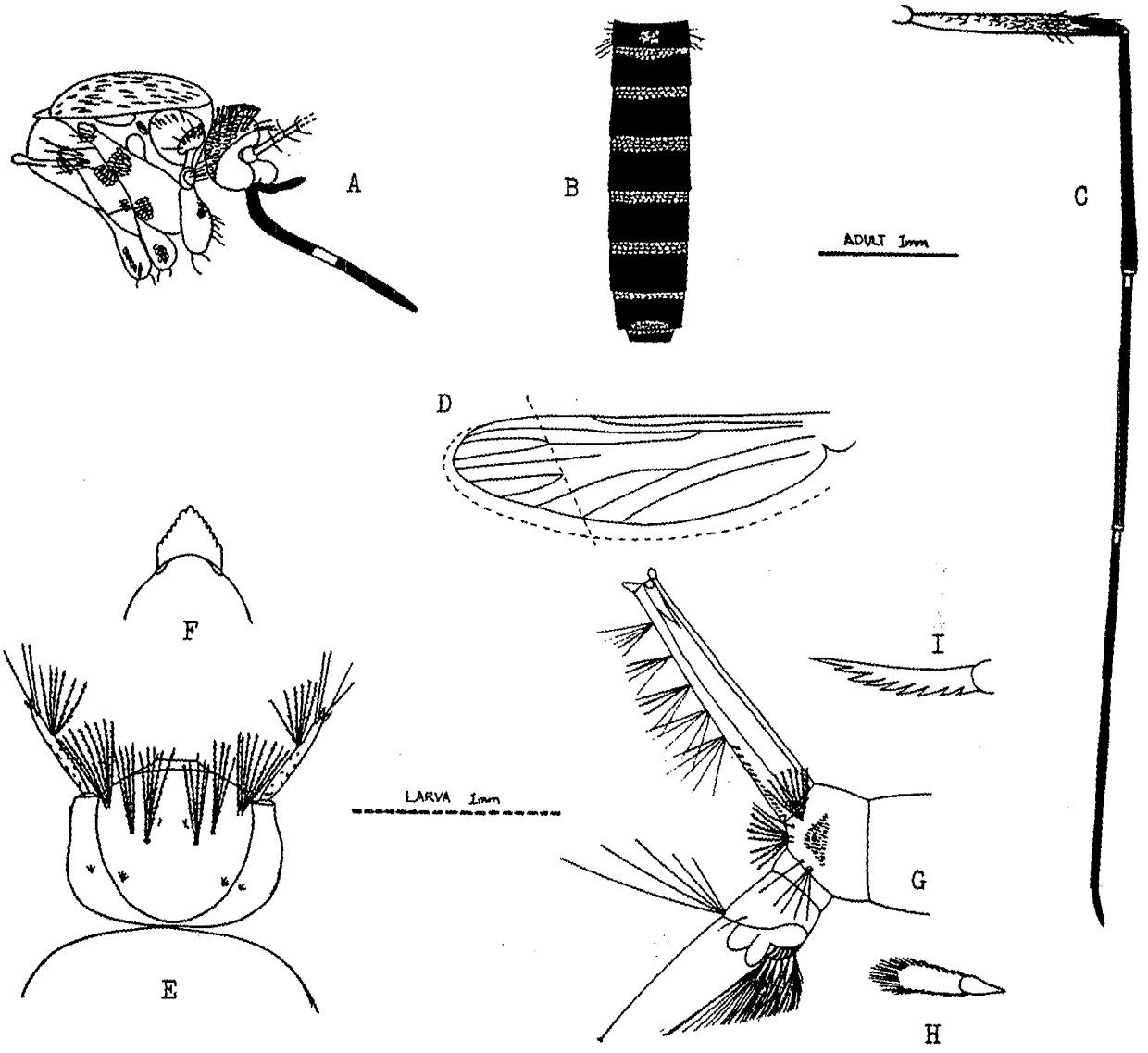
Cx sitiens breeds in brackish waters left by high tides; sometimes in fresh water. The adults bite man readily at night; and will feed on other mammals and birds. The adults will disperse for very long distances (up to 35 km) from coastal breeding areas. The species assumes a major pest status in circumstances where disturbance or impoundments alter the natural drainage and flow in tidal areas.

RELATION TO DISEASE

Cx sitiens is not noted as a vector of disease in Australia, but is susceptible to infection with RRv.

DISTRIBUTION

Beebingarra Creek, Jun 1978, AEW. Broome, Sep 1978, AEW; Feb-Mar 1984, MEC; Jun 1984, MEC; Jul-Oct 1985, SH. Cape Lambert, Jul 1984, MEC. Carnarvon, Apr 1981, AH/CS; Mar 1984, MEC. Carnarvon, Babbage Is., Nov-Dec 1980, AH/CS; May 1981, AH/CS. Dampier, May 1984, MEC; Sep-Oct 1984, MEC. Derby, Mar-Apr 1977, AEW; Aug-Sep 1978; Sep-Oct 1978, AEW; Feb-Mar 1984, MEC; Mar



Culex (Culex) sitiens

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Wing (detail of vein pattern); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

1985, AEW. Derby, Black Rock, Mar 1977, AEW. Exmouth, Aug 1984, MEC; Mar 1985,MEC. Ivanhoe, Apr 1957, AKO. Kalumburu, Mar 1953, EPH/EJB; Mar 1954, EPH. Kununurra, Jul 1978, PFSL/AEW; Jun 1980, OA; Aug-Sep 1980, OA; Feb 1981, OA; Mar 1984, MEC. La Grange, Oct 1978, AEW. Mowanjum, Sep 1978, AEW. Port Hedland, Feb-Mar 1984, MEC; May 1984, MEC. Roebourne, Feb-Mar 1953, EPH/EJB; Feb 1954, EPH; Oct 1984, MEC. Wickham, Apr 1986, PFSL. Wyndham, Jul 1978, AEW; Dec 1980, OA; Feb 1984, MEC.

SPECIES WITH WHICH IT MAY BE CONFUSED

Cx sitiens is readily confused with a number of other species with a banded proboscis, but is distinguished by the narrow band on the proboscis; the apical dark sternal band; and the position of the wing forks.

Culex (Culex) squamosus (Taylor) 1914

Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond. 1914*:691.
Type locality: Townsville, Queensland.
Synonymy: *Culex annulata* Theobald, F.V., 1905. *Ann. Hist.-nat. Mus. Hung., 3*:98.
Culex annulirostris Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond. 1914*:696.
Culex taylori Edwards, F.W., 1921. *Bull. Ent. Res., 12*:78.

ADULT FEMALE

A large dark robust *Culex* species with a banded proboscis and with mottled wings. Head with narrow yellow scales on vertex to occiput; darker laterally with broad flat pale scales on side of head; upright forked scales numerous, pale in midline, darker laterally. Torus with a few darkish scales medially. Clypeus bare. Palp dark scaled with white scales at apex; about 0.23x length of proboscis. Proboscis dark with pale band extending from 0.35-0.58 from base; about 0.89x length of forefemur. Scutal integument brown; clothed with fine black scales and with some paler scales anteriorly; small patch of broad, blunt ended upright pale scales in front of wing root. Scutellum with narrow black scales on all three lobes, and a few pale scales on midlobe. Pleural integument dark brown; propleuron with a few long white scales; anterior pronotum and posterior pronotum with narrow pale and black scales; long broad white scale patches on lower and upper sternopleuron, and on anterior mesepimeron. Abdominal tergites black with narrow basal white bands which are indented at the midline, a few apical median white scales on VII, and VIII with apical yellow band; stenites dark scaled with basal median white scale patches. All coxae with mottled light and dark scales. Hindfemur mottled; tibia slightly mottled; tarsi all dark with narrow apical and basal pale bands on I-IV, V with basal band only; pulvilli present. Wing mottled with light and dark scales on all veins. Haltere with stem pale basally and darker apically; club black.

LARVA

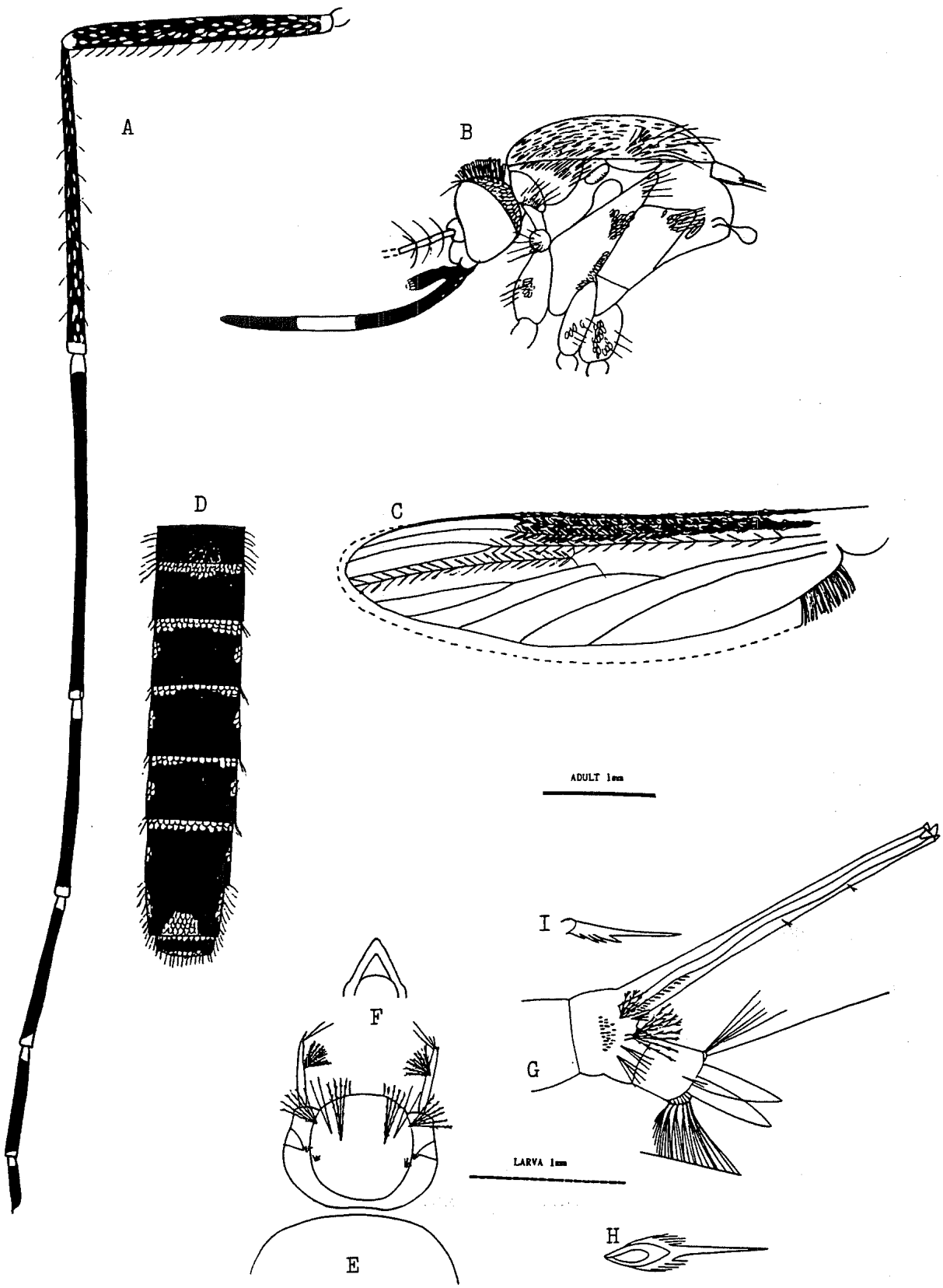
Antenna with pale base and darker at tip, beyond insert of 1-A; about 0.55x length of head; seta 1-A multibranched, plumose, inserted about 0.6 from base. Head about 1.37x as wide as long; about equal in width to thorax; seta 4-C with 2 small simple branches; 5-C with 4 pectinate branches; 6-C with 2 pectinate branches; 7-C with 6-8 pectinate branches; 8-C with 3 small simple branches; 9-C with 5 small simple branches. Abdominal segment VIII with lateral comb with 16-24 scales in an irregular patch; each scale being a strong spine with basal fringe; seta 1-VIII with 5 branches; 2-VIII with 3-4 branches; 3-VIII with 7-9 branches; 4-VIII with 3 branches; 5-VIII with 4 branches. Siphon index about 9.8; siphon about 5.3x length of saddle; seta 1- S with 2 pairs of bifid tufts, inserted in apical half of siphon; pecten with about 12 fringed teeth on basal 0.25 of siphon. Saddle complete; seta 1-X bifid; 2-X with 5 branches; 3-X single; 4-X with 6 pairs of branched setae on grid; precratal tufts absent. Anal papillae long and pointed; about 0.75x length of saddle.

BIOLOGY

Cx squamosus is restricted to the northern parts of W.A. It breeds in fresh water sites in creeks, pools, and wheel ruts, generally in more permanent sites with some algae. The adults do not bite man, but are taken in light, CO_2 baited or bird baited traps. Populations of this species are never very high.

RELATION TO DISEASE

Both Kunjin and Sindbis viruses have been isolated from *Cx squamosus*, but the vector status of the species remains unclear.



Culex (Culex) squamosus

A: Hindleg; B: Adult head and thorax (lateral); C: Wing (detail of scaling on some veins shown); D: Abdomen (dorsal); E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

DISTRIBUTION

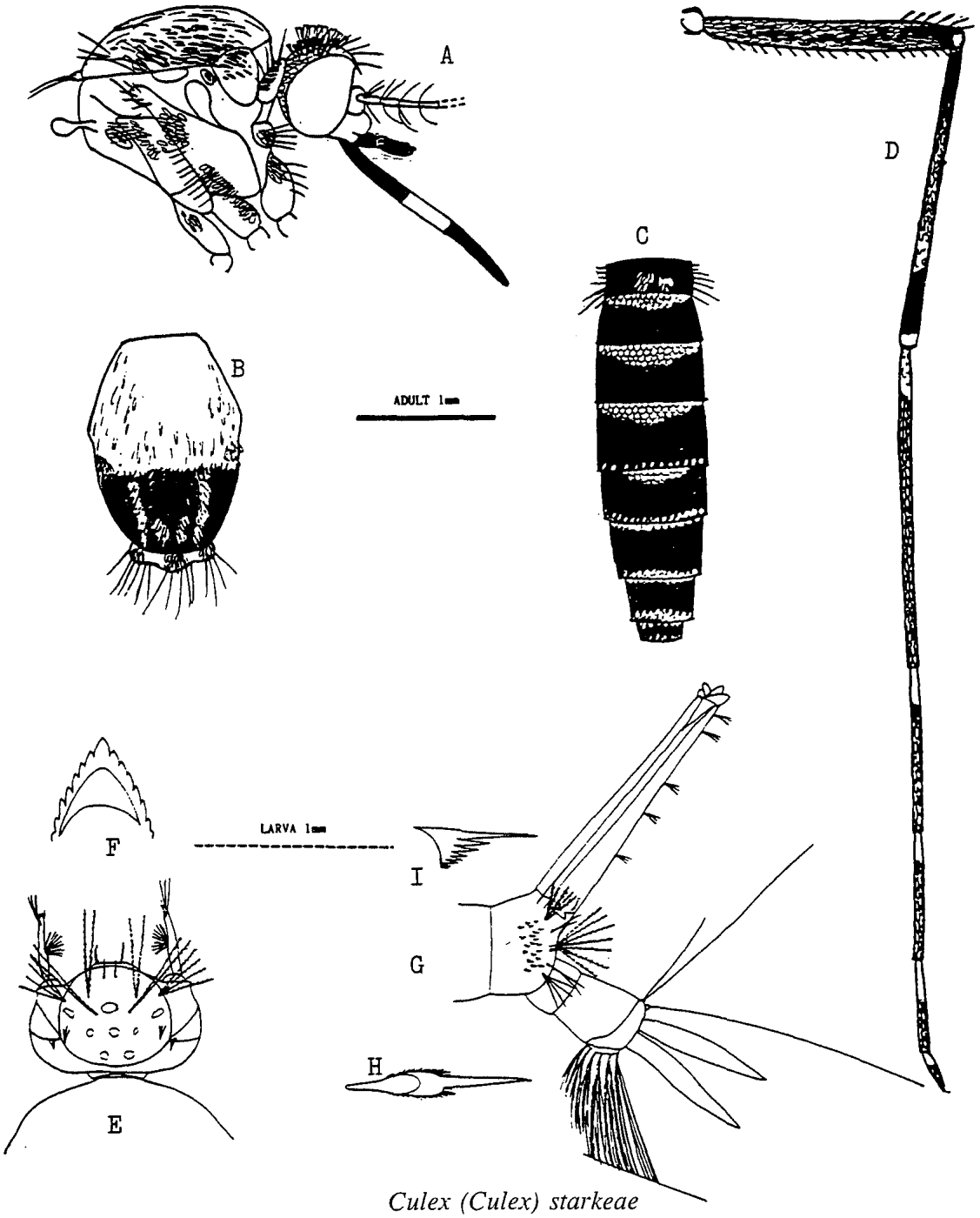
Kalumburu, Mar 1953, EPH/EJB. Kununurra, Apr 1975, PFSL.

SPECIES WITH WHICH IT MAY BE CONFUSED

This species is easily recognised by the banded proboscis and mottled wings.

Culex (Culex) starkeae Stone and Knight 1958

Stone, A. and Knight, K.L., 1958. *Proc. Ent. Soc. Wash., 60:*69.
(Nom. Nov. for *Culex basicinctus* Edwards).
Type locality: Townsville, Queensland.
Synonymy: *Culex basicinctus* Edwards, F.W., 1922. *Bull. Ent. Res., 12:*96.



Culex (Culex) starkeae

A: Adult head and thorax (lateral); B: Thorax (dorsal); C: Abdomen (dorsal); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

ADULT FEMALE

A medium sized species with a pale band on the proboscis and with the scutum having distinct yellow creamy scaling on the anterior half. Head with narrow pale scales above; broad white and dark scales on sides of head; upright forked scales numerous. Torus with a few pale scales mesially. Clypeus bare. Palps dark, mottled on apical half, with pale scales at apex; about 0.25x length of proboscis. Proboscis dark with pale band extending from 0.4-0.64 from base; about 0.8x length of forefemur. Scutal integument dark brown; clothed with yellow cream scales on anterior 0.66, dark behind; with patch of blunt elongate upright pale scales in front of wing root; some pale scales around prescutellar space. Scutellum with narrow pale scales on all three lobes. Pleural integument brown; with narrow pale scales on anterior pronotum and posterior pronotum; some broad pale scales posteriorly on posterior pronotum; patches of broad flat pale scales on propleuron, anterior and posterior sternopleuron, anterior and upper mesepimeron. Abdomen with tergites dark brown to black with white basal bands with lateral patches, narrow apical borders on segments VI-VIII; sternites pale scaled with large subapical brown patches on segments IV-VIII. Forecoxa mottled with pale and dark scales; midcoxae and hindcoxae pale scaled. Hindfemur mottled; tibia dark with median anterior pale streak on middle half, with white apex; tarsi I-IV with broad pale basal bands, V with narrow basal band. Wing dark scaled. Haltere with pale stem; club dark with pale scales.

LARVA

Antenna pale on basal 0.8, tip dark; small spicules on basal 0.5; about 0.7x length of head; seta 1-A with 10+ branches, inserted inwardly at about 0.5 from base of antenna. Head about 0.6x as long as wide; about 0.5x width of thorax; sometimes with scattered dark patches on dorsal surface; seta 4-C single, inserted forward of 5-C; 5-C and 6-C with 2 frayed branches; 7-C with 3-4 frayed branches. Prothoracic setae with 1-P to 3-P long and single on common raised boss; 4-P with 2 shorter branches; 5-P and 6-P single and long; 7-P with 3 long branches. Abdominal segment VIII with lateral comb of 19-28 fringed spines in a triangular patch; seta 1-VIII with 4-5 pectinate branches; 2-VIII and 4-VIII with 2 short simple branches; 3-VIII with 6-7 long pectinate branches; 5-VIII with 3-5 simple branches. Siphon curved dorsally at very apex with valve hairs modified to hooks; index about 5.6; about 3.1x length of saddle; well developed acus present; seta 1-S with 5-6 pairs of tufts with 2-3 short branches on apical 0.7 of siphon; pecten with about 6 sharply denticulate spines on basal 0.1 of siphon. Anal segment with saddle complete; seta 2-X with 2 branches; 3-X single; 4-X 6-7 pairs of tufts on grid. Anal papillae long and pointed; about 1.5x length of saddle.

BIOLOGY

Cx starkeae breeds in ground pools, rock holes and swamps, always in association with filamentous algae. The species is relatively uncommon, and is restricted to northern parts of W.A. The adults feed preferentially on mammals, occasionally on man, but also will feed on birds. It is captured occasionally in light, CO_2 baited, and animal baited traps.

RELATION TO DISEASE

One strain of Sindbis virus has been isolated from this species, but its vector status remains unclear.

DISTRIBUTION

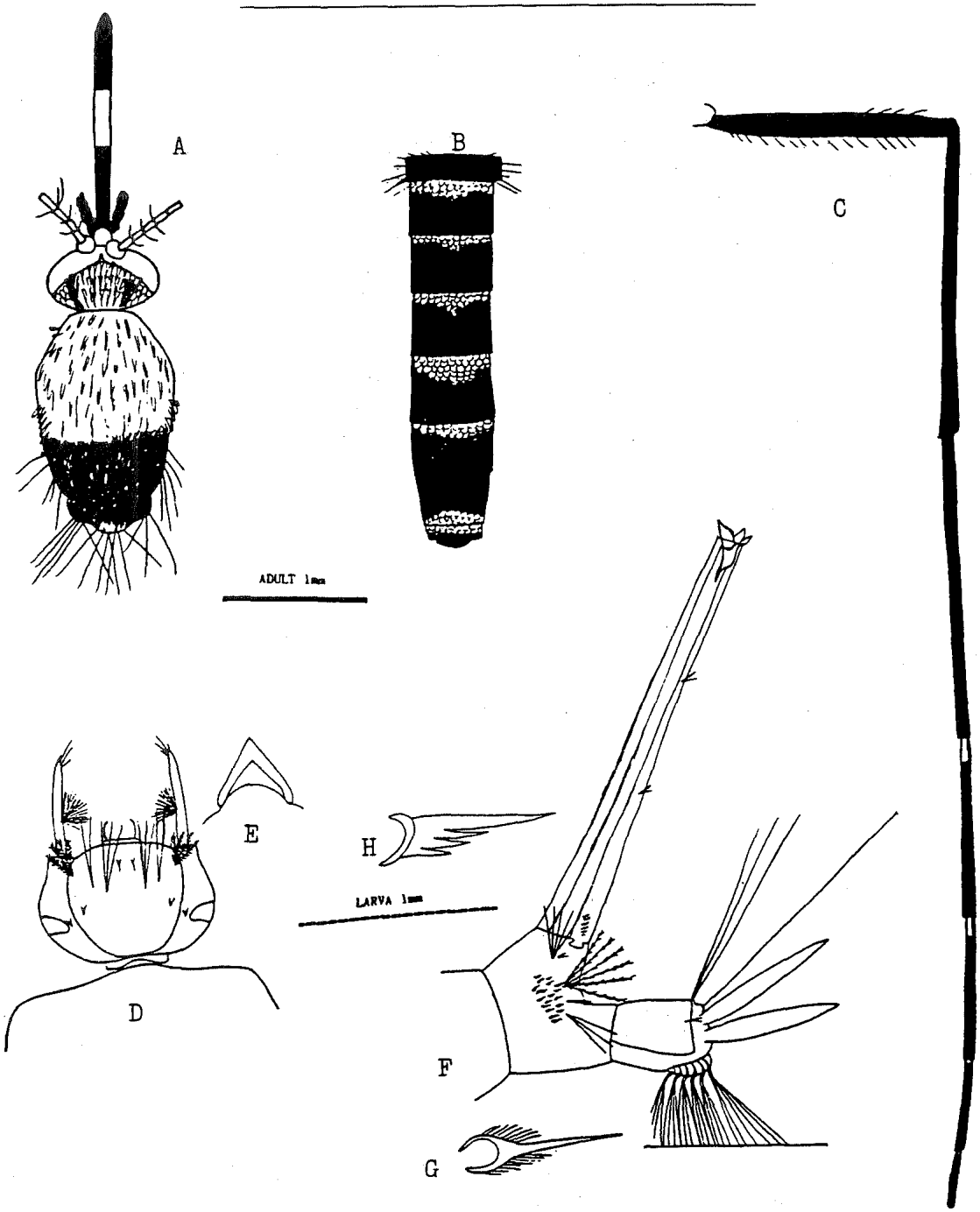
Balgo, Mar 1981, AEW. Billiluna, Mar 1981, AEW. Camballin, May 1979, AEW; Jul-Aug 1979, AEW. Derby, 40km S, Mar 1977, AEW. Kalumburu, Mar 1951, EJB; Aug 1979, AEW. Kimberley Downs, May 1979, AEW. Kununurra, May 1973, PFSL; Apr 1974, PFSL; Apr 1975, PFSL; Jun 1976, AEW; Nov 1976, AEW. Lake Argyle NE, Jul 1978, AEW. Lake Argyle SW, Jul 1978, PFSL/AEW. Lissadel, Jul 1978, PFSL/AEW. Marble Bar, Mar 1979, AEW. Millstream, Oct 1970, DHC; Apr 1979, AEW. Ord River, CSIRO, Apr 1953, AKO. Parrys Creek, Jun 1976, AEW. Turkey Creek, Jul 1978, PFSL/AEW. Wittenoom, Mar 1954. Wyndham, Apr 1953, AKO.

SPECIES WITH WHICH IT MAY BE CONFUSED

Cx starkeae is most easily confused with another relatively uncommon *Culex* species *Cx vicinus*. *Cx starkeae* can be separated by the presence of yellowish cream scales on the anterior scutum and with anterior and posterior lines of pale scales on tibiae. Scutal scaling in *Cx vicinus* is white.

Culex (Culex) vicinus (Taylor) 1916

Taylor, F.H., 1916. *Proc. Linn. Soc. N.S.W., 41*:569.
Type locality: Stapleton, Northern Territory.
Synonymy: *Culex annulata* Taylor, F.H., 1914. *Trans. R. Ent. Soc. Lond, 1914*:695.
Culex basicinctus Edwards, F.W., 1921. *Bull. Ent. Res., 12*:78.



Culex (Culex) vicinus

A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

ADULT FEMALE

A medium sized mosquito with a banded proboscis, and with the scutum clothed in white scales on anterior two thirds. Head with narrow white decumbent scales above, darker laterally and behind eye border; pale broad scales on side of head; upright forked scales numerous. Clypeus bare. Palps dark; about 0.23x length of proboscis. Proboscis dark with pale band extending from 0.45-0.62 from base. Scutal integument brown; anterior 0.67 densely clothed in narrow white scales, dark brown to bronze behind; patch of broad, blunt ended scales in front of wing root. Scutellum with narrow bronze scales on all lobes. Pleural integument dark brown; a few broad pale scales on propleuron, upper and lower sternopleuron and upper mesepimeron. Abdomen with tergites dark scaled with pale basal bands on II-VIII; sternites pale scaled with indistinct subapical band of scattered dark scales. All coxae with some pale and/or dark scales anteriorly. Hindfemur and tibia dark, unmottled; hindtarsi I-IV with narrow pale basal bands, V with basal band very narrow. Wing dark scaled. Haltere all dark.

LARVA

Antenna pale at base, darker apically; about 0.81x length of head; 1-A with about 20 simple branches, inserted about 0.43 from base. Head about 0.7x as long as broad; about half width of thorax; seta 4-C with one forked branch; 5- C with 3 branches; 6-C bifid; 7-C with 4 plumose branches; 8-C and 9-C small, bifid. Abdominal segment VIII with lateral comb with 16-19 scales in irregular patch, each scale consisting of a spine with a basal fringe; seta 1- VIII with 5 plumose branches; 2-VIII and 4-VIII bifid; 3-VIII with 6 plumose branches; 5-VIII with 3 branches. Siphonal index about 8.5; siphon about 5.4x as long as saddle; seta 1-S with two pairs of bifid tufts at midpoint and near apex; pecten with 6 fringed teeth restricted to very base of siphon. Saddle complete; seta 1-X small, forked; 2-X with 3 branches; 3-X single; 4-X with 6 pairs of branched setae on grid; precratal tufts absent. Anal papillae long and pointed; about 1.36x length of saddle.

BIOLOGY

Cx vicinus breeds in open sunlit waters, generally more permanent ground pools and swamps. The larvae are found resting in filamentous algal mats, and may be difficult to locate. Adults do not bite man readily, but are occasionally captured in light, CO_2 baited or avian baited traps, generally in the mid to late dry season in the north of the State.

RELATION TO DISEASE

None known.

DISTRIBUTION

Derby, Mar-Apr 1977, AEW. Kununurra, Apr 1974, PFSL; Jun 1976, AEW. Mitchell Plateau, Jul 1981, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

See *Cx starkeae*.

Culex (Culex) ENM's sp. No.92

ADULT FEMALE

Cx ENM's sp. No.92 is a very small species with a dark scaled scutum; unmottled femora; and tergites with basal pale bands.

LARVA

Lateral comb scales with central spine extending beyond basal fringe by about 0.25x length of spine. Siphonal index about 8.0; seta 1-S with 5-6 pairs of tufts, each with 4 branches. Head with seta 6-C with 1-2 branches; 5-C bifid and distinctly weaker than 6-C.

BIOLOGY

Larvae of *Cx* ENM's sp. No.92 have been collected from the margins of shallow, semi-shaded ground pools with sandy substrate and emergent vegetation. This is a rare species and little is known of the adult biology.

RELATION TO DISEASE

None known.

DISTRIBUTION

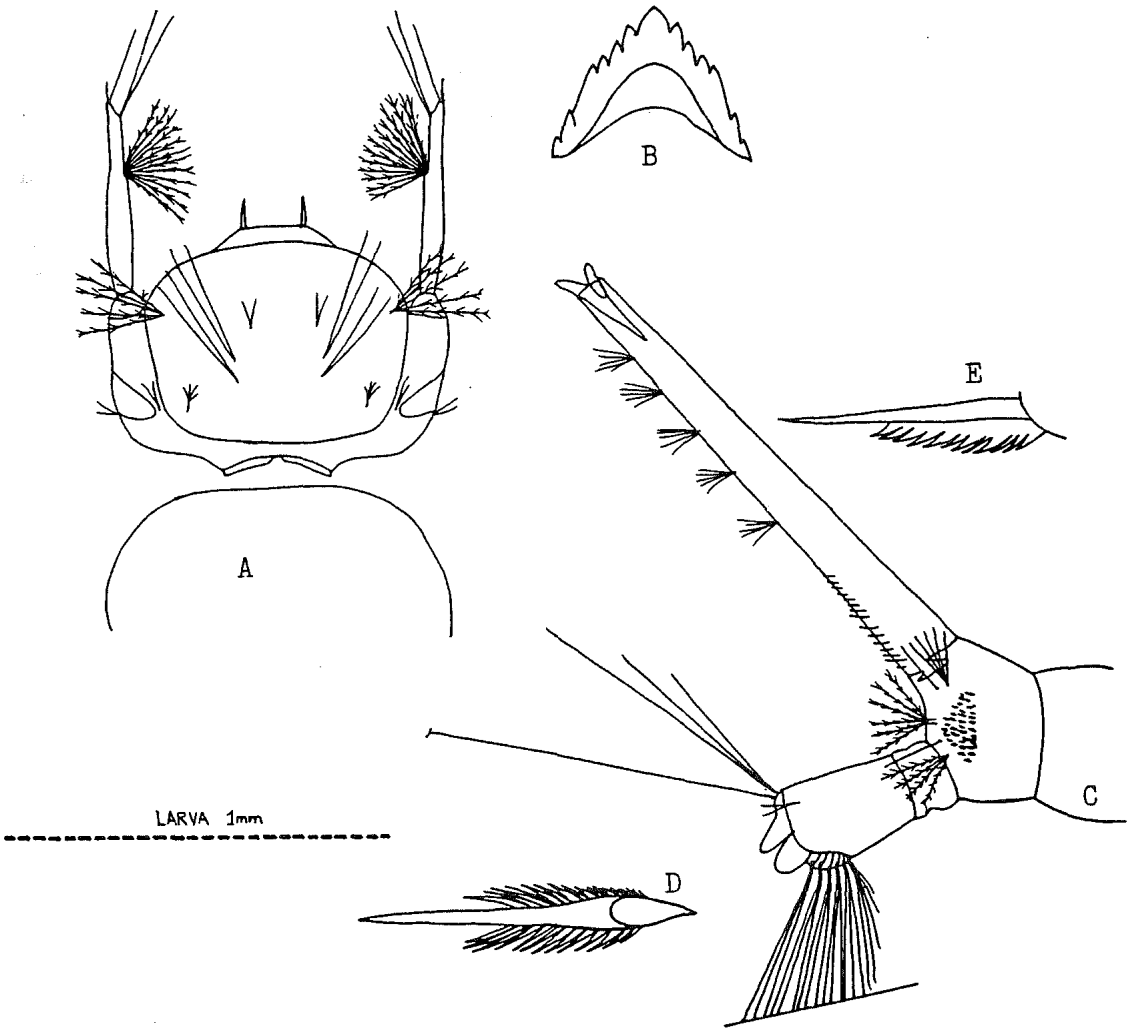
Gregorys Gorge, PFSL. Marble Bar, Sep 1974, JHS. Millstream, Apr 1971, MSU/MIT.

Subgenus : *Culiciomyia*

SUBGENERIC CHARACTERS

Adult: Small to medium sized species. Proboscis and palps uniformly dark. Antenna longer than proboscis. Tarsi all dark. Wings dark scaled.

Larva: Antenna at least 0.5x length of head; 1-A at or beyond midpoint. Lateral comb of numerous fringed scales. Siphon with well developed acus. Ventral brush with 4 pairs of tufts on grid. Anal papillae always longer than saddle.



Culex (Culex) ENM's sp. No.92
A: Larval head (dorsal); B: Mentum; C: Abdominal segment VIII (lateral); D: Lateral comb scale (detail); E: Pecten teeth (detail).

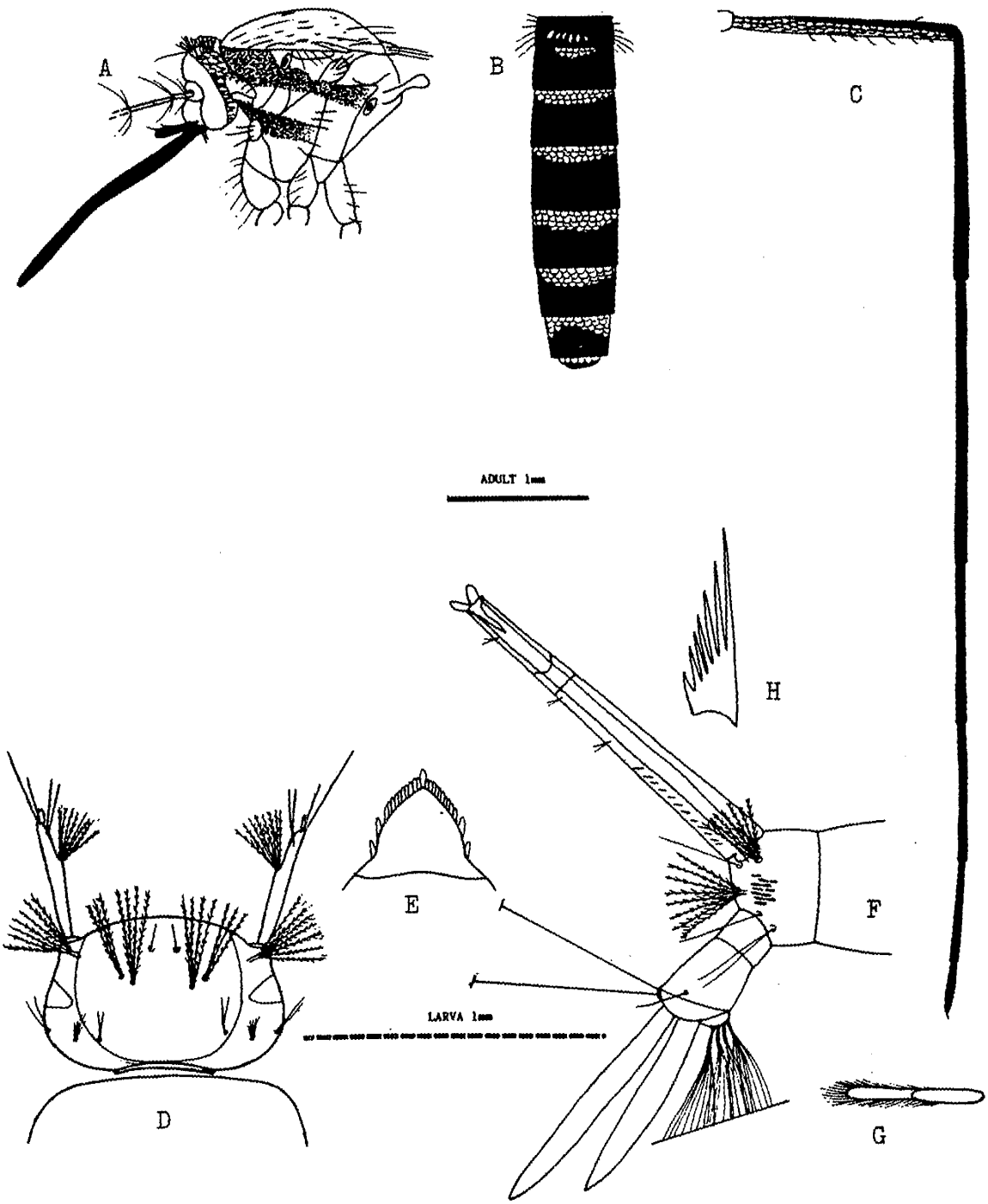
KEYS: ADULT FEMALES: see key to subgenera of Culex (page 213).
LARVAE: see key to subgenera of Culex (page 214).

Culex (Culiciomyia) pullus Theobald 1905

Theobald, F.V., 1905. *Ann. Hist.-Nat. Mus. Hung., 3*:87.
Type locality: Muina, New Guinea.
Synonymy: *Culex muticus* Edwards, F.W., 1923. *Bull. Ent. Res., 14*:6.

ADULT FEMALE

A small species readily recognised by transverse dark bands on the pleural integument. Head with narrow decumbent pale scales on vertex extending to occiput; pale eye border of broad scales; broad appressed scales on side of head; upright forked brown scales on occiput and laterally. Palp dark scaled; about 0.14x length of proboscis. Proboscis dark scaled; equal in length to forefemur. Scutal integument brown; clothed in fine bronze/brown scales. Scutellum clothed in fine bronze scales. Pleura bare of scales; pleural integument pale cream with two transverse brown stripes extending from posterior pronotum to upper mesepimeron, and from propleuron to lower sternopleuron; 1 lower mesepimeral bristle present. Abdomen with tergites black with pale basal bands with lateral pale patches; sternites all pale. Hindfemur pale ventrally almost to apex; tibia and tarsi all dark. Wing dark scaled. Haltere with pale stem and dark club.



Culex (Culiciomyia) pullus

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

LARVA

Antenna uniformly brown, about 0.66x length of head; 1-A inserted at about 0.8 from base; antenna with spicules. Head about 0.65x as long as broad; equal in width to thorax; seta 4-C single; 5-C with 4 branches; 6-C with 3 branches; 7- C with 6-8 branches. Abdominal segment VIII with lateral comb with 28-33 fringed scales in a triangular patch; seta 1-VIII with 6 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 8 pectinate branches; 5-VIII bifid. Siphon index about 7.5; siphon about 4.3x length of saddle; with weakly sclerotised band extending from 0.625-0.7 from base; seta 1-S with 3 pairs of 2-3 branched tufts on apical half of siphon; pecten with 12 strongly fringed teeth on basal part of siphon. Saddle complete; setae 1-X to 3-X single; 4-X with 4 pairs of branched tufts on grid; precratal tufts absent. Anal papillae long, pointed; about 2.3x length of saddle.

BIOLOGY

Cx pullus breeds in fresh water swamps, ground pools, wheel ruts, grassy drains and has been found in various domestic containers, and occasionally in tree holes. This species is most abundant in the wet season. The adults do not appear to bite man, but will take mammalian and avian baits. They have been collected in light, mammal and avian baited traps, and in CO_2 baited traps.

RELATION TO DISEASE

Two isolates of Kunjin virus are reported from this species, and Eubenangee virus has been isolated from a mixed pool of mosquitoes including *Cx pullus*. However, the vector status of this species remains unclear and it is not considered to be a major vector.

DISTRIBUTION

Balgo, Mar 1981, AEW. Broome, Mar 1984, MEC. Camballin, May 1979, AEW. Derby, Mar 1985, AEW. Kalumburu, Jul 1978, PFSL/AEW. Kununurra, Nov 1973, PFSL; Apr 1974, PFSL; Apr 1975, PFSL; Oct 1975, PFSL; Oct 1976, AEW; Apr 1977, AEW; Nov-Dec 1977, AEW; Jun-Jul 1978, PFSL/AEW; Feb-Mar 1984, MEC. Palm Spring, Oct 1984, MEC. Parrys Creek, Apr 1977, AEW. Roebourne, Nov 1984, MEC.* Wyndham, Feb 1984, MEC. Yeeda, Mar 1967, EJB. (* specimen not seen or verified by an experienced medical entomologist.)

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

Subgenus : *Lophoceraomyia*

SUBGENERIC CHARACTERS

Adult: Small to medium species. Head with broad flat scales on eye border. Palps and proboscis dark. Tarsi always dark. Palps short, less than 0.25x length of proboscis. Antenna longer than proboscis. Lower mesepimeral bristles present. Wing scales scanty.

Larvae: Characters diverse: head usually broader than long, antenna as long as head, setae 5-C and 6-C usually 1-3 branched. Siphon long and slender, 10-16 pecten teeth. Anal segment with saddle complete; seta 4-X with 5-6 pairs of tufts on grid.

Note: The status of the subgenus *Lophoceraomyia* in W.A. is unclear. A number of new, undescribed species have been recognised, and early collection records may be suspect as they refer to taxa known at the time of the collection, but may represent collections of currently recognised taxa. For example, records referring to *Cx fraudatrix*, a species confirmed from Queensland, are in all probability misidentifications.

The species of this subgenus are not very common, though small numbers may be collected from time to time. The treatment here is limited, and recognises that there are significant problems with interpretation of historical records, particularly where specimens have been lost and cannot be checked against current taxonomic criteria.

KEY TO ADULT FEMALES OF *CULEX (LOPHOCERAOMYIA)* IN WESTERN AUSTRALIA

(based on key prepared by Dr E.N. MARKS)

1. –	Scutum with golden or creamy scales; head with at least some pale upright forked scales on vertex	2
–	Scutal scaling bronze or black; head with all upright forked scales dark	3
2. –	Tergites with basal white bands; scutal scaling all golden or creamy	*Cx (Lop) cylindricus*
–	Tergites with basal lateral pale patches; scutum with creamy/golden scales on fossa, variable bronze scaling elsewhere	*Cx (Lop)* ENM's sp. No.154
3. –	Tergites II-VII with complete basal bands (may be inconspicuous)..	*Cx (Lop) cubiculi*
–	Tergites II-VII otherwise	4
4. –	Tergites all dark	*Cx (Lop) fraudatrix* (part)
–	Tergites with lateral basal patches on segments IV-VII	5

5. – Tergites with large lateral basal pale patches on II-VII, may meet in midline on VI-VII (Thoracic integument light brown) ..... *Cx (Lop)* ENM's sp. No.167

– Tergites with lateral basal patches inconspicuous on II-III, larger on IV-VII 6

6. – Thoracic integument light to mid brown ..... *Cx (Lop) fraudatrix* (part)

– Thoracic integument dark brown to black ..... *Cx (Lop) hilli*

KEY TO 4TH INSTAR LARVAE OF *CULEX (LOPHOCERAOMYIA)* IN WESTERN AUSTRALIA

There are no reliable characters for separating the larvae of the species known from W.A. The following key may be of some use, but the characters are variable, for example, the dark band on the siphon may be absent in some specimens. More link-bred material must be gathered before a definitive key can be produced.

1. – Siphon with dark band about 0.5 from base ..... *Cx (Lop) cubiculi* *Cx (Lop) fraudatrix* *Cx (Lop)* ENM's sp. No.167

– Siphon without band 2

2. – Head setae 5-C and 6-C bifid, plumose; 5-C about 2x length 6-C ... *Cx (Lop) cylindricus*

– Head setae 5-C and 6-C simple, 2-3 branched, equal in length ..... *Cx (Lop) hilli*

Culex (Lophoceraomyia) cubiculi Marks, 1989

Marks, E.N., 1989. [Nom.Nov. for *Cx fraudatrix-annulata* (Taylor)] in *The Culicidae of the Australasian Region. Vol. 8.* (pp. 94-96). Entomology Monograph No.2. Uni. Qld. & Uni. Syd. in collaboration with Comm. Dept. Comm. Serv. and Hlth.

Type locality: Stapleton and Daly River, Northern Territory.

Synonymy: *Lophoceratomyia annulata* Taylor, F.H., 1916. *Proc. Linn. Soc. N.S.W., 41:* 571.

Cx cubiculi is a new name for *Cx fraudatrix-annulata,* and the latter name appears in all previous literature.

ADULT FEMALE

A small, slender black mosquito. Head with appressed narrow black scales on vertex; paler broad scales on sides of head; upright forked scales confined to occiput. Clypeus bare, black. Palp black; about 0.11x length of proboscis. Proboscis long and black; about 1.3x length of forefemur. Scutal integument black; clothed in fine black scales. Scutellum with fine black scales on all three lobes. Pleural integument black with a small patch of translucent scales on upper sternopleuron. Abdomen with tergites black scaled with straight narrow basal creamy bands; sternites pale scaled. Forecoxa with patch of translucent scales; midcoxae and hindcoxae with white scale patch. Hindfemur dark black with pale ventral streak almost to apex; tibia and tarsi all dark. Wings dark scaled. Haltere with base of stem pale, club dark.

LARVA

(Not seen)

BIOLOGY

There is little data on the biology of this species. Adults have been taken in chicken baited traps, and in CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

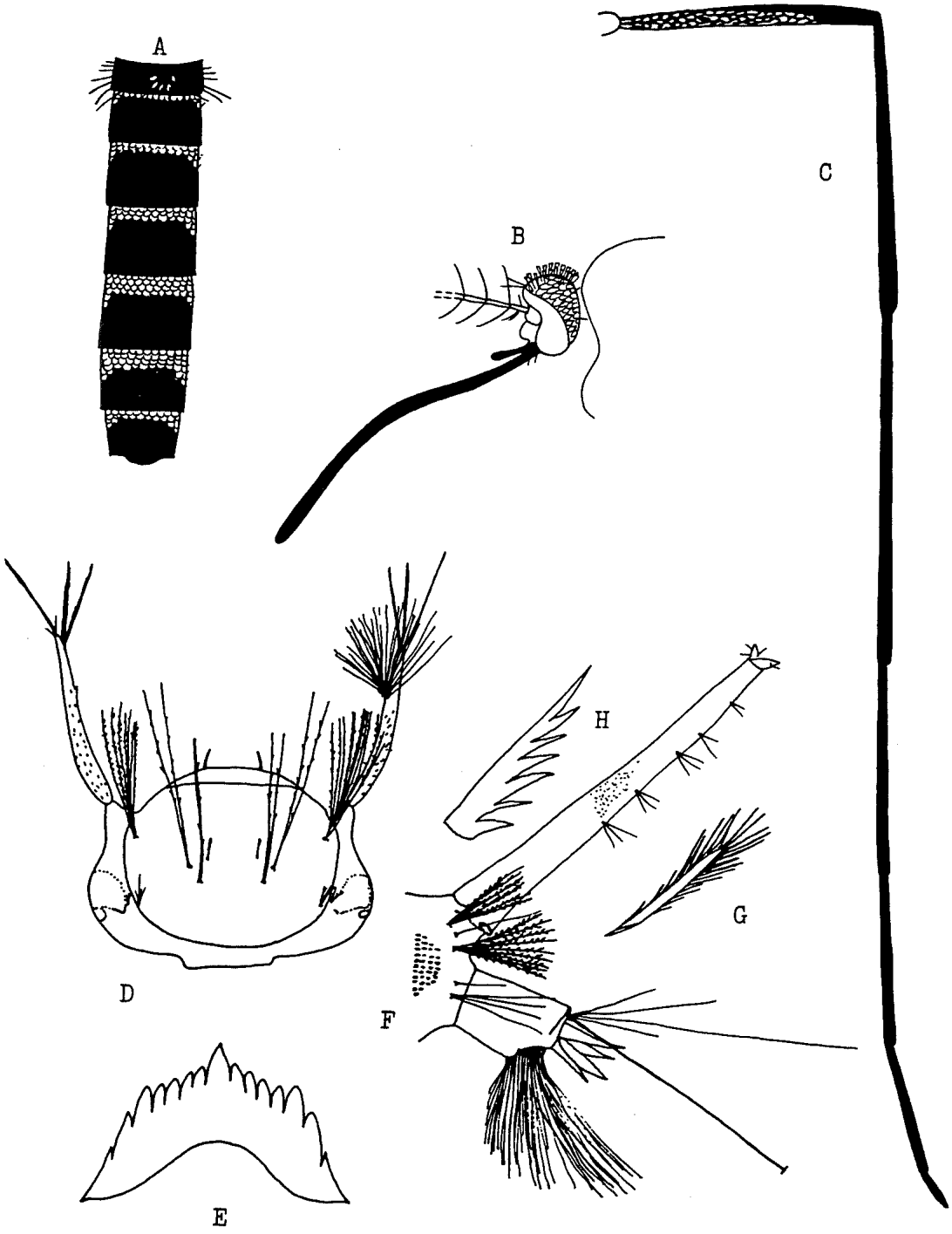
Kununurra, PFSL.

SPECIES WITH WHICH IT MAY BE CONFUSED

The exotic *Cx fraudatrix* is essentially identical, but has tergites all dark.

Culex (Lophoceraomyia) cylindricus Theobald 1903

Theobald, F.V., 1903. *Mon. Cul., 3:* 202.
Type locality: South Queensland.
Synonymy: None.



Culex (Lophoceraomyia) cylindricus
A: Abdomen (dorsal); B: Adult head (lateral); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

ADULT FEMALE

A small drab species. Head with narrow golden/bronze scales above, darker to sides; broad flat pale scales laterally; upright forked scales numerous, pale. Palp all dark; about 0.13x length of proboscis. Proboscis long, all dark; about 1.18x length of forefemur. Scutal integument red/brown; clothed with fine narrow bronze scales, with paler scales on anterior margin and laterally, yellowish scales around prescutellar area. Scutellum clothed with narrow yellowish scales on all three lobes. Pleural integument light brown; appressed broad translucent scales on upper and lower sternopleuron; 1 lower mesepimeral bristle present. Abdomen with tergites dark scaled with basal white bands, slightly broader laterally; sternites pale fawn. All coxae with patches of appressed translucent scales. Hindfemur dark with pale streak on basal 0.67 ventrally; tibia and tarsi all dark. Wing dark scaled. Haltere with pale stem, club dark.

LARVA

(Not seen) N.V. Dobrotworsky [in: *Proc. Linn Soc. N.S.W., 82* (1957): 317-321; and 'Mosquitoes of Victoria' (1965. Melb. Uni. Press)] illustrates, but does not describe the larva of *Cx cylindricus* as he indicates that it is indistinguishable from that of *Cx orbostiensis*, except that *Cx cylindricus* has a dark band across the middle of the siphon. The figure is redrawn after Dobrotworsky (1965).

BIOLOGY

Cx cylindricus breeds in fresh water pools, open or shaded, in creeks and swamps with emergent or overhanging vegetation. The adult has been recorded biting man and cattle, and blood meal identification indicates that the species will also feed on reptiles.

RELATION TO DISEASE

None known.

DISTRIBUTION

Doorawarrah, May 1985, MEC. Kalumburu, Jul 1978, AEW. Mooka, May 1985, MEC.

Culex (Lophoceraomyia) fraudatrix (Theobald) 1905

Theobald, F.V., 1905. *Ann. Hist.-Nat. Mus. Hung., 3:* 94.
Type locality: Freidrich-Wilhelmshafen, New Guinea.
Synonymy: *Culex molestus* Weidemann, C.R.G., 1828. *Aussereuropaische zweiflugelige insecten., 1:* 542.
Culex cairnsensis Taylor, F.H., 1919. *Proc. Linn. Soc. N.S.W., 43:* 837.

In Australia, *Cx fraudatrix* is known to occur in north Queensland. The records from the N.T. and W.A. are at best tentative, and most likely refer to other species. The W.A. collections all date from the fifties, and all were collections of either Eric Britten or Ernest Hodgkin. These collections were of larval material, and no specimens are available for confirmation. The identification of these specimens is considered unreliable, and it is not considered that *Cx fraudatrix* occurs in W.A.

DISTRIBUTION

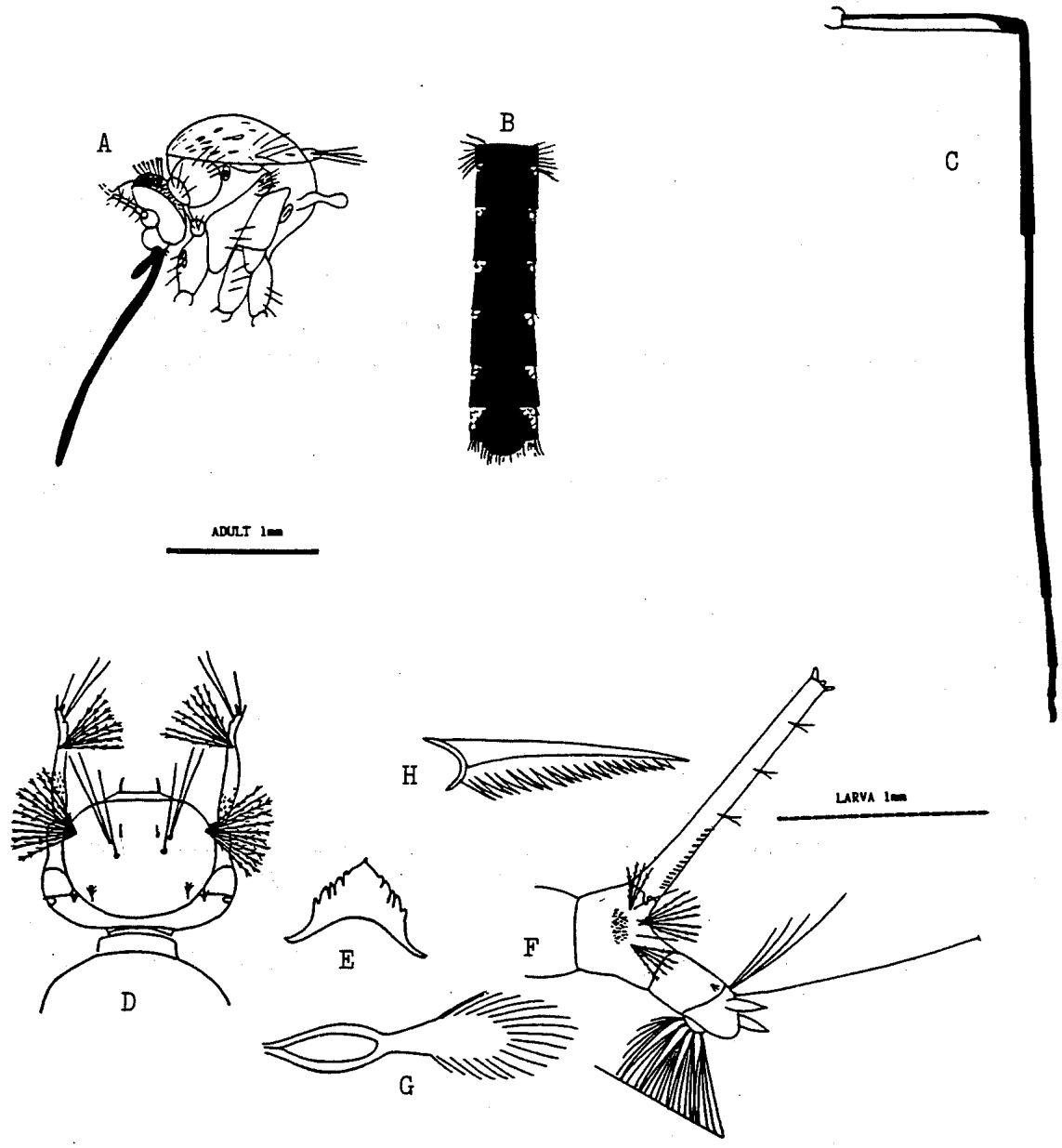
Kalumburu, Mar 1953, EPH/EJB; Mar 1954, EPH. Millstream, Jun 1953, EPH/EJB; Mar 1954, EPH; Jun 1954, EPH. Millstream, Dawsons Springs, Jun 1954, EPH. Millstream/Roebourne, Jun 1954, EPH. Northampton. Upper Chapman.

Culex (Lophoceraomyia) hilli Edwards 1922

Edwards, F.W., 1922. *Bull. Ent. Res., 13:* 95.
Type locality: 70 miles south of Darwin, Northern Territory.
Synonymy: *Culex australis* Taylor, F.H., 1915. *Proc. Linn. Soc. N.S.W., 40:* 178.

ADULT FEMALE

A small slender dark mosquito. Head clothed in broad dark scales on vertex; broad white scales on sides; upright forked scales very sparse or absent. Palp black scaled; about 0.16x length of proboscis. Proboscis long slender and black scaled; about 1.13x length of forefemur. Scutal integument dark brown to black; clothed in narrow black scales. Scutellum with narrow black scales on all three lobes. Pleural integument dark, bare of scales. Abdomen with tergites black scaled with lateral basal white triangular patches, small and inconspicuous on segments II-III, more obvious and larger on segments IV- VII; sternites with pale yellowish scales. All femora black with ventral pale streak reaching to 0.75 from base; tibiae and tarsi all dark. Wings dark scaled. Haltere with pale stem basally and darker towards club, club dark.



Culex (Lophoceraomyia) hilli

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

LARVA

Antenna uniformly brown, spiculate; about 0.82x length of head; seta 1-A multibranched, inserted about 0.7 from base. Head about 0.7x as long as broad; brown in colour; seta 4-C small, single; 5-C single; 6-C bifid; 7-C with 12 branches; 8-C with 4-5 branches; 9-C with 4 branches. Abdominal segment with lateral comb with 35-50 fringed scales in triangular patch; seta 1-VIII with 4 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 7-8 pectinate branches; 5-VIII with 5 pectinate branches. Siphon index about 7.1; siphon about 3.67x length of saddle; with dark band on 0.5-0.6 from base; acus present; seta 1-S with 3 bifid tufts; pecten with 11-13 strongly fringed teeth on basal 0.33 of siphon. Saddle brown, complete; seta 1-X small, with 4 branches; 2-X with 4-5 branches; 3-X single; 4-X with 5 pairs of setae on grid; precratal tufts absent. Anal papillae long and pointed; about 0.67x length of saddle.

BIOLOGY

Larvae collected in shallow, swampy water bodies with *Melaleuca* and *Pandanus* upper storey, and dense aquatic vegetation and organic debris. Adults may be taken in CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Ord River, 1981, AEW.

Culex (Lophoceraomyia) ENM's sp. No.154

ADULT FEMALE

Cx ENM's sp. No.154 is very similar to *Cx cylindricus*. *Cx* sp. No.154 has basal lateral pale patches on tergites. The scutum has creamy/golden scales anteriorly and on fossa; with a variable amount of bronze scaling elsewhere.

LARVA

Unknown.

BIOLOGY

No data.

RELATION TO DISEASE

None known.

DISTRIBUTION

Millstream, Apr 1971, DHC; Nov 1979, ENM.

Culex (Lophoceraomyia) ENM's sp. No.167

ADULT FEMALE

Scutal scaling bronze to black. Tergites with large lateral basal patches on segments II-VII; may almost meet in midline on segments VI-VII, also sometimes on III-V. Thoracic integument lightish brown.

LARVA

Head medium brown. Antenna darker beyond insert of seta 1-A. Seta 5-C and 6- C bifid. Siphon with dark band. Saddle not darker than siphon.

BIOLOGY

No data.

RELATION TO DISEASE

None known.

DISTRIBUTION

Kununurra, Jul 1978, PFSL/AEW. Ord River, PFSL. Turkey Creek, Jul 1978, PFSL/AEW.

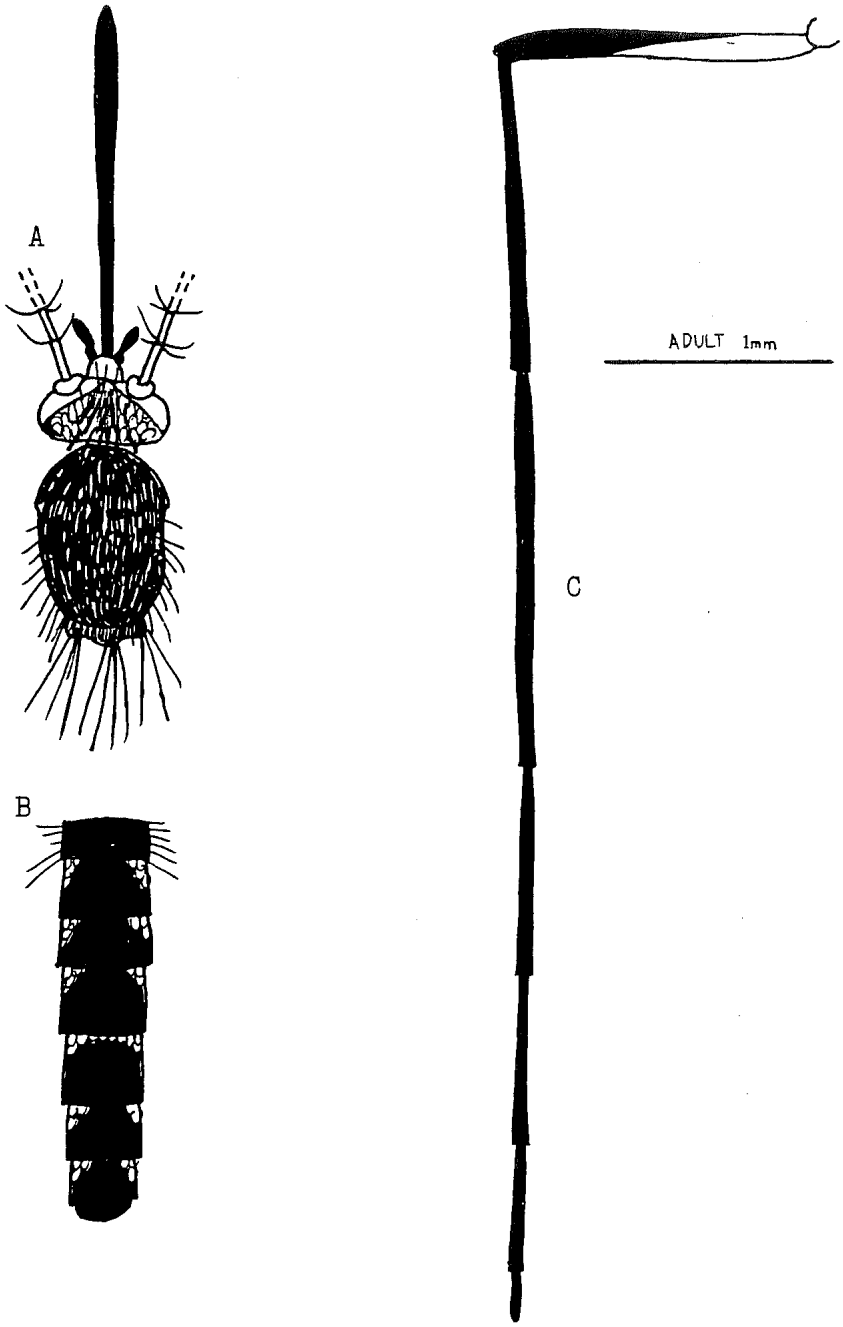
Subgenus : *Lutzia*

SUBGENERIC CHARACTERS

Adult: Large species. Decumbent scales on head narrow in vertex. No eye border of broad scales. Antenna longer than proboscis. Scutellum with narrow scales on all lobes. At least 6 lower mesepimeral bristles.

Larva: Predacious species. Head rather elongate; mouthbrushes thickened, curved, strongly pectinate apically, reduced to about 40 brushes. Antenna short, simple; without spicules. Seta 1-3P of prothorax on distinct tubercle. Siphon shorter than saddle. Anal papillae shorter than saddle.

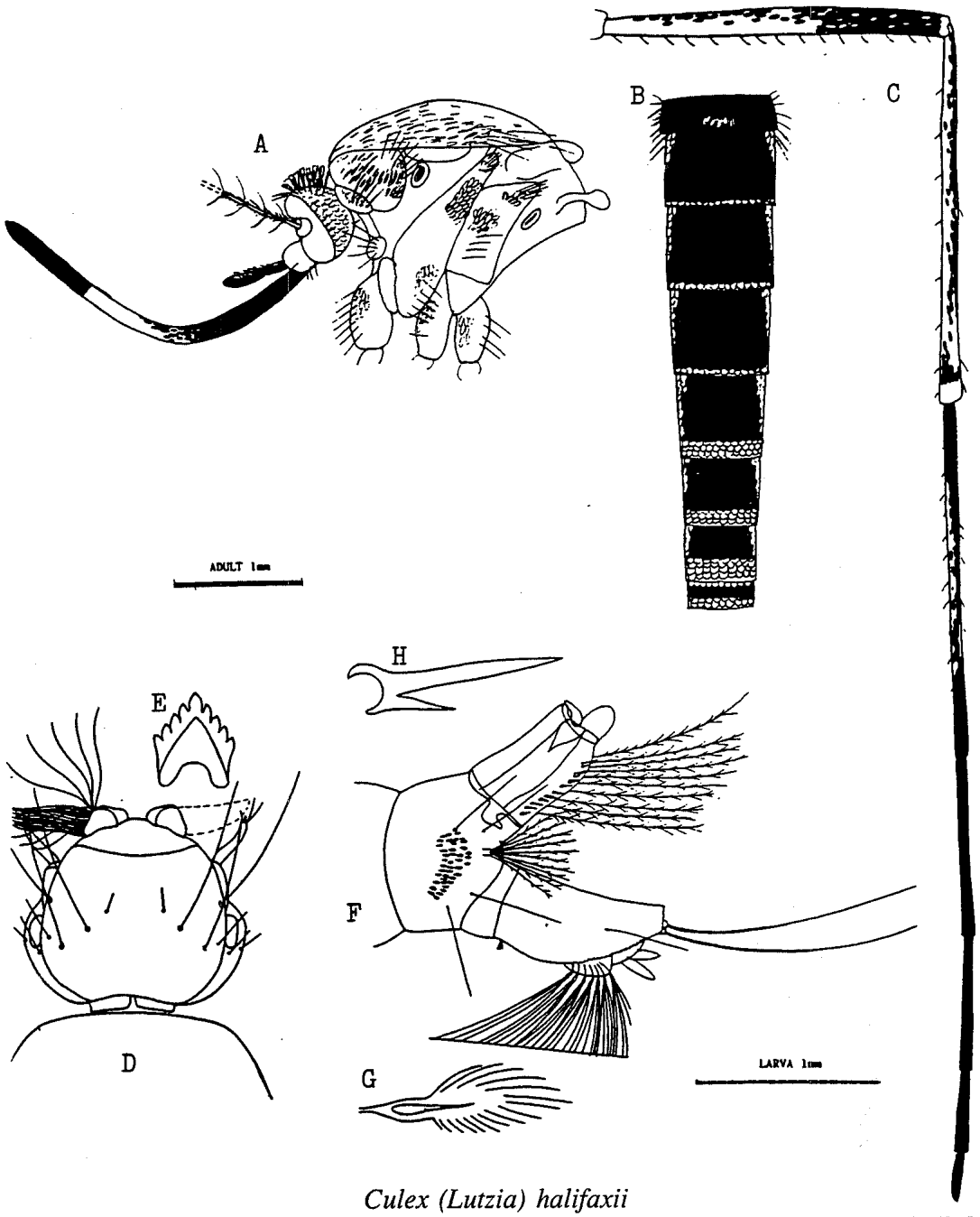
KEYS: ADULT FEMALES: see key to subgenera of Culex (page 213).
LARVAE: see key to subgenera of Culex (page 214).



Culex (Lophoceraomyia) ENM's sp. No.167
A: Adult head and thorax (dorsal); B: Abdomen (dorsal); C: Hindleg.

Culex (Lutzia) halifaxii Theobald 1903

Theobald, F.V., 1903. *Mon. Cul., 3:* 231.
Type locality: Dindings, Malaya.
Synonymy: *Culex multimaculosus* Leicester, G.F., 1908. *Stud. Inst. Med. Res. F.M.S., 3:* 155.
Culex aureopunctis Ludlow, C.S., 1910. *Canad. Ent., 42:* 195.
Culex vorax Edwards, F.W., 1921. *Bull. Ent. Res., 12:* 327.
Culex raptor Edwards, F.W., 1922. *Indian J. Med. Res., 10:* 275.



Culex (Lutzia) halifaxii

A: Adult head and thorax (lateral); B: Abdomen (dorsal); C: Hindleg; D: Larval head (dorsal); E: Mentum; F: Abdominal segment VIII (lateral); G: Lateral comb scale (detail); H: Pecten teeth (detail).

ADULT FEMALE

A very large robust species with white band on proboscis. Head with narrow decumbent scales on vertex; broad flat scales laterally; upright forked scales pale and dark, numerous. Torus with small patch of appressed pale scales mesially; segment I of antenna with pale scales in basal band. Clypeus bare. Palp dark scaled with some pale scales on dorsal surface; about 0.18x length of proboscis. Proboscis dark scaled, pale below on middle 0.33, slightly paler above at about 0.67 from base; about 1.14x length of forefemur. Scutal integument brown; clothed with narrow bronze scales, with paler areas on anterior edges, above wing root and around prescutellar space. Scutellum with narrow pale scales on all three lobes. Pleural integument brown; appressed broad white scales on anterior pronotum and posterior edge of posterior pronotum; posterior pronotum with appressed brown/bronze to white scales on anterior 0.75; appressed white scales on propleuron, upper and lower sternopleuron, anterior and upper mesepimeron; a few scattered white scales on posterior and lower mesepimeron; 5 lower mesepimeral bristles present. Abdomen with tergites dark

brown with lateral basal white triangular patches, apical yellowish band (narrow on II-VI), VII with apical half of pale yellowish scales; sternites pale scales with dark apicolateral patches on II- VI; VII with apical dark band; VIII dark. All coxae with patches of appressed pale scales. Forefemora, midfemora and tibiae dark scaled with row of anterior pale spots. Hindfemur pale ventrally on basal 0.5, mottled dorsally almost to apex; tibia dark with mottled pale streak ventrally on basal 0.8, dark at apex; hind tarsi I mottled, II-V dark. Wings dark scaled. Haltere with stem pale, club dark.

LARVA

(Not known from W.A. – the following description is based on N.T. specimens) Antenna same colour as head; about 0.28x length of head; seta 1-A small, single, outward projecting, inserted about 0.3 from base. Head 0.83x as long as wide; about 0.62x width of thorax; setae 4-C to 9-C of head single. Abdominal segment VIII with lateral comb with 35-40 scales with apical fringe in triangular patch; setae 1-VIII, 2-VIII, 4-VIII and 5-VIII single; 4-VIII with 10 pectinate branches. Siphon index about 1.9; siphon about 0.89x length of saddle; covered in small spicules; siphonal seta 1-S with about 10 3-branched pectinate tufts along the whole ventral surface; pecten with 10 teeth over whole length of siphon (some teeth may be twin spines). Saddle complete, elongate dorsally and covered in small tooth like spicules; setae 1- X to 3-X single; 4-X with 7 pairs of tufts on grid; with one precratal tuft. Anal papillae short, pointed.

BIOLOGY

The larvae are predatory. They are often collected in domestic container habitats, but are also found in fresh to brackish ground pools, shaded or open. The variety of breeding sites make them difficult to characterise simply. The adults bite man only rarely, if at all.

RELATION TO DISEASE

None known.

DISTRIBUTION

Derby, Aug 1984, MEC. Kununurra, Mar 1984, MEC.

Subgenus : *Neoculex*

SUBGENERIC CHARACTERS

Adult: Small to medium species. Tarsi always dark scaled. Lower mesepimeral bristles absent.

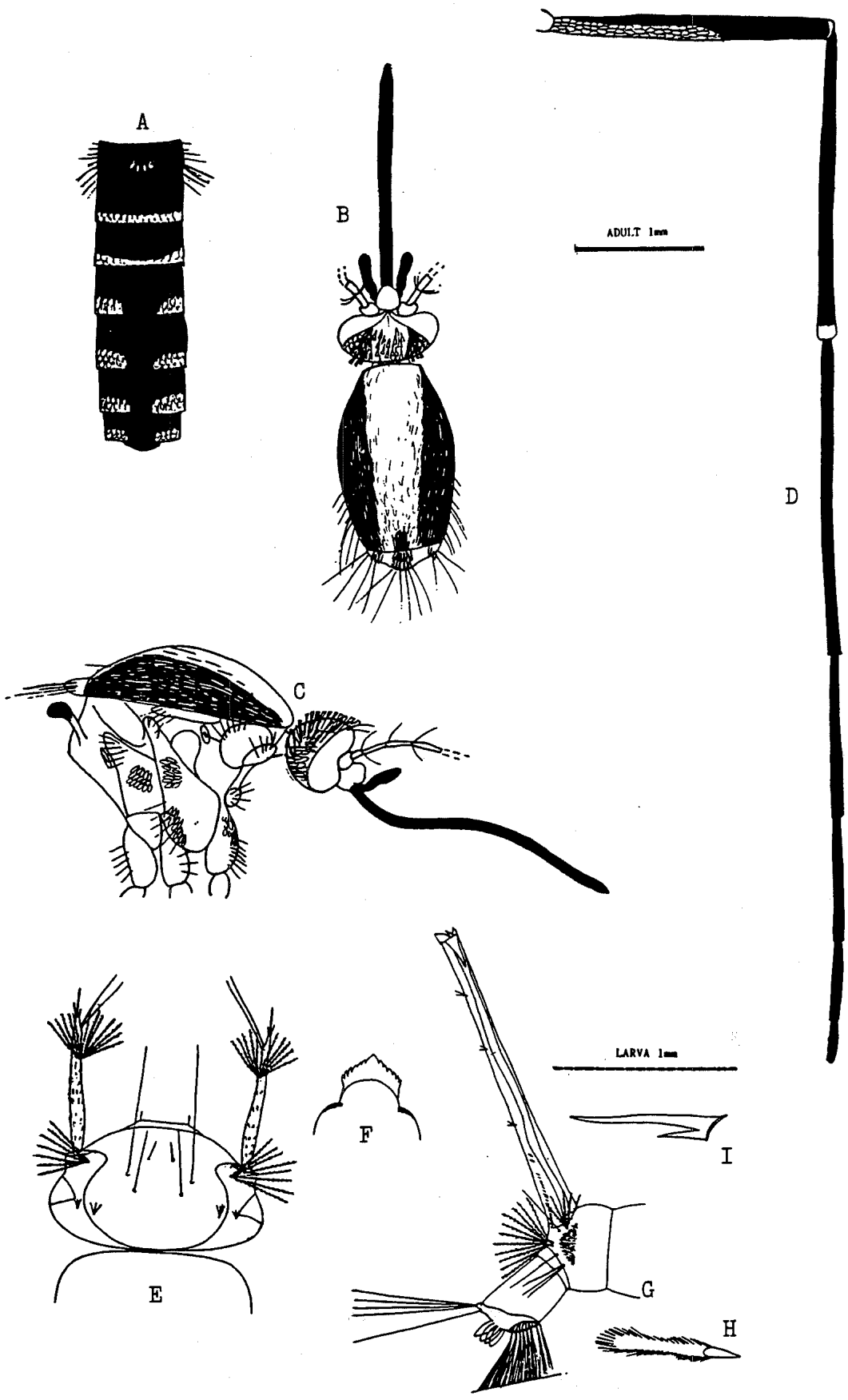
KEYS: ADULT FEMALES: see key to subgenera of Culex (page 213).
LARVAE: see key to subgenera of Culex (page 214).

Culex (Neoculex) latus Dobrotworsky 1956

Dobrotworsky, N.V., 1956. *Proc. Linn. Soc. N.S.W., 81:* 108.
Type locality: Kewdale, W.A.
Synonymy: None.

ADULT FEMALE

A medium sized species with a striking median golden band on thorax and head. Head with long narrow golden scales on vertex and occiput; darker laterally; upright forked scales numerous, similarly coloured to decumbent scales. Torus integument orange brown, bare. Clypeus bare. Palp black; about 0.16x length of proboscis. Proboscis black, slightly longer than forefemur. Scutal integument red/brown; with broad median band of narrow golden scales (continuous with yellow scales on head and scutellum). Scutellum with narrow golden scales on midlobe, a few on lateral lobes. Pleural integument brown; narrow curved black scales on posterior pronotum; appressed broad white scales on posterior and upper sternopleuron and upper mesepimeron. Abdomen with tergites black scaled with apical white bands, broken in midline on segments II-VII; tergite I with median apical white patch; sternites dark scaled with apical white patches. Forecoxa with patch of dark scales, midcoxa and hindcoxa with patches of pale scales. Hindfemora with pale ventral streak on basal 0.8; tibiae and tarsi all dark. Wings dark scaled. Haltere with pale stem and dark club.



Culex (Neoculex) latus

A: Adult abdomen (dorsal); B: Adult head and thorax (dorsal); C: Adult head and thorax (lateral); D: Hindleg; E: Larval head (dorsal); F: Mentum; G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Pecten teeth (detail).

LARVA

Antenna strongly spiculate, dark at base and apex, pale in middle; about 0.96x length of head; seta 1-A multibranched, pectinate, inserted about 0.67 from base. Head 0.62x as long as broad; setae 4-C to 6-C single; 7-C with 7-8 pectinate branches. Abdominal segment VIII spiculate; lateral comb with 70+ fringed scales in irregular triangular patch; seta 1-VIII with 6-7 pectinate branches; 2-VIII and 4-VIII single; 3-VIII with 11 pectinate branches; 5-VIII with 3 branches. Siphon index about 10; siphon about 4.68x length of saddle; acus present; siphonal seta 1-S with 3 tufts, each with 1-2 branches, short and inconspicuous; pecten with about 18 teeth on basal 0.3 of siphon, with strong denticles on basal teeth. Saddle covered with spicules, slightly cut away above grid; seta 1-X small, single; 2-X with 4 branches; 3-X single, long; 4-X with 6 pairs of tufts on grid; 2 precratal tufts present. Anal papillae pointed; about 0.3x length of saddle.

BIOLOGY

Cx latus is confined to the wetter parts of the south west. Larvae have been found in *Melaleuca* swamps with discoloured water. Adults do not bite man, and little is known of the biology of this species.

RELATION TO DISEASE

None known or suspected.

DISTRIBUTION

Albany, Aug 1956, EJB. Ashburton, Jun 1955, EJB. Augusta, Oct 1974, PFSL. Dardanup, Nov 1952, DLM. Denmark, Aug 1956, EJB. Donnybrook, Jan 1953, JHC. Donnybrook, 16km NE, Jan 1953, JHC. Drakesbrook, DLM; Sep 1952, FNR; Mar 1955, EJB. Fremantle, Jun 1955, EJB. Harvey, Apr 1955, EJB. Kewdale, Nov 1952, DLM; Oct 1953, FNR. Manjimup, May 1956, EJB. Murray, May 1956, EJB. Peel Estate, Nov 1942, DLM. Rockingham, Jun 1955, EJB. Serpentine/Jarrahdale, Jun 1955, EJB.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

CHAPTER 21: genus *CULISETA*

Only one species, *Culiseta atra*, is known from W.A., and is restricted to the wet south west portion of the State.

GENERIC CHARACTERS

Adult: Head clothed in narrow curved decumbent scales, with upright forked scales on vertex. Proboscis is moderately long and female palps short. At least a few fine spiracular bristles always present. Postspiracular area usually bare. Lower mesepimeral bristles present. Female claws simple and pulvilli absent. Ventral surface of basal region of subcosta of wing with patch of setae (subcostal bristles). Female abdomen bluntly rounded.

Larva: Siphon generally long with 1-S being a single pair of setae inserted at the base of the siphon.

KEYS: ADULT FEMALES: see key to the genera (page 93).
LARVAE: see key to the genera (page 94).

DESCRIPTIONS OF SPECIES

Culiseta (Culicella) atra Lee 1944

Lee, D., 1944. *Proc. Linn. Soc. N.S.W., 69:* 215.
Type locality: Perth, W.A.
Synonymy: none.

ADULT FEMALE

A small to medium slender dark species. Head clothed in very fine narrow curved golden to clear scales on vertex; appressed flat white scales laterally; strong black upright forked scales on occiput. Palps thin, black scaled; about 0.18x length of proboscis. Proboscis long, slender, black scaled; about 1.17x length of forefemur. Scutal integument red/brown and clothed in fine black and bronze scales; strong rows of bristles present. Scutellum with strong bristles and fine pale and bronze scales on all lobes. Pleura with yellow/brown integument; patches of narrow bronze scales on anterior pronotum and posterior pronotum; 1 strong lower mesepimeral bristle; 2-3 fine spiracular bristles. Abdomen with tergites uniformly black scaled with bluish reflections; sternites pale. Hindfemur pale below on basal 0.6, otherwise black; hindtibia and tarsi all black, with bluish reflections. Wing dark scaled; subcostal bristles present. Haltere with pale stem, club dark.

LARVA

Antenna about 0.8x length of head, slightly darker towards apex; seta 1-A is multibranched, plumose, inserted about 0.7 from the base of the antenna; antenna distinctly narrower apically of insert 1-A. Head about 0.7x as long as wide; about same width as thorax; seta 4-C single; 5-C with 5 branches; 6-C bifid; 7-C with 5-6 branches; 8-C bifid; and 9-C single. Pleural groups of setae as follows: 1-P, 2-P, 5-P, and 6-P are all single; 3-P and 4-P are bifid; and 7-P with 3 branches. Abdominal segment VIII with lateral comb forming a triangular patch of over 50 fringed scales; setae 2-VIII and 4-VIII single; 1-VIII with 6-9 branches; 3-VIII with 6-7 branches; and 5-VIII with 5- 6 branches. Siphon long and thin; siphon index is about 5.0; siphon about 3.8x length saddle; seta 1-S single, inserted at base of siphon; pecten consisting of 12-15 denticulate spines extending to 0.45 from base of siphon. Saddle forms a complete ring, cut away posteriorly below; seta 1-X single; 2-X with 7-10 branches; 3-X with 3 large and 2 small branches; 4-X with 7 pairs of multibranched setae on grid; 2 precratal tufts. Anal papillae short, pointed; about 0.3x length of saddle.

BIOLOGY

Cs atra is generally restricted to south of the 60mm isohyet. The species breeds in still fresh water sites which have decaying leaves on the substrate, and are discoloured by tannins. Other species in the genus lay their eggs in small rafts on the water surface and it is expected that *Cs atra* will have a similar habit.

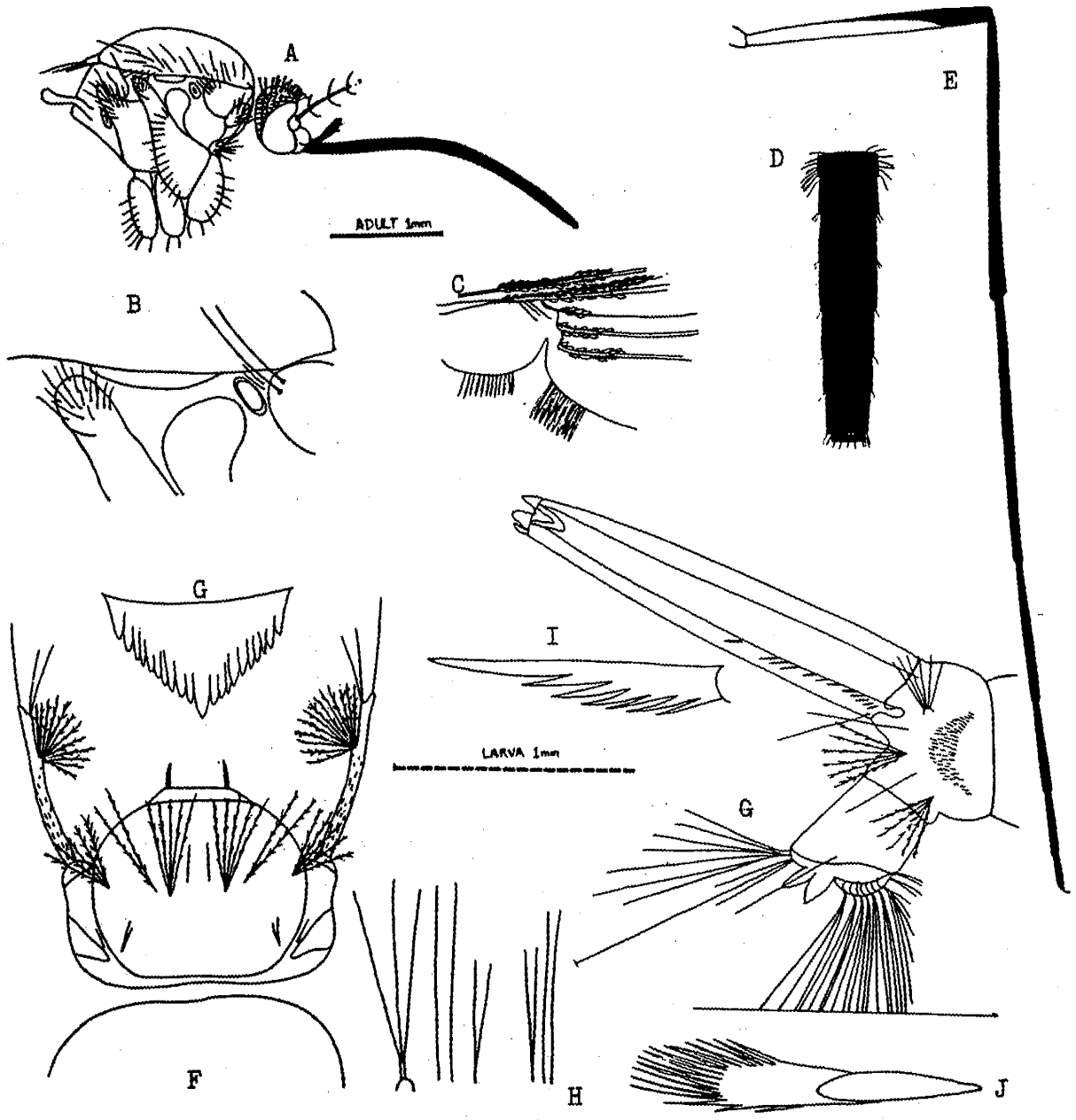
Little is known of the biology of the adults of this species. The adult female occasionally enters avian baited traps, and is sometimes collected in light and CO_2 baited traps.

RELATION TO DISEASE

None known.

DISTRIBUTION

Albany, Aug 1956, EJB; 1958, EJB. Augusta, Oct 1974, PFSL. Balingup, May 1956, EJB. Bridgetown, May 1956, EJB. Bullsbrook, Sep 1980, AEW; Oct 1980, PFSL. Bunbury, 1958, EJB; Nov 1985, Ed. Canning R., Apr-May 1975, RH; Mar 1979, PFSL. Canning R., Canning, Mar-Apr 1975, PFSL.



Culiseta (Culicella) atra

A: Adult head and thorax (lateral); B: Spriracular and prealar bristles (detail); C: Wing (detail of subcostal bristles); D: Abdomen (dorsal); E: Hindleg; F: Larval head (dorsal); G: Mentum; H: Prothoracic setae 1P-7P; I: Abdominal segment VIII (lateral); J: Lateral comb scale (detail); K: Pecten teeth (detail).

Canning R., Clontarf, May 1963, JBF; Oct 1973, PFSL. Darkan, 1958, EJB. Denmark, Aug 1956, EJB; 1958, EJB. Donnybrook, 16km NE, Jan 1953, JHC. Forrest National Park, May 1973, SJM. Jandakot, Oct 1974, PFSL. Joondalup, Jan-Mar 1978, AB. Katanning, 1958, EJB. Lake Chandala, Aug-Sep 1980, AEW; Oct 1980, PFSL. Lake Goollelal, Jan-Mar 1978, AB; Jan 1982, PFSL. Manjimup, May 1956, EJB. Midland, 1958, EJB. Muchea, 5km N, Sep 1980, AEW. Nannup, NVD. Nornalup, 1958, EJB. Perth, Nov 1943, PNF. Perth, Canning, Jul 1973, PFSL. Perth, Ferndale, Apr 1975, PFSL. Perth, Maylands, Oct 1974, PFSL. Porongorup, 1958, EJB. Serpentine/Jarrahdale, May 1956, EJB. Stirling Range, 1965, NVD. Swan, Aug 1956, EJB. Swan R., Bassendean, Mar 1975, PFSL. Tambellup, Aug 1956, EJB; 1958, EJB. Toodyay, 1958, EJB. Upper Blackwood, May 1956, EJB. Walpole, Wrest Point, Oct 1975. Wanneroo, Jun 1955, EJB. Yanchep, 1958, EJB

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

CHAPTER 22: genus *MANSONIA*

Only one species, *Mansonia uniformis*, is found in W.A. This species is restricted to the northern parts of the State. The genus *Mansonia* is closely related to *Coquillettidia* (see comments in Chapter 19).

GENERIC CHARACTERS

Adult: Proboscis never swollen at tip. Palps in female not more than 0.25x length of proboscis. Vertex with numerous upright forked scales and clothed in narrow decumbent scales. Postspiracular bristles present. Lower mesepimeral bristles present. All claws in female simple; pulvilli absent. Wing scales generally broad.

Larva: Antennae long, with 1-A being large and branched, arising less than 0.5x from base; 2-A and 3-A inserted well before tip, around midpoint. Mentum generally small. Thorax contains large paired tracheal dilatations. Lateral comb teeth form single row of a few simple spines. Siphon is short; seta 1-S single pair of setae; pecten absent; valves modified for piercing plant stems. Saddle is complete ring; precratal tufts present.

KEYS: ADULT FEMALES: see key to the genera (page 93).
LARVAE: see key to the genera (page 94).

DESCRIPTIONS OF SPECIES

Mansonia (Mansonoides) uniformis (Theobald) 1901

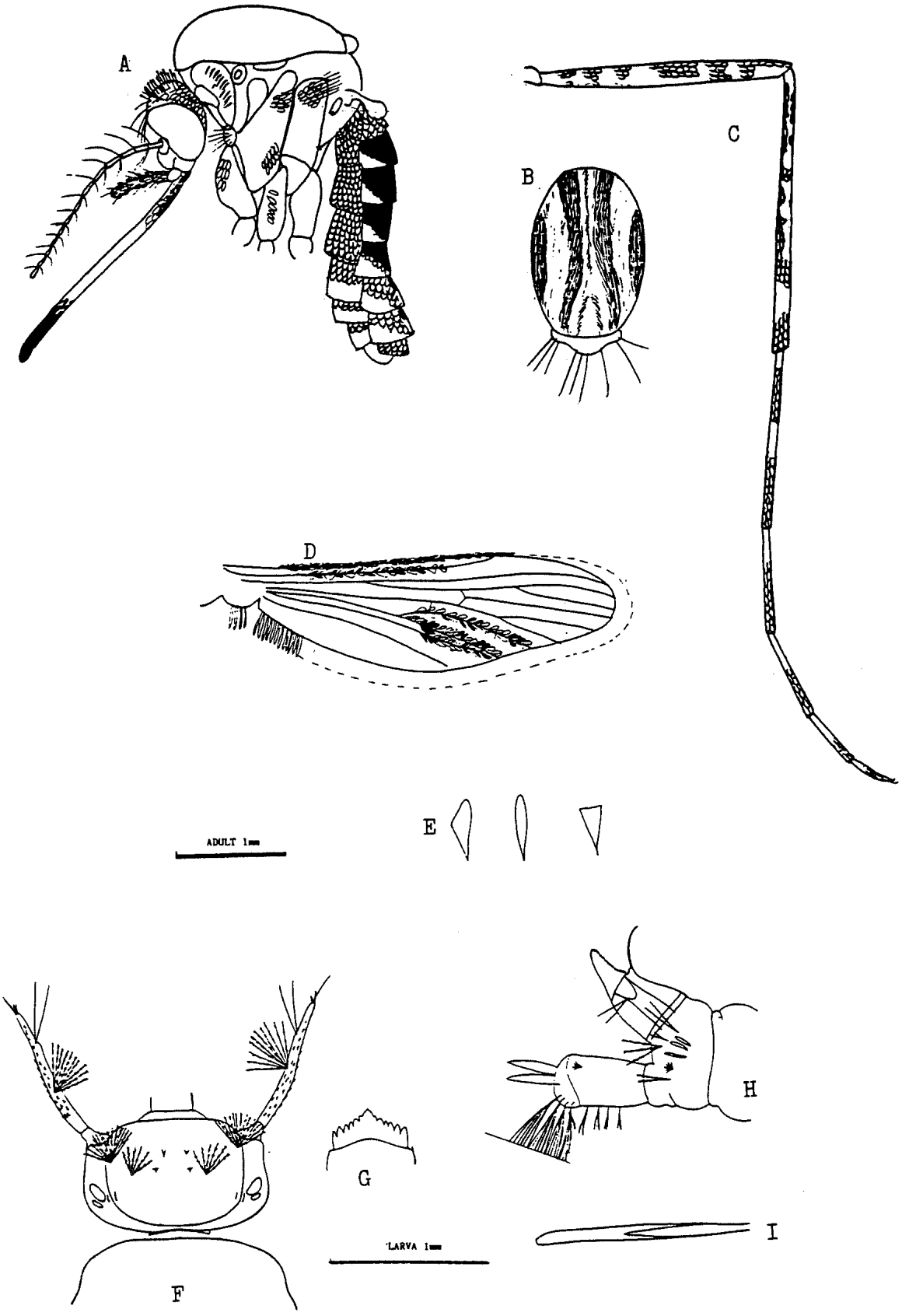
Theobald, F.V., 1901. *Mon. Cul., 2:*180 (as *Panoplites uniformis).*
Type locality: Quilon, Travancore, India.
Synonymy: *Mansonia reversus* Theobald, F.V., 1901. *Mon. Cul., 2:*189 (as *Panoplites).*
Mansonia australiensis Giles, G.M., 1902. *A handbook of gnats or mosquitoes.....:* 2nd Ed. p355.
Mansonia marquesensis Dyar, H.G.,1925. *Insec. Inscit. menst., 13:*43.

ADULT FEMALE

A medium sized species with a characteristically mottled appearance; and an upturned, blunt ended abdomen. Head clothed in narrow, curved white scales on vertex; appressed broad flat white scales laterally; upright forked scales numerous, brown. Palp mottled with white tip, clothed in broad blunt ended scales; about 0.3x length of proboscis. Proboscis is 0.85x length of forefemur; dark at tip, with broad creamy/brown band on middle 0.4. Scutal integument brown with a pattern of longitudinal lines formed by rows of bronze and greenish/white narrow scales. Scutellum with greenish/white narrow scales on midlobe, bronze scales on lateral lobes. Pleural integument brown; sparse narrow white scales on posterior pronotum, anterior pronotum, propleuron; patches of appressed broad white scales on lower and upper sternopleuron, and anterior mesepimeron; 6 post spiracular bristles. Abdomen broadly blunt ended; tergites dark scaled with subapical, lateral creamy patches and subapicolateral white triangular patches; sternites creamy scaled with white apically, and with a diffuse lateral subapical dark patch. Appressed white scales on all coxae. Femora and tibiae of all three legs with pale bands and spots along whole length; hindtarsus I with broad white basal and median bands, hindtarsus II to V with broad white basal band only. Wings mottled with broad, blunt ended, asymmetrical scales. Haltere with pale stem and dark club.

LARVA

Antenna concolourous, 1.15x length of head; 1-A with 9-10 branches, inserted about 0.4 from base. Head about 0.6x as broad as long; 0.8x width of thorax; seta 4-C small, bifid; 5-C small, with 3 branches; 6-C with 6-8 branches; 7-C with 9 plumose branches. Abdominal segment VIII with lateral comb of 2-3 simple spines in a row; setae 1-VIII, 4-VIII and 5-VIII all bifid; 2-VIII single; 3-VIII with three branches. Siphon shorter than saddle, index about 0.6; seta 1-S single pair of bifid setae inserted at about midpoint of siphon; pecten absent. Valves modified into saw tooth for piercing plant stems. Saddle forms complete ring, long and narrow in shape; seta 1-X with 5 small branches; 2-X with about 10 branches; 3-X with about 8 branches; 4-X with about 5 pairs of tufts on grid; 4 precratal tufts present. Anal papillae short, pointed; about 0.5x length of saddle.



Mansonia (Mansonoides) uniformis

A: Adult head and thorax (lateral); B: Thorax (dorsal); C: Hindleg; D: Wing (detail of scaling on some veins shown); E: Wing scales (detail); F: Larval head (dorsal); G: Mentum; H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail).

BIOLOGY

Breeds in permanent and semi-permanent, fresh to brackish water holes. Eggs laid in a cluster under the surface of aquatic plants. Water hyacinth, cumbungi *(Typha* species) and reeds *(Eleocharis* species) are favoured breeding sites. Larva and pupa attach to plants where they are not easily dislodged, and are very difficult to find.

Adults bite man readily, mainly at night, but also during the day (in shaded situations). They also bite other animals and birds. Females are attracted to light and are readily captured in most traps (light, CO_2 baited, animal or bird baited traps). The adults generally do not disperse far from the breeding site. This species can be a significant pest near to the breeding site, particularly in the mid to late dry season (July to November).

RELATION TO DISEASE

Not implicated as a disease vector in Australia, but is a vector of filariasis *(Wuchereria bancrofti)* elsewhere in its range. Laboratory data indicate that it is susceptible to infection with both RRv and Kunjin virus. Edge Hill virus has been isolated from this species in Queensland; and RRv has been isolated from the *Ma uniformis* in the Murray Valley. Japanes Encephalitis has been isolated from this species in Malaya.

DISTRIBUTION

Carnarvon, Feb 1984, MEC.* Drysdale R., Aug 1979, AEW. Kalumburu, Jul 1978, PFSL/AEW. Kununurra, Nov-Dec 1973, PFSL; Nov-Dec 1974, PFSL; Apr 1975, PFSL; Oct-Nov 1975, PFSL; Oct-Nov 1976, AEW; Apr 1977, AEW; Nov-Dec 1977, AEW; Jun- Jul 1978, PFSL/AEW; Dec 1979, OA; Mar-Jun 1980, OA; Aug-Dec 1980, OA; Jan-May 1981, OA. Wyndham, Dec 1979, OA. (* not seen or varified by an experienced medical entomologist.)

SPECIES WITH WHICH IT MAY BE CONFUSED

Ma uniformis may be confused with *Ae alternans* by the novice. *Ae alternans* has a pointed abdomen, and is usually much larger.

CHAPTER 23: genus *TRIPTEROIDES*

Three species of *Tripteroides* are recorded from W.A. One, *Tp magnesianus* is a relatively rare species in the Kimberleys, which is at the western extremity of its tropical range. The other two are closely related and are more common. *Tp atripes* has a wide distribution throughout the State and has a wide overlap with *Tp punctolateralis* in the northern half of the State.

GENERIC CHARACTERS

Adult: Vertex clothed with broad flat scales; upright forked scales are few in number and confined to occiput. Scutal scaling variable. Scutellum with broad flat scales. Spiracular bristles present; lower mesepimeral bristles absent. Pleura covered with broad flat appressed scales. Legs slender, hindtarsus I usually longer than tibia. Claws of female equal, simple; pulvilli absent. Abdomen blunt ended, segment VIII of female usually broad and bristly.

Larva: Head small; antennae short with seta 1-A small, inserted beyond midpoint of antenna. Thorax and abdomen generally clothed in stout stellate setae. Thoracic spines present and generally well developed. Lateral comb always a single row of teeth; seta 1-VIII always more strongly developed than other pentad hairs. Pecten absent, but siphon covered in numerous setae, some of which may form a 'false' pecten. The ventral brush (seta 4-X) always a single pair of setae.

KEY TO ADULT FEMALES OF TRIPTEROIDES IN WESTERN AUSTRALIA

1. –	Ornate species with azure blue band on vertex of head; silver scales on pleura and abdomen	TRIPTEROIDES *Tp (Trp) magnesianus*
–	Drab species with white or creamy ornamentation	[POLYLEPIDOMYIA] 2
2. –	Dorsal head scaling very dark or black; no pale scales at base proboscis or palps; scutal scaling bronze	*Tp (Pdp) atripes*
–	Dorsal head scaling light fawn; pale scaling at base palps and proboscis	*Tp (Pdp) punctolateralis*

KEY TO 4TH INSTAR LARVAE OF TRIPTEROIDES IN WESTERN AUSTRALIA

1. –	Meso and meta thoracic spines well developed	2
–	Meta thoracic spines only	*Tp (Trp) magnesianus*
2. –	Head setae 6-C with 3 branches; 7-C bifid	*Tp (Pdp) punctolateralis*
–	Head setae 6-C with 6 branches; 7-C with 4 branches	*Tp (Pdp) atripes*

DESCRIPTIONS OF SPECIES

Subgenus : *Polylepidomyia*

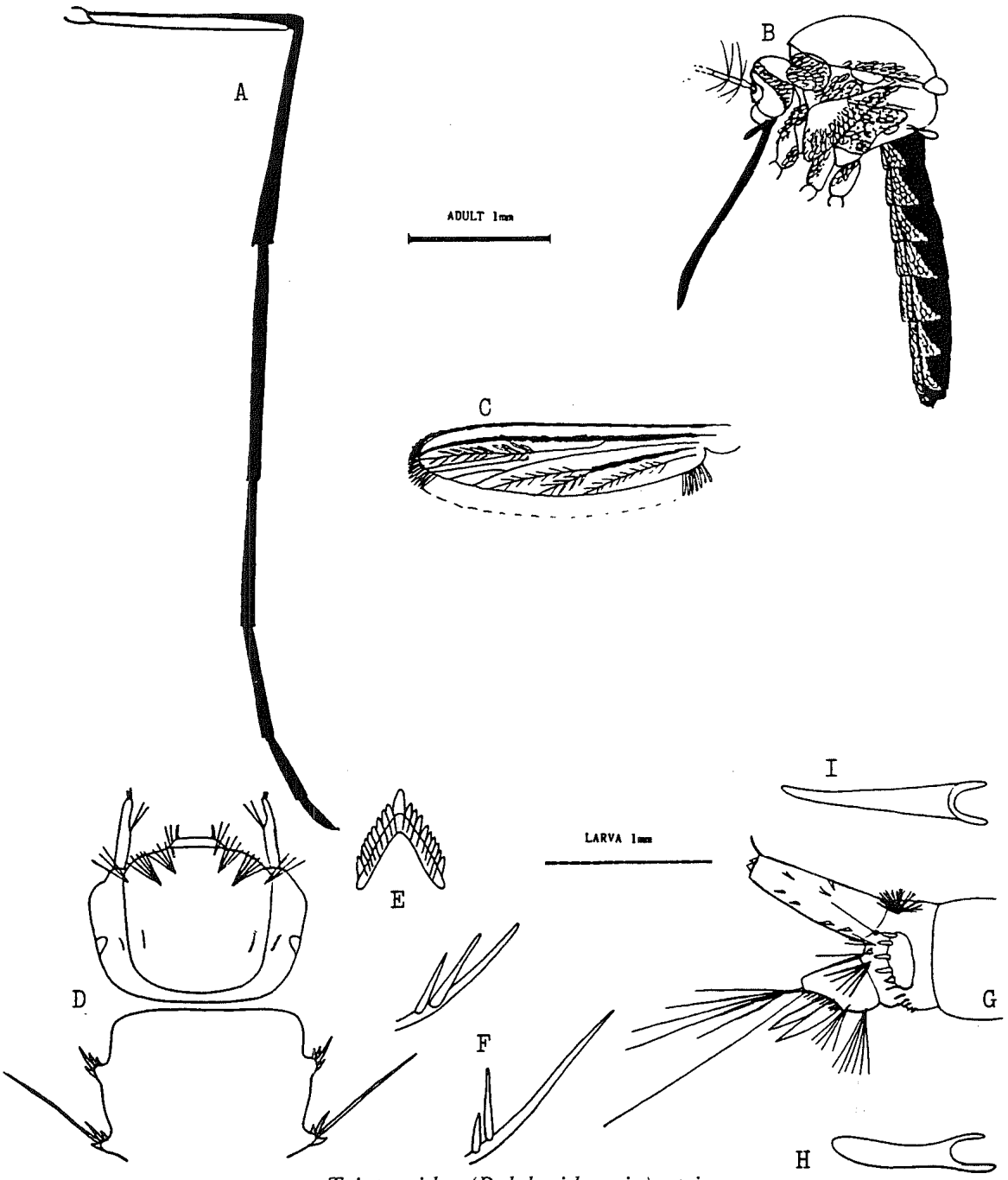
SUBGENERIC CHARACTERS

Adult: Without silvery ornamentation on thorax and legs, and no azure blue scales on eye border. Drab species. Usually with one posterior pronotal bristle. Plume scales of wing narrow, fairly dense.

Larva: Subgeneric characters not evident. Maxillae without strong apical horns. Dorsolateral plate of mesothorax with or without spine. Comb teeth in single row.

Tripteroides (Polylepidomyia) atripes (Skuse) 1889

Skuse, F., 1889. *Proc. Linn. Soc. N.S.W., 3*:1750.
Type locality: Several locations in New South Wales.
Synonymy: *Tripteroides apicotriangulata* Theobald, F.G., 1910. *Mon. Cul., 5*:211.



Tripteroides (Polylepidomyia) atripes

A: Hind leg; B: Adult head, thorax and abdomen (lateral); C: Wing (detail of scaling on some veins shown); D: Larval head (dorsal); E: Mentum; F: Mesothoracic and metathoracic spines (detail); G: Abdominal segment VIII (lateral); H: Lateral comb scale (detail); I: Siphonal setae (false pecten) (detail).

ADULT FEMALE

A very small, drab species, recognised by the broad appressed scaling on the sides of the thorax. Head clothed in dark appressed scales above, with narrow white eye border extending into broad lateral white patches. Torus and clypeus bare. Palps very short and dark, about 0.08x length of proboscis. Proboscis black, approximately same length as forefemur. Scutal integument dark brown; clothed in densely appressed narrow fawn to brown scales; some pale scales form a small band laterally above the wing root and around the prescutellar space. Scutellum with broad dark scales on all lobes. All pleural segments densely clothed in appressed broad white scales except for the anterior sternopleuron. Abdomen with tergites dark brown/black with apicolateral white triangular patches; sternites all white. All coxae with patches of appressed broad white scales. All legs dark scaled except femora which are pale ventrally on basal 0.5-0.8. Wing dark scaled. Haltere all brown.

LARVA

Antenna darker than head; about 0.43x length of head; seta 1-A stout, bifid, inwardly projecting; inserted about 0.63 from base. Eye spots are small. Head about 0.8x as long as broad; seta 4-C bifid; 5-C with 6-7 branches; 6-C with 6 branches; 7-C with 3 branches. Stout stellate setae well developed on thorax and abdomen. Mesothoracic and metathoracic spines present. Abdominal segment VIII with lateral comb consisting of 5 thick blunt spines in a single row on a basal plate; row continued as 4-5 separate spines, becoming finer basally, and appearing to join mid ventrally; seta 1-VIII is strongly stellate; 2-VIII and 4-VIII single; 3-VIII with 3 branches; 5-VIII with 5 branches. Siphon index is about 2.8; siphon narrower at tip; seta 1-S with 3 branches subbasally; with row of 2 branched setae along whole length of siphon; subdorsal and dorsal setae on siphon at about midpoint; pecten absent but strong siphonal setae may form a false pecten of about 4 simple spines, extending beyond midpoint of siphon. Saddle cut away posterioventrally, but forms a complete ring; posterior edge of saddle with fringe of strong spines; seta 1-X with 4 branches; 2-X with 5 branches; 3-X single, long; 4-X a single pair of 5-6 branched setae; precratal tufts absent. Anal papillae long and pointed; about same length as saddle.

BIOLOGY

Larvae of *Tp atripes* can be found in tree holes, and in domestic container habitats such as rainwater tanks. The adults bite man, generally alighting on the tip of the nose. The species is very uncommon and is never found in great numbers.

RELATION TO DISEASE

None known.

DISTRIBUTION

Albany. Augusta/Margaret R. Bridgetown. Brookton. Broome, LEC. Collie. Corrigin. Denmark. Derby, LEC. Dryandra, Feb 1956, DLM. Fitzroy Crossing, May 1954, EPH. Goomalling. Harvey. Kalgoorlie. Kellerberrin. Kulin. Kunmunya, May 1944, Da. Lake Grace. Leonora. Manjimup. Melville Camp, Mar 1944. Mowanjum, Oct 1978, AEW. Mt Marshall. Narrogin. North Dandalup R., Jan 1984, PFSL. Northam. Ord River, Jun 1944, CFHJ. Toodyay. Upper Blackwood. Wanneroo. West Arthur. Wyalkatchem. Wyndham/Kimberley Research Station, Feb 1953, RL. Yanchep National Park, Nov 1985, ALD. York.

SPECIES WITH WHICH IT MAY BE CONFUSED

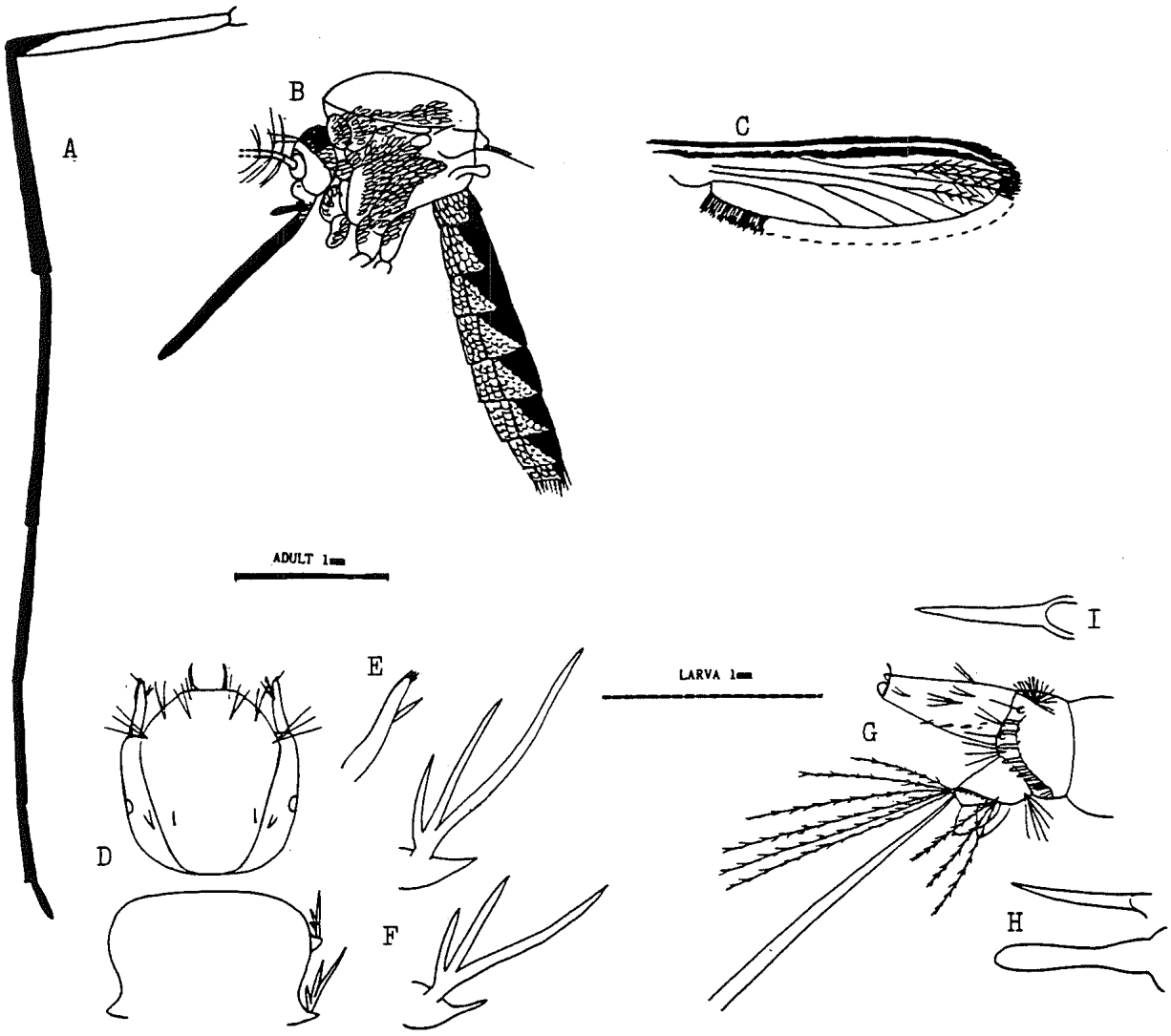
Tp atripes and *Tp punctolateralis* form a species pair and can be difficult to separate. *Tp atripes* is a southern species, and northern records are suspect, generally dating from a period when *Tp punctolateralis* and *Tp atripes* were considered to be the same species. To separate the old records would require careful re-examination of all specimens, and the reader should be wary of the northern records which probably refer to *Tp punctolateralis*.

Tripteroides (Polylepidomyia) punctolateralis (Theobald) 1903

Theobald, F.V., 1903. *Entomologist, 36:*156.
Type locality: South Queensland.
Synonymy: *Tripteroides occidentalis* Brug, S.L., 1934. *Bull. Ent. Res., 25:*506.

ADULT FEMALE

Again a very small drab species. Head clothed in appressed broad fawn to brown scales above, with narrow white eye border extending to white apressed scales laterally. Torus with some white scales dorsally. Clypeus bare. Palp short, dark; about 0.15x length of proboscis. Proboscis dark; about 1.12x length of forefemur. Scutal integument brown; densely clothed in appressed narrow fawn scales, with white scales above wing root and around prescutellar space. There is a small patch of forward projecting bristles above the wing root. Scutellum with appressed white scales on all three lobes. Pleura densley clothed in appressed broad white scales on all segments except anterior sternopleuron. Abdomen with tergites densely clothed in broad black scales, with lateral apical white triangular patches which nearly join on segment VII, tergite I is pale laterally and black mesially; sternites all white scaled. Coxae all densely clothed in appressed white scales. Hindfemur pale on basal 0.8, dark above; tibiae and tarsi all dark. Wing is dark scaled. Haltere with pale stem and dark club.



Tripteroides (Polylepidomyia) punctolateralis

A: Hindleg; B: Adult head, thorax and abdomen (lateral); C: Wing (detail of scaling on some veins shown); D: Larval head (dorsal); E: Antenna (detail); F: Mesothoracic and metathoracic spines (detail); G: Abdominal segment VIII (lateral); H: Lateral comb scales (detail of dorsal and ventral scales); I: Siphonal setae (false pecten - detail).

LARVA

Antenna brown, 0.33x length of head; seta 1-A single, inwardly projecting, inserted about 0.4 from base; antenna distinctly thinner beyond insertion of 1-A. Mentum with 10-11 teeth. Head equal in length and width; about 0.78x width of thorax; seta 1-C down curved; 4-C single; 5-C and 6-C bifid; 7-C with 2-3 branches. Thoracic setae as follows: 1-P, 3-P, 4-P and 7-P multibranched (25-30), stellate; 2-P, 5-P and 6-P single. Mesothoracic and metathoracic spines well developed. Thorax and abdomen covered in strong stellate setae. Abdominal segment VIII with lateral comb consisting of 7-8 stout spines in single row on basal plate, with a further 5 detached spines which join on ventral midline; seta 1-VIII stellate with 30 branches; 2-VIII and 4-VIII single; 3-VIII bifid; 5-VIII with 3 branches. Siphon dark; index is about 2.6; siphon about 1.8x length of saddle; seta 1-S with a 3 branched seta subbasally, and a row of 11 bifid setae extending almost to apex of siphon; dorsal and subdorsal bifid setae in ring near midpoint of siphon; pecten absent, but strong siphonal setae may form a false pecten of about 4 simple spines extending to about 0.4 from base. Saddle complete dark ring with apical fringe of spines; seta 1-X with 3 branches; 2-X with 6 branches; 3-X bifid and 4-X a single pair of three branched setae; precratal tufts absent. Anal papillae short rounded; about 0.47x length of saddle.

BIOLOGY

Larvae found in tree holes, rot holes in fallen logs, and in domestic containers such as rainwater tanks. Adults occasionally taken in avian baited traps, light or CO_2 baited traps. Adults will bite man in the evening or during the day in shaded protected sites. Adults generally alight on the nose when seeking blood.

RELATION TO DISEASE

None known.

DISTRIBUTION

Broome, Sep-Oct 1950, EJB; May 1953, AKO; Aug 1953, EJB; Mar 1967, EJB; Feb- Mar 1984, MEC; May 1984, MEC; Apr-May 1985, MEC. Coolgardie, 42Km S.E., Oct 1965, NVD. Derby, Apr 1951, EJB; Apr 1953, AKO; Aug 1953, EJB; Mar 1977, AEW; Apr 1977, AEW; Sep 1978, AEW; Feb-Mar 1984, MEC; May 1984, MEC; Mar 1985, AEW; Mar 1985, MEC. Fitzroy Crossing, Jun 1954. Halls Creek, May 1951, EJB; Jul 1953, EJB. Kununurra, Apr-Jun 1972, PFSL; Nov-Dec 1972, PFSL; Jan 1973, PFSL; Apr-May 1973, PFSL; Nov 1973, PFSL; Apr 1974, PFSL; Nov-Dec 1974, PFSL; Nov- Dec 1977, AEW. Lake Argyle, NE, Jul 1978, AEW. Mabel Down Stn, Nov 1984, MEC. Millstream, Oct 1970, DHC; Apr 1971, DHC; Oct 1979, DHC. Ord River, Jun 1944, CFHJ. Parrys Creek, Jun 1976, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

See *Tr atripes.*

Subgenus : *TRIPTEROIDES*

CHARACTERS OF THE SUBGENUS

Adult: Ornate species, pleuron or abdomen or both with at least some silver scales. Anterior vertex at eye border with azure blue scales. Palps very short, 2 segmented. Antenna usually less than 0.7 of proboscis. Silver markings generally seen on femora.

Larva: Subgeneric characters not recognised for larvae.

Tripteroides (Tripteroides) magnesianus (Edwards) 1924

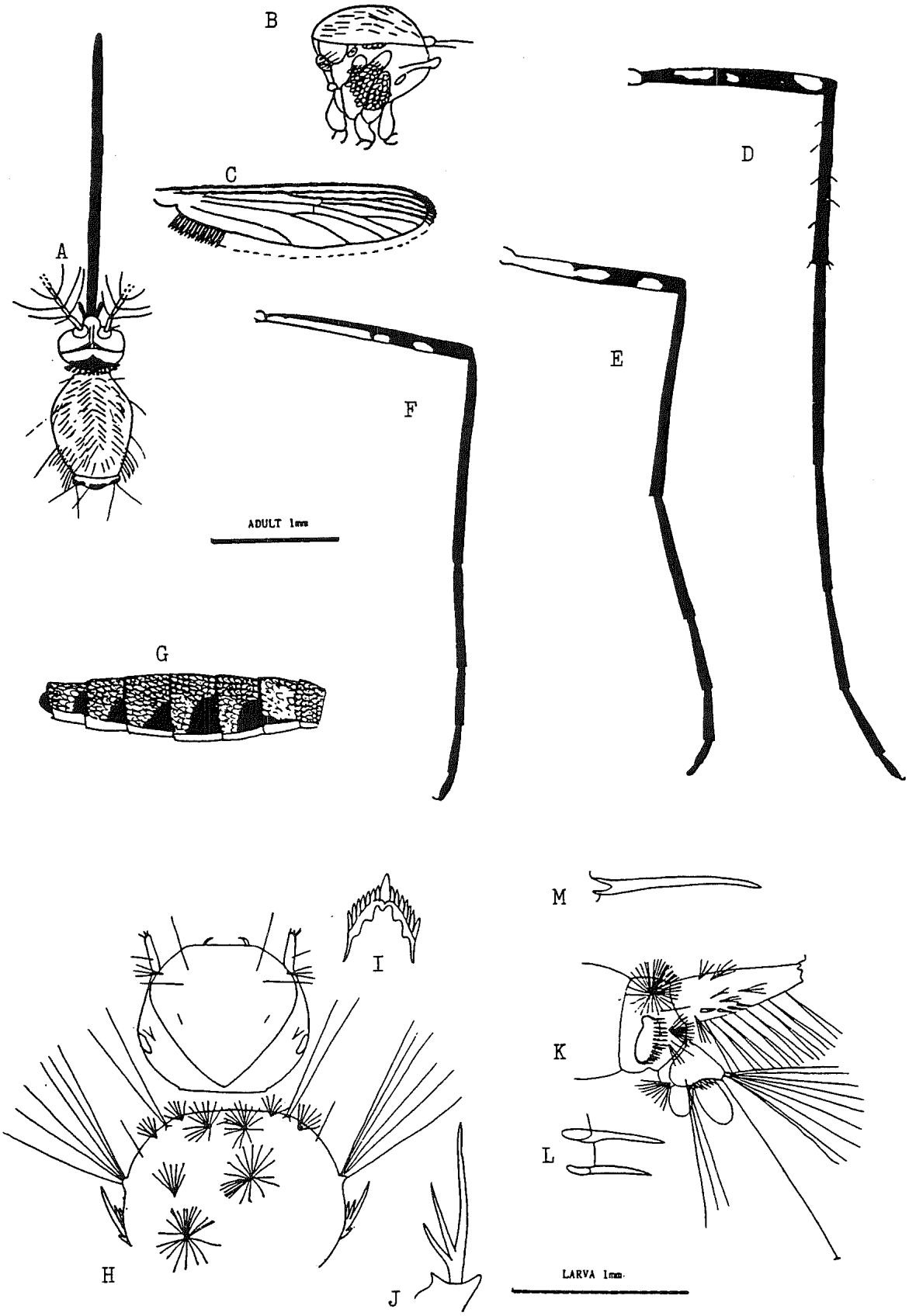
Edwards, F.W., 1924. *Bull. Ent. Res., 14:* 361.
Type locality: Magnetic Island, north Queensland.
Synonomy: none.

ADULT FEMALE

Tr magnesianus is a small, highly ornamented species. Azure blue eye border, black on occiput, silver laterally; black upright forked scales confined to occiput. Clypeus and torus bare. Palps very short, black scaled; about 0.07x length of proboscis. Proboscis long and slender, black scaled; about 1.4x length of forefemur. Scutal integument is orange/brown, sparsely clothed in fine black scales. Scutellum with patch of appressed silver (appear black in some lights) on each lobe. Pleural integument is yellow/orange with broad patch of appressed silver scales covering the supspiracular area, post spiracular area, upper and posterior sternopleuron, and the lower and anterior mesepimeron; small spiracular bristles present. Abdomen with tergites black scaled with red/purple reflections; basal lateral triangular patch on dark, non-reflective black scales; apicolateral silver patch extending along posterior border of tergite; sternites clothed in metallic golden scales. All coxae with appressed silver scales. Femora black scaled with median and apical silver patches; tibiae and tarsi all dark. Wings dark scaled. Haltere with basal stem pale yellow, upper stem and club black.

LARVA

Head and antenna brown. Antenna short, similar diameter over whole length; about 0.24x length head. Seta 1-A single, projecting outward, inserted at 0.44 from base. Mentum with 7 teeth on each side. Seta 1-C stout, appressed to head and curved ventrally; 5-C and 6-C single; 7-C with 1-3 branches. Strong meta thoracic spine only. Thorax and abdomen clothed in strong stellate setae. Prothoracic setae : 1-P stellate with about 17 branches; 2-P, 5-P and 6-P single; 3-P stellate with 12 branches; 4-P and 7-P both stellate with about 20 branches. Lateral comb with about 23 simple spines on basal plate, stout dorsally and gradually finer ventrally; no detached comb scales. Seta 1-VIII stellate with 30-40 branches; 2-VIII and 4-VIII single;



Tripteroides (Tripteroides) magnesianus

A: Adult head and thorax (dorsal); B: Thorax (lateral); C: Wing (detail of scales on some veins shown); D: Foreleg; E: Midleg; F: Hindleg; G: Abdomen (lateral); H: Larval head and thorax (dorsal); I: Mentum; J: Metathoracic spine (detail); K: Abdominal segment VIII (lateral); L: Lateral comb scale (detail); M: Siphonal setae (false pecten - detail).

3-VIII stellate with 13 branches; 5-VIII with 3-4 branches. Siphon tapering; index about 3.0; about 3x length saddle; with small hooked dorsal valve hairs. Seta 1-S subventral with 4 branches and 8 1-2 branched ventral tufts. Row of dorsal and subdorsal setae about midpoint of siphon. Saddle short complete ring with apical fringe of strong spines up to 0.4x length saddle. Seta 1-X with 3 branches; 2-X with 9 branches; 3-X single; 4-X single pair of 5 branched setae. Precratal tufts absent. Anal papillae long and rounded, 1.4x length of saddle.

BIOLOGY

Tr magnesianus is a tropical species. The larvae have been found in tree holes and rot holes in stumps. *Ae notoscriptus* and *Ae 'ENM' s species 76'* have been found breeding with *Tr magnesianus* in the Northern Territory. Adults of *Tr magnesianus* will enter light and CO_2 baited traps. The adults will bite man, alighting on the nose, biting during the day in sheltered forest areas.

RELATION TO DISEASE

None known.

DISTRIBUTION

Kalumburu, Jul 1978, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

CHAPTER 24 : genus *URANOTAENIA*

Only one species, *Uranotaenia albescens,* has been collected on a few occasions in the east Kimberley region.

GENERIC CHARACTERS: URANOTAENIA

Adult: Generally very small species. Vertex mainly broad flat scales. Proboscis long, slender, frequently swollen apically. Palps short. Scutum usually very strongly arched. Pleura often with distinct lateral lines of irridescent scales. Scutellum with broad flat scales. Abdomen short, blunt ended. Claws, short, simple and subequal; pulvilli absent. Wing frequently with some pale irridescent scales. Wing with microtrichia of membrane fine and seemingly absent. Anal wing vein sharply down curved at end and ends slightly anterior of the base of the cubital fork.

Larva: Head often longer than wide. Antenna short. Maxillary suture never developed. Setae 5-C and 6-C often developed into single flattened spines. Lateral comb always present, usually as single row on a basal plate. Siphon well developed with distinct acus; pecten almost always developed; seta 1-S a single pair and never inserted at base. Saddle usually complete.

KEYS: ADULT FEMALES: see key to the genera (page 93).
LARVAE: see key to the genera (page 94).

DESCRIPTIONS OF SPECIES

Uranotaenia albescens Taylor 1914

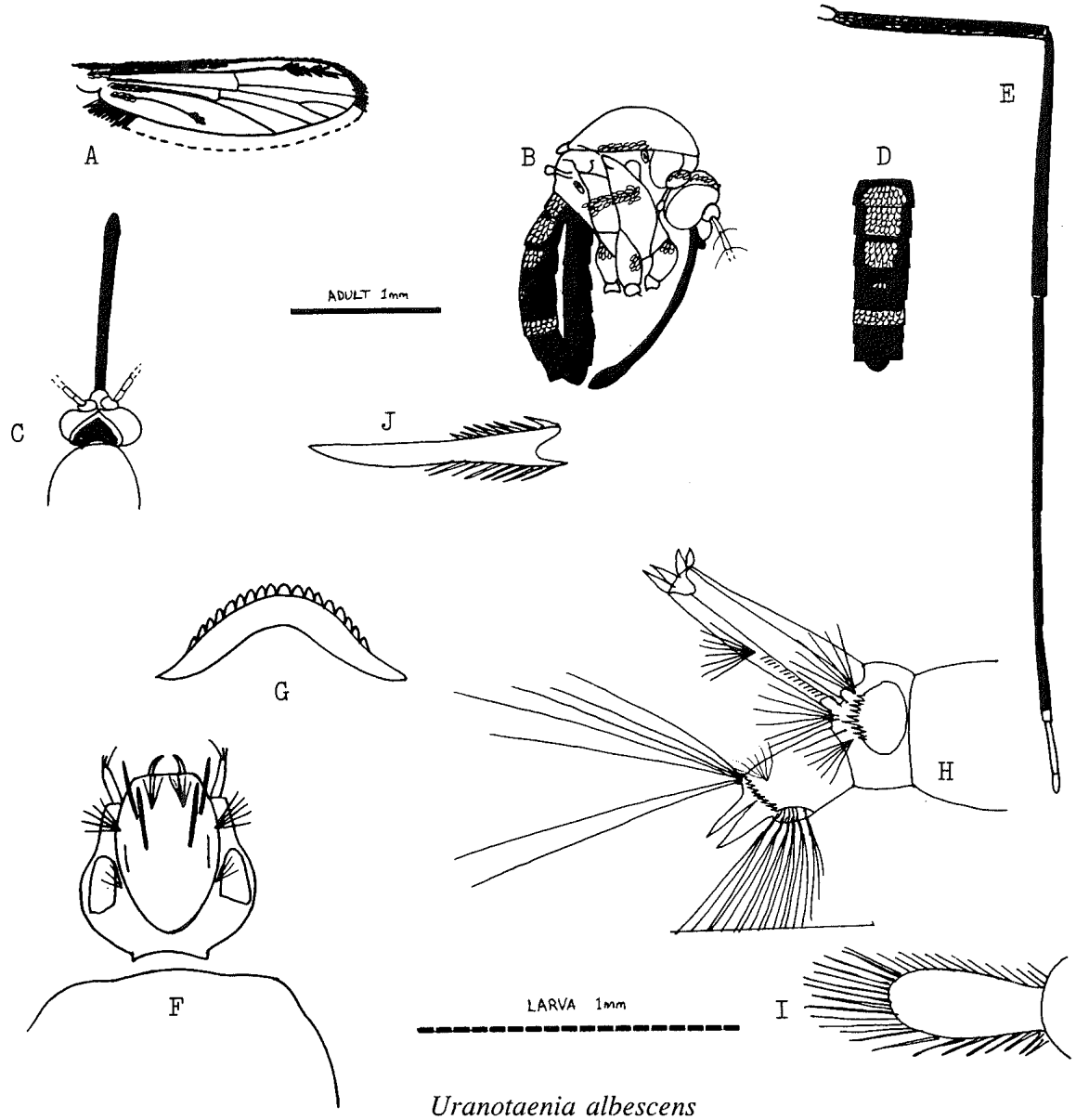
Taylor, F.W., 1914. *Trans. R. Ent. Soc. Lond., 1914:* 705.
Type locality: Townsville, Queensland.
Synonomy: none.

ADULT FEMALE

Ur albescens is a very small dark species, with characteristic abdominal markings. Head with eye border of white appressed broad scales; appressed broad white csales along occiput; black scales mesially; white scales extend laterally and form part of the lateral line of scales beginning on anterior pronotum; upright forked scales absent. Torus and clypeus bare. Palps black scaled, very short, about 0.1x length of proboscis. Proboscis black scaled and swollen at tip; 0.78x length of forefemur. Scutal integument black; densely clothed in short, fine, narrow black scales with a distinct line of appressed broad white scales in front of wing root. Scutellum clothed in fine narrow black scales on all three lobes. Pleural integument black; largely bare with a band of appressed broad white scales from anterior pronotum through the upper sternopleuron to the mid mesepimeron. All coxae with patches of appressed broad white scales. Abdomen with tergites black scaled; with broad median white patch covering segments I and II; apical median patch covering half of tergite III; broad apical white band on tergite V; sternites dark scaled. Hind femora dark with silver/white streak ventrally reaching almost to tip; tibia and hindtarsi I and II all dark; hindtarsus III with basal 0.17 dark, apical 0.83 white; tarsi IV and V all white. Wing dark scaled. Haltere with pale stem, club dark.

LARVA

Head and antenna dark. Antenna short, about 0.14x length of head. Head about 1.06x longer than broad; about 0.6x width of thorax; seta 4-C with 3-4 branches; 5-C and 6-C both single, flattened spines; 7-C with 5-7 branches. Prothoracic setae : 1-P, 2-P, 4-P, 5-P, 6-P all single; 3-P with 6-10 branches; 7-P bifid. Abdominal segment VIII with lateral comb as a row of 7-9 fringed spines on a basal plate; seta 1-VIII with 5-8 branches; 2-VIII and 4- VIII both single; 3-VIII with 6-7 pectinate branches; 5-VIII with 5 branches. Siphon curved dorsally, index about 3.5; about 1.7x length of saddle; seta 1- S a single pair of setae with about 8 branches, inserted at 0.63 from base of siphon; pecten consists of 10-13 rounded fringed scales extending to level of seta 1-S. Anal segment with saddle complete with posterior fringe of short spines; seta 1-X with 6 branches; 2-X with 5 branches; 3-X bifid; 4-X with 5 pairs of multibranched setae on grid; 1 precratal tuft occasionally present. Anal papillae long and pointed, about 0.77x length of saddle.



Uranotaenia albescens

A: Wing; B: Adult head, thorax and abdomen (lateral); C: Head (dorsal); D: Abdomen (dorsal); E: Hindleg; F: Larval head (dorsal); G: Mentum; H: Abdominal segment VIII (lateral); I: Lateral comb scale (detail); J: Pecten teeth (detail).

BIOLOGY

Larvae of *Ur albescens* are generally found in the shaded shallow margins of freshwater pools or backwaters of freshwater streams, amongst vegetation or debris, the water generally being coated with an oily scum from rotting vegetation.

Adults will enter CO_2 baited traps placed near the breeding site. They do not appear to disperse for any real distance from the breeding site. The adults will generally not bite man, but may alight and probe, taking some blood if disturbed at a sheltered resting site. Resting sites are humid, shaded sites such as drain culverts and stream vegetation.

RELATION TO DISEASE

Bovine Ephemeral fever virus has been isolated from a mixed pool containing *Ur albescens*. However, there is no evidence to support a role in the transmission of disease, and none is suspected.

DISTRIBUTION

Kununura, AEW.

SPECIES WITH WHICH IT MAY BE CONFUSED

None.

APPENDIX A

PRESERVATION OF MOSQUITO SPECIMENS FOR STUDY

This appendix presents a brief guide to the preservation of both adult and larval material for future study and as a reference collection. A useful general reference is K.R. Norris and M.S. Upton (1974) 'The collection and preservation of insects' published by the Australian Entomological Society.

LABELS

As you will note from the distribution data in this manual, future workers are completely dependent on what you place on the label of your specimen for data on the collection. If insufficient data is put on the label, a future worker cannot determine distribution or get other relevant data from the specimen. For collections to be used by other workers, and for specimens to be evaluated and confirmed by a recognised medical entomologist, full collection details are required. All specimens should be labelled immediately with as much detail as possible. Do not delay labelling as the specimens may be moved or misplaced making future labelling impossible.

The data which must go on the main label is:

Locality, State
Date, (time)
Collector
Catch type
Catch number (if part of a long series and needed for reference)
Habitat type

A second label should give the identity of the specimen, who determined the identity and a date of determination.

Additional information (for example, location code of associated larval and pupal skins in link bred material) can be placed on additional labels.

LARVAE

Larval mosquitoes are killed by placing them in hot, almost boiling water for a few minutes. Larvae killed this way have the body extended so that all the important taxonomic features are clearly visible. The larvae are stored in 70% ethyl alcohol (ethanol). If there is no access to hot water, the larvae can be placed directly into 70% ethanol. Do not use commercial methylated spirits as prolonged storage will blacken the specimen. Australian Customs retain control over the use of ethanol, though permission can be obtained for genuine insect collectors, and should be no problem for institutions. Alternatively, isopropyl alcohol may be used. Always label the specimen carefully as soon as it is placed in alcohol, so that it is always identifiable as to location, date and time of collection, and collector. Specimens in alcohol should be labelled in pencil or Indian ink which will not run in alcohol. The collection should be kept out of the light, as the insect cuticule will gradually disintegrate if exposed to light for prolonged periods.

There are generally two main types of larval reference collection. The first is whole larvae preserved in alcohol. Such specimens are useful in that they can be examined whole, and manipulated to expose relevant features. However, the specimens become brittle over time, and are easily damaged when handled. Setae can be dislodged and the diagnostic features quickly lost.

The second type of reference collection involves the mounting of larval specimens on glass microscope slides. There are numerous methods for preparing specimens on slides. The following method is a rapid and easy technique for making good and long lasting slide preparations using larvae stored as described above.

PREPARATION OF LARVAL SLIDES

(The method is illustrated in diagram 1.)

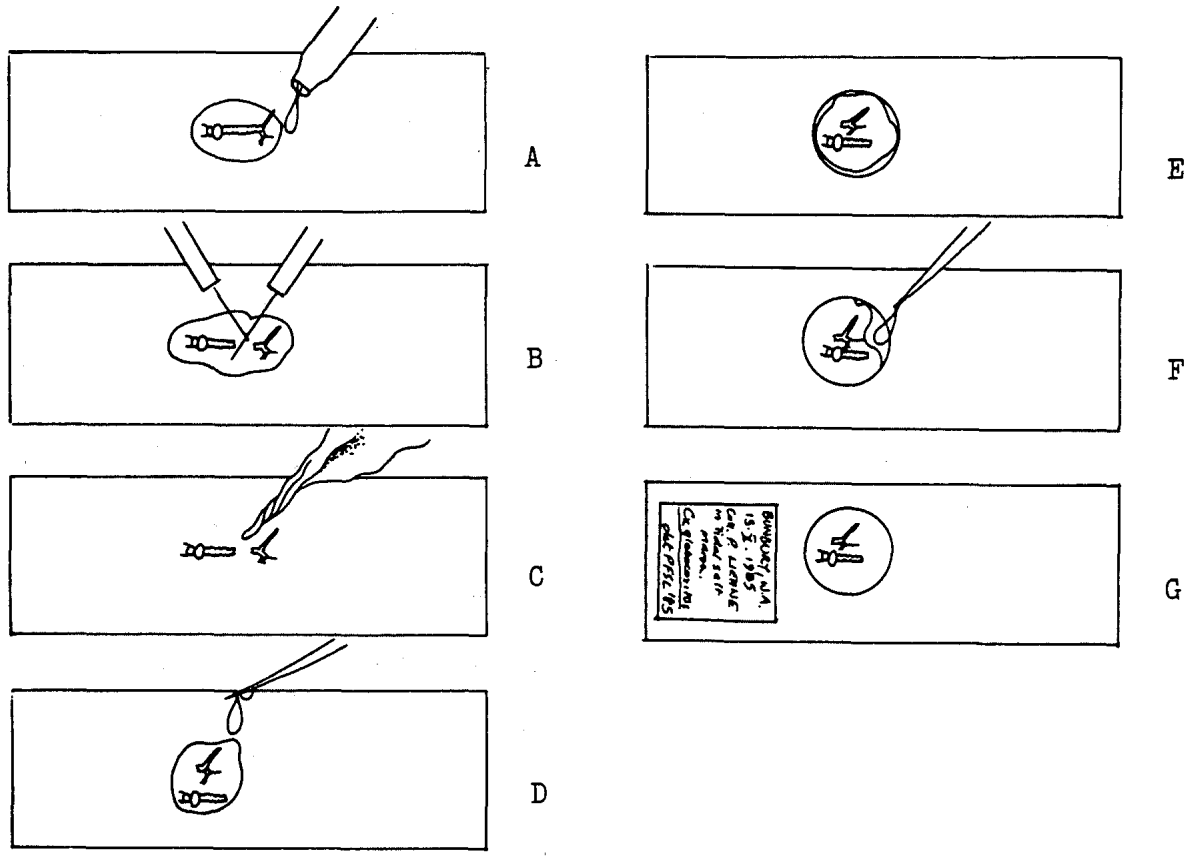
1: The larvae are taken out of 70% ethanol and placed in 2-ethoxy-ethanol (cellusolve) for 12-18 hours. This will clear the specimen so that it can be viewed with a microscope. Failure to do this will result in specimens which are opaque, and in which the diagnostic features are often obscured. The larvae should not be kept in cellusolve for longer than about 18 hours or the cuticle will be dissolved and critical features may be lost.

2. After 12-18 hours in cellusolve the larva should be returned to 70% alcohol (as this is miscible with the mounting medium (euparal)).

3. The larva is placed on a clean microscope slide in a drop of 70% alcohol (Figure 1A). Only one larva should be mounted on each slide. Locate the larva in the centre of the slide each time to make it easier to manipulate and view a series of slides.

4. The larva is cut at the join of abdominal segments V and VII so that the terminal abdominal segments can be viewed in a lateral aspect whilst the dorsal aspect of the head and thorax are seen (Figure 1B). It is a good practice not to separate both halves completely, but to keep them joined by a small section of cuticle. Some people mount whole larvae of *Anopheles*, to show the dorsal aspect of the entire larva, but it is wise to prepare most specimens as indicated above. All culicine mosquitoes should be mounted with the terminal abdominal segments in a lateral aspect.

FIGURE 1 : MAKING SLIDE PREPARATIONS OF MOSQUITO LARVAE



5. Mop up excess alcohol with a tissue being careful not to touch the specimen (Figure 1C). You must not let the larva dry out - proceed to step 6 immediately.

6. Cover the larva with euparal. Position the two halves again if necessary (Figure 1D).

7. Place a clean coverslip over the larva (Figure 1E) being careful not to trap air bubbles in the middle of the slide.

8. Add additional euparal to remove any air bubbles at the edges of the slide (Figure 1F).

9. Label with a stick-on label containing full details of the collection: locality, date, collector, habitat, species identification, who did the identification, date of identification (Figure 1G).

10. The slides should be stored in a horizontal position, protected from dust for a few days to allow the euparal to harden. Additional euparal may need to be added as it has a tendency to shrink slightly as it dries. Once dry, the slide may be stored in a slide box. The slides should be stored in the dark to better preserve the specimens.

(Note: The chemicals used in preparing larval mounts should be treated with care. Avoid exposure to the skin, eyes or mouth, use in a well ventilated room.)

Once the slides have cured, they are quite robust and sturdy, though they should always be treated with care as the slide or cover slip may break.

ADULTS

Adults captured in traps or by other means are best killed using chemicals such as chloroform, ether or ethyl acetate. These can be used in a special killing bottle, or simply by placing a cotton pad with a small amount of chemical in a sealed plastic bag with the insects. These chemicals are toxic and flammable, so adequate precautions and care must be taken. Do not use household insecticides as the chemicals may discolour and damage the specimens. An alternative is to use a cyanide killing bottle which consists of a small amount of potassium cyanide in plaster of Paris set in the base of a jar with a tight fitting lid. Adult insects are preserved in a dry state, generally by pinning them using special insect pins. It is best to pin adults immediately after they are killed. If this is not possible, the adults can be stored dry in an airtight jar, packed loosely in tissue paper to prevent the specimens from jolting each other and being damaged. Dry insects are very brittle and are very easily damaged. Label the pinned insects immediately with full details of the collection.

Adults which have been allowed to dry out may be softened by placing in a humidity chamber for a day or so. A humidity chamber can be easily constructed from a plastic box with an airtight lid by placing a small jar of warm water in its base. Care should be taken not to allow the insect specimens to get wet. If the chamber is to be maintained for some time, an antifungal (for example phenol) should be placed in with the water.

The following instructions give a method for pinning adult mosquitoes, and can be used for other small insects. Larger insects are pinned directly onto insect pins. Because of the size of mosquitoes, they are pinned using minuten pins and polyporous pith.

PINNING ADULT MOSQUITOES

(The steps in pinning adult mosquitoes are illustrated in Figure 2.)

1. The pith is cut to a length of 1.5-2.0cm. Place the minuten pin through the pith at one end so that the base of the minuten is almost to the pith (Figure 2A).

2. Holding the pith, the sharp point of the minuten pin is pushed into the thorax of the mosquito - either through the lateral thorax or from below between the coxae (Figure 2B). Do not push the pin right through the insect, but aim to leave the tip of the pin just below the surface.

3. Push a No.4 or No.5 insect pin through the other end off the pith and use a guide to place the pith at the correct height below the head of the pin (Figure 2C).

(A simple pinning guide can be constructed from a scrap block of wood by drilling a series of holes with a very fine drill. The depth of the holes should be 20mm for height of the pith, 15mm for the main label, and 12mm for the second label. Such guides are not necessary, but allow the final collection to be standardised and neater in presentation.)

4. A full label should be written with details of locality, date, collector, habitat; and catch type (and number). This should then be located on the pin using the second of the guide holes (Figure 2D). Once the specimen is identified, a second label showing the species identification, who did the identification, date of identification can be affixed in a similar manner using the third hole (Figure 2E).

5. Two alternatives for pinning using pith are shown in Figure 2F and 2G, one using a cube of pith, and the other the method described above.

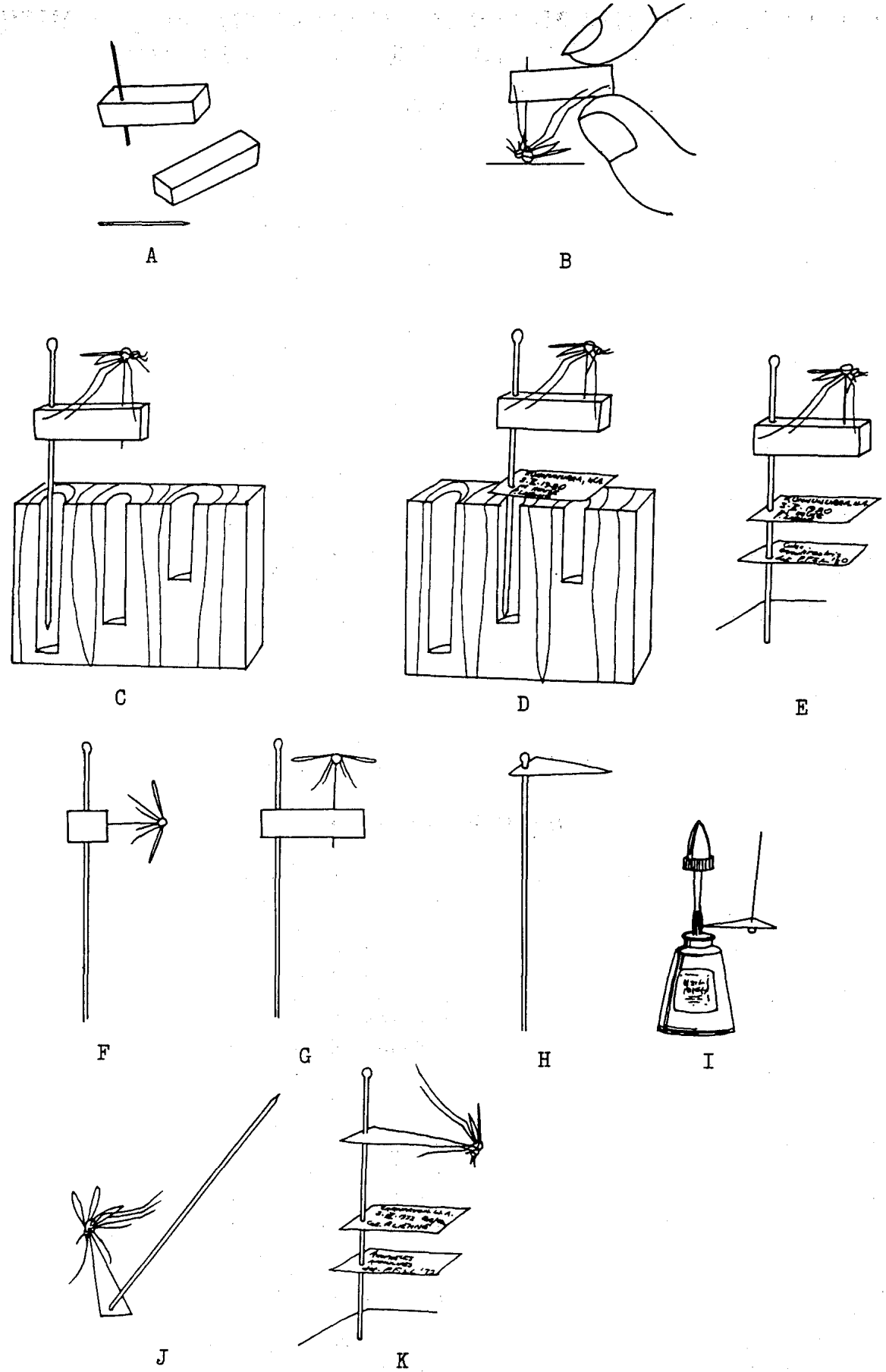
6. If pith is not available, mosquitoes can be mounted on cardboard points. A small triangle of cardboard (1cm long) is mounted on a No.4 or No.5 insect pin and pushed through to the head of the pin (Figure 2H). This is then touched with nail polish on the tip so as to leave a small drop of polish (Figure 2I). This is then immediately touched onto the insect which becomes glued to the cardboard point (Figure 2J). The specimen can then be moved down the pin to the correct height and labelled in the usual manner (Figure 2K). This is an easy method, but the specimens are not as easily examined. It is better to use the pith method for preparing pinned specimens.

STORAGE, HANDLING AND VIEWING

Pinned adult mosquitoes should be kept in a light-proof insect box. It is important to keep the specimens out of strong light as the colours fade and the cuticle deteriorates if exposed to light for prolonged periods of time. Care should be taken to ensure that the insects are protected from museum pests which eat and destroy specimens. These can be kept at bay by ensuring that the insect box is always kept charged with naphthalene. A simple trick is to heat an insect pin and drive the warm pin through a moth ball. The moth ball will cool and fuse to the pin and may be pinned in the corner of an insect tray or specimen box (be sure to place the box so that the moth ball is at the bottom).

The insects must be handled with care as they are very brittle when dry. Use entomological forceps to pick specimens out of the collection for examination. A simple viewing stage for pinned insects is made by fixing a cone of plasticine to a small metal lid. The insect and stage can then be moved around so as to allow viewing of the feature under investigation.

FIGURE 2 : MOUNTING ADULT MOSQUITO SPECIMENS



APPENDIX B:

CHECKLIST OF THE MOSQUITO SPECIES FOUND IN SOUTH AUSTRALIA AND THE NORTHERN TERRITORY

SOUTH AUSTRALIA

Ae (Cha) calabyi
Ae (Cha) wattensis
Ae (Fin) alboannulatus
Ae (Fin) mallochi
Ae (Fin) notoscriptus
Ae (Fin) rubrithorax
Ae (Hal) australis
Ae (Mac) stoneorum
Ae (Mac) tremulus
Ae (Mac) ENM's sp 125
Ae (Muc) alternans
Ae (Och) calcariae
Ae (Och) camptorhynchus
Ae (Och) clelandi
Ae (Och) continentalis
Ae (Och) eidsvoldensis
Ae (Och) flavifrons
Ae (Och) linesi
Ae (Och) luteifemur
Ae (Och) nigrithorax
Ae (Och) purpuriventris
Ae (Och) sagax
Ae (Och) silvestris
Ae (Och) spilotus
Ae (Och) stricklandi
Ae (Och) theobaldi
Ae (Och) vigilax
Ae (Och) vittiger
Ae (Psk) bancroftianus
Ae (Psk) postspiraculosis

An (Ano) atratipes
An (Cel) annulipes

Cq (Coq) linealis
Cq (Coq) 'Ben Lomond' sp

Cx (Cux) annulirostris
Cx (Cux) australicus
Cx (Cux) globocoxitus
Cx (Cux) molestus
Cx (Cux) quinquefasciatus
Cx (Lop) cylindricus
Cx (Neo) fergusoni

Cs (Cuc) inconspicua
Cs (Net) hilli

Mansonia Sp??

Tr (Rah) atripes
Tr (Rah) tasmaniensis

NORTHERN TERRITORY

Ad (Ady) catasticta

Ae (Adm) alboscutellatus
Ae (Cha) elchoensis
Ae (Cha) wattensis
Ae (Fin) alboannulatus
Ae (Fin) britteni
Ae (Fin) kochi
Ae (Fin) mallochi
Ae (Fin) notoscriptus
Ae (Fin) purpureus
Ae (Fin) quasirubithorax gp.
Ae (Och) normanensis
Ae (Och) phaecasiatus
Ae (Och) pseudonormanensis
Ae (Och) sapiens
*Ae (Och) theobaldi**
Ae (Och) vigilax
Ae (Och) vittiger
Ae (Och) ENM's sp 71
Ae (Och) ENM's sp 85
Ae (Och) ENM's sp 159
Ae (Lor) ?dasyorrhus
Ae (Mac) stoneorum
Ae (Mac) tremulus
Ae (Mac) ENM's sp 70
Ae (Mac) ENM's sp 76
Ae (Mac) ENM's sp 121
Ae (Mac) ENM's sp 125
Ae (Mac) ENM's sp 126
Ae (Muc) alternans
Ae (Neo) lineatopennis
Ae (Och) eidsvoldensis
Ae (Och) explorator
Cx (Cux) vicinus
Cx (Cux) ENM's sp 32
Cx (Cux) ENM's sp 68 (?=32)
Cx (Cux) ENM's sp 92
Cx (Lop) cubiculi
Cx (Lop) cylindricus
*Cx (Lop) fraudatrix**
Cx (Lop) fraudatrix-annulata
Cx (Lop) hilli
*Cx (Lop) petersi****

NORTHERN TERRITORY (Continued)

Ae (Och) ENM's sp 165
Ae (Psk) bancroftianus
Ae (Rhi) longirostris
*Ae (Stg) aegypti***
Ae (Stg) katherinensis
Ae (Ver) carmenti
Ae (Ver) funereus
Ae (Ver) ?parasimilis
Ae (Ver) reesi
Ae (?Subgen Nov) *daliensis*
Ae (?Subgen Nov) ENM's sp 160
Ae (?Subgen Nov) ENM's sp 161

An (Ano) bancroftii
An (Ano) powelli
An (Cel) amictus
An (Cel) annulipes s.l.
An (Cel) annulipes CAG's sp B
An (Cel) annulipes CAG's sp D
An (Cel) farauti s.l.
An (Cel) farauti sp No. 1
An (Cel) farauti sp No. 3
An (Cel) hilli
An (Cel) meraukensis
An (Cel) novaguinensis
*An (Cel) punctulatus**

*Cq (Coq) crassipes**
Cq (Coq) xanthogaster
Cq (Coq) ENM's near crassipes

Cx (Cui) pullus
Cx (Cux) annulirostris
Cx (Cux) australicus
Cx (Cux) bitaeniorhynchus
Cx (Cux) crinicauda
Cx (Cux) palpalis
Cx (Cux) quinquefasciatus
Cx (Cux) sitiens
Cx (Cux) squamosus
Cx (Cux) starkeae
*Cx (Cux) tritaeniorhynchus**

Cx (Lop) ENM's sp 154
Cx (Lop) ENM's sp 155
Cx (Lop) ENM's sp 167
Cx (Lut) halifaxii

Ho ENM's sp 157

Ma (Mnd) uniformis

Mi (Eto) elegans
Mi (Ing) ENM's sp 172
Mi (Mim) metallica
Mi (Mim) ENM's sp 166

Ml genuostris

Tx (Tox) speciosus

Tp (Rac) sylvestris var. hilli
*Tp (Pol) atripes**
Tp (Pol) punctolateralis
Tp (Trp) magnesianus
Tp (Trp) quasiornatus

Ur (Pfc) diagonalis
Ur (Pfc) hirsutifemora
Ur (Ura) albescens
Ur (Ura) albosternopleura
Ur (Ura) antennalis
Ur (Ura) amiensis
Ur (Ura) argyrotarsis
Ur (Ura) lateralis
Ur (Ura) moresbyensis
Ur (Ura) nivipes
Ur (Ura) novaguinensis
Ur (Ura) tibialis
Ur (Ura) ENM's sp 45
Ur (Ura) ENM's sp 49
Ur (Ura) ENM's sp 82
Ur (Ura) ENM's sp 149
Ur (Ura) ENM's sp 156

* DOUBTFUL RECORDS
** IMPORTED SPECIES, NOT PRESENTLY OCCURRING IN THE N.T.
*** AWAITING CONFIRMATION.
ENM : Elizabeth Mark's list of new and previously undescribed species.
CAG : Chris Green's list of sibling species of *Anopheles annulipes.*

GLOSSARY

ACUS: Sclerotised hook at the base of the siphon.
ANAL VEIN: *(A)* Wing vein (see Fig.14.9 page 91).
ANAL PAPILLAE: Anal gills, organs which maintain correct water balance within the mosquito larva. Attached to the end of the anal segment.
ANAL SEGMENT: Terminal segment (X) of larva.
ANTENNAL TUFT: A tuft of hairs inserted at about the midpoint of the larval antenna (seta 1-A).
ANTERIOR PRONOTUM: (APN) One of the lateral sclerites on the adult thorax (see Fig.14.7 page 89).
ANTERIOR SPIRACLE: (AS) Mesothoracic spiracle on the adult thorax (see Fig.14.7 page 89).
ANTHROPOPHILIC: Preferring a human host as a source of blood.
APICAL: At the end furtherest from the centre of the animal (i.e. at the apex).
AUTOGENY: Ability of newly emerged female to produce one egg batch without first taking a blood meal.
BASAL: At the end closest to the centre of the animal (i.e. at the base).
CEPHALUS: Head (cephalic: of the head).
CERCI: Paired female genital processes at the end of the adult abdomen extending beyond abdominal segment VIII in some species.
CLYPEAL SPINE: The first of the cephalic setae (1-C) on the larval head.
CLYPEUS: Larva: One of two chitinised plates forming the larval head capsule. Adult: A small plate directly below the torus (of little diagnostic significance).
COSTA: *(C)* Wing vein at leading edge of wing (see Fig.14.9 page 134).
COXA: Articulated joint on leg which joins leg to thorax.
CRATAL HAIRS: Modified setae on the larval anal segment where the bases of a number of paired hairs (4-X) have fused together to form a grid structure.
CREPUSCULAR: Active at sunset and sunrise.
CUBITUS: *(Cu)* Wing vein (see Fig.14.9 page 91).
DIMORPHIC: Occurring in two distinct morphological forms.
DISTAL: See apical.
DIURNAL: Activity pattern predominantly during daylight.
DORSAL: Upperside or back.
ENDEMIC: Surviving or occurring regularly or continuously in an area.
ENDOPHILIC: Habit of feeding indoors.
EPHEMERAL: Habitats which are marginal and suitable for mosquito breeding only on rare occasions (for example, arid zones with unpredictable and infrequent rainfall). Mosquito species which survive in such habitats.
EPICRANIAL PLATE: The lateral chitinised larval head plate holding the eyes and antenna.
EPIDEMIC: Not occurring regularly or continuously in an area but reintroduced periodically from outside.
EXOPHILIC: Habit of feeding outdoors.
FEMUR: Segment of leg (see Fig.14.4 page 87).
FLAGELLUM: Segment of the adult antenna. 15 flagellar segments make up the adult antenna, each with a whorl of fine setae.
FOSSA: (F) The area of the scutum just forward of the scutal angle.
FRONS: The area on the adult head between the eyes.
HALTERE: A vestigal wing in the adult which acts as a balance organ.
HYPOSTIGIAL: Membranous area between the postspiracular area and the posterior pronotum.
INSTAR: Larval development stage. It is generally the fourth instar larva that is of sufficient size to ensure identification to species level.
LABIUM: See proboscis.
LATERAL: At or towards the side.
LATERAL COMB: A lateral patch of scales on the larval abdominal segment VIII.
MEDIA: *(M)* Wing vein (see Fig.14.9 page 91).
MENTUM: Chitinous toothed plate visible ventrally on the larval head. Used as a diagnostic feature. The overall shape and the number of teeth on each side may be important for identification.
MERON: Plate on lateral adult thorax (see Fig.14.7 page 89).
MESEPIMERON: (MEP) A large rectangular sclerite on the adult lateral thorax (see Fig.14.7 page 89).
MESIAL/MEDIAN: At or towards the middle.

MESOTHORAX: The middle thoracic segment. In the larva the three thoracic segments are fused but are defined by three distinct lines of setae. In the adult the mesathorax consists of the scutum and scutellum and most of the lateral sclerites and membranous areas.

METAMERON: Plate an adult lateral thorax (see Fig.14.7 page 89).

METAPLEURON: One of the plates forming the adult metathorax (see Fig.14.7 page 89).

METATHORAX: The third thoracic segment. In the adult it consists of the postnotum and the metapleuron.

MOUTHBRUSH: Dense group of hairs at the front of the larval head used to draw food particles into the mouth. In some species *(Ae alternans* and *Cx halifaxii)* these are modified for predation and appear as a few strongly thickened toothed bristles.

NOCTURNAL: Biting activity at night.

OCCIPUT: Area on the adult head above the vertex and next to the thorax.

OCULAR SETAE: Setae on the eye border of the adult.

ORNITHOPHILIC: Taking blood meals exclusively from birds.

OVIPOSITION: Act of laying eggs by the female mosquito.

PARATERGITE: A small area on the lateral adult thorax just below the scutum between the spiracle and the prealar area (see Fig.14.7 page 89).

PATHOGEN: An organism or agent of disease.

PECTEN PLATE: The pecten are fused into a pecten plate on the lateral surface of segment VIII in larval anophelines.

PECTEN TEETH: Row of small spines/teeth extending from base on ventral siphon.

PLEURA: General term for thoracic segments and sclerites.

POSTERIOR PRONOTUM: (PPN) One of the lateral sclerites on the adult thorax (see Fig.14.7 page 89).

POSTNOTUM: Part of the adult metathorax - a broad plate extending from the scutellum to the abdomen (see Fig.14.7 page 89).

POSTSPIRACULAR AREA: (PSP) A sclerite immediately below and behind the anterior spiracle on the adult thorax (see Fig.14.7 page 89).

PREALAR AREA: (PRA) A raised boss on the dorsal tip of the sternopleuron (see Fig.14.7 page 89).

PRECRATAL TUFTS: Detached hairs on the larval anal segment inserted before the cratal hairs (4-X) on the grid.

PRESCUTELLAR SPACE: (PSS) The area of the scutum medially before the scutellum.

PROBOSCIS: The proboscis on the adult consists of an outer sheath enclosing elongate mouthparts.

PROPLEURON: (PPL) A small raised boss above the coxa of the foreleg on the anterior edge of the adult thorax (see Fig.14.7 page 89).

PROTHORAX: The first of the three fused segments forming the thorax. In the adult it incorporates the anterior and posterior pronotum, the spiracular area and the propleuron.

PROXIMAL: See basal.

PULVILLUS: Feathery structure in Culex species on the last tarsal segment (tarsi V) (see Fig 14.4 page 87).

RADIUS: *(R)* Wing vein (see Fig.14.9 page 91).

REMIGIAL BRISTLES: These bristles lie on the dorsal surface of the remigium on the wing.

REMIGIUM: The common base of wing veins *R, M, Cu* and *A*.

SADDLE: A chitinised plate which covers the dorsal surface of the anal segment. The saddle may completely ring the anal segment in some species.

SCLERITES: Hardened (sclerotised) plates of cuticle, which, are linked by membranous cuticle to form the exoskeleton of the mosquito.

SCUTAL ANGLE: (SA) A slight ridge on the scutum above the mesothoracic spiracle.

SCUTELLUM: (Sc) A small plate joined posteriorly to the adult scutum. The scutellum has three lobes in culicines, but is a single lobe in anophelines.

SCUTUM: (S) The dorsal surface of the adult thorax.

SETAE: Fine hairs or bristles on adult and larval mosquitoes. A variety of larval setae are illustrated on page 126.

SIPHON: The breathing organ attached to the larval abdominal segment VIII. Not present in Anophelines.

SIPHON INDEX: A measure of the ratio between the length of the siphon and its width at the base (see page 86).

SPIRACULAR AREA: (SP) A membranous area directly anterior to the anterior spiracle on the adult thorax (see Fig.14.7 page 89).

STERNITE: The ventral plate of each adult abdominal segment.

STERNOPLEURON: (STP) A large sclerotised plate on the lateral thorax of the adult (see Fig.14.7 page 89).

SUBCOSTA: *(Sc)* Wing vein (see Fig.14.9 page 91).

SUPRAALAR REGION: (SU) The area of the scutum just above the wing root.

SUPSPIRACULAR AREA: (SSP) This is a continuation of the sclerite forming the postspiracular area and lies directly below the spiracle on the adult thorax (see Fig.14.7 page 89).

TARSI: Last five segments of the leg, the last segment usually having paired claws.

TAXON: General term used to describe any unit in a classification hierarchy (e.g. species, genus, etc.).

TERGITE: The dorsal plate of each adult abdominal segment.

TIBIA: Segment of leg (see Fig.14.4 page 87).

TORUS: The base of the antenna on the adult.

VECTOR: Species capable of, or known, to transmit a disease.

VENTRAL: Underside or front.

VERTEX: Area above the eyes on the adult head.

VIRAEMIA: The period during which a virus is found in relatively high concentration in the blood of a vertebrate prior to the development of antibodies by the vertebrate. It is during viraemia that a vector can pick up the virus during a blood meal.

ZOONOSE: A human disease which has a basic survival cycle involving non-human vertebrates, may or may not be vector borne.

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ATK	(no data)
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MMC	McCORMICK
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Mil	MILES
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