

NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

PART II. THE ZOOGEOGRAPHY OF THE SUBGENUS *OCHLEROTATUS*,
WITH NOTES ON THE SPECIES.

By I. M. MACKERRAS, M.B., Ch.M., B.Sc.,
Linnean Macleay Fellow of the Society in Zoology.

(Eight Text-figures.)

[Read 27th July, 1927.]

Edwards in 1924 recognized seventeen valid species of this subgenus of *Aedes* from the mainland and Tasmania, later (1926) raising the number to twenty. In the present paper a further new species is added while two names are reduced to synonymy, bringing the total down to nineteen. The total representation of the subgenus in the Australasian region is twenty-two species.

Two distinct faunal elements are to be recognized (Edwards, 1924):

- A. Females with well developed lower mesepimeral bristles; male hypopygium with well developed apical and reduced basal lobes to the side-piece, appendage of the claspette well developed. Affinities Holarctic. 14 species.
- B. Females without lower mesepimeral bristles; male hypopygium with well developed basal and reduced apical lobes to the side-piece, appendage of the claspette reduced, usually bristle like. Affinities Neotropical. 8 species.

It is with the origins of these two groups and the explanation of the apparent anomalies of their distribution that we are here primarily concerned.

The same author (1922b) epitomizes the distribution of the subgenus in the following terms: "This subgenus includes the great majority of the Palaearctic and Nearctic species of *Aedes*, and attains its maximum development in the north temperate parts of these regions; it is almost or quite unrepresented in the Ethiopian and Oriental regions, but appears again with numerous representatives in southern Australia, and one or two in New Zealand. Many species also occur in the Neotropical region, and it is possible, therefore, that Australia was colonized by way of South America, especially as some of the South American, New Zealand and Australian species show rather marked affinities. We may perhaps assume from this that the subgenus is an old-established one".

The Oriental fauna as known at present, and it must be remembered that this region has been well collected, is entirely deficient in *Ochlerotatus*, the only species recorded (Edwards, 1922a) being a Palaearctic invader in the Punjab and an Australian invader (*A. vigilax* Sk.) in the south-east. There is no reason whatever to suppose that the subgenus once flourished but has now become extinct. The barrier was probably largely, if not entirely, a climatic one.

There is, then, definite evidence for the belief that Australia was colonized from South America. This evidence is greatly strengthened in the case of Group A by the local distribution in eastern Australia, a line of investigation

which also clearly indicates that the two groups followed different routes and entered this country from different directions.

In Group A, nine species are strictly "Antarctic" in distribution, *i.e.*, dominant in Tasmania, while those occurring also in New South Wales are restricted to the highlands of the Divide with extensions to the coast in spring. This distribution is particularly well exemplified by *A. flavifrons* Sk. and *A. camptorhynchus* Thoms. *A. nivalis* Edw., on the other hand, is a Kosciusko-Barrington Tops species which apparently misses the Blue Mountains and is rare in Tasmania, a somewhat different, but equally typical "Antarctic" distribution. The other five species require brief individual mention. *A. stricklandi* Edw. is southern and western, while *A. burpengaryensis* Theo. is known from South Queensland and is represented in Bass Strait by *A. clelandi* Tayl. and in New South Wales by a form intermediate between these two, which was found at Myall Lakes in spring. These species conform to the same general faunistic localization. *A. sagax* Sk. (including *A. wilsoni* Tayl.) is distributed west of the Divide and is of little value in the present discussion, although its greater prevalence in the more southerly part of its range is what one would expect in a member of the "Antarctic" group. Finally, *A. vittiger* Sk. is a summer species ranging from Townsville, Qld., to Leeton, in southern New South Wales, a distribution which would conform quite well with a northern origin.

It must be remembered, however, that the limitation of different faunal elements to particular environments, though very striking, is not absolute. There is a definite amount of overlapping and similar extensions are met with in individual species of other groups. The important fact is that the local distribution of Group A is precisely that of other Diptera which are believed to have entered Australia from Antarctica.

Group B presents a different problem. Its Neotropical affinities would suggest an antipodal origin, but the local distribution is unequivocally against Antarctic radiation. Of the eight species *A. imprimens* Walk. is found in New Guinea and the adjacent islands, *A. vigilax* Sk. is widespread on the east coast of Australia and extends into the Oriental region as far as Siam, *A. normanensis* Tayl. is not known south of Queensland, while *A. rubrithorax* Macq. and *A. aculeatus* Theo. are both coastal species ranging from South Queensland into New South Wales. All these species point in the clearest manner to an entry from the north. *A. theobaldi* Tayl., like *A. sagax* Sk., is distributed west of the Divide from Queensland to Victoria and is therefore of little value, though its greater prevalence in the more northerly part of its range tends to bring it into line with the other species of its group. Two species, *A. antipodeus* Edw. and *A. albirostris* Macq., are found in New Zealand and are important as indicating an eastward extension of the line of migration which brought them to Australia. I would suggest that this group entered Australia from the north by one of the Gondwanaland arcs of islands which Harrison (1927) indicated as being very successful in explaining other similar distributions.

The more general lines of evidence cannot be entered into here, but the conclusions may be summarized in the following terms. Group A developed in the temperate parts of the Holarctic region and was unable to extend to the southward except along the ridge of cooler elevated country on the western side of the Americas. Keeping to this higher western side, it extended into the temperate southern part of South America and radiated thence through Antarctica into southern Australia, where its climatic limitations are very well shown in the local and seasonal distribution. This migration occurred at a time

when New Zealand was cut off from participation in this element. Group B, on the other hand, originated in the Neotropical region, and almost certainly in the warmer, more low-lying eastern portion. Its line of eastward extension was directly in warm latitudes. Such an extension implies the existence of a Gondwanaland, or of its equivalent in a chain of islands (Harrison, 1927) linking South America to northern Australia and extending eastward to New Zealand. Both these radiations would ante-date the Oriental invasion which is the dominant element in the Australian mosquito fauna. It will be seen that these conclusions imply the acceptance of the Wegener or some similar hypothesis.

The early stages of but two species, *A. vittiger* Sk. and *A. vigilax* Sk., have been described, though a number have been bred. The larvae of all the species are very difficult to find, even in districts where the adults are so numerous as to be a pest. Even when it is possible to find a few pupae, the larvae frequently cannot be discovered. In certain instances, however, they appear to be able to lie hidden in the mud at the bottom of a pool for prolonged periods.

The male hypopygium presents valuable group characters which are, in all the Australian species, sufficiently well marked to afford easy and rapid determination. Such species as *A. theobaldi* Tayl., however, show the undesirability of elevating the two groups to separate subgeneric rank. The presence or absence of lower mesepimeral bristles on the other hand is not quite so constant, since these structures are absent in the male of *A. flavifrons* Sk., though well developed in the female, and they are quite variable in *A. rubrithorax* Macq., but when present in this species are always very weak. In *A. stricklandi* Edw. they are weaker than is usual in Group A, but are markedly longer and stouter than in *A. rubrithorax* Macq. A more convenient though unnatural grouping may be made on the presence or absence of white rings on the tarsal segments. This character also is not completely satisfactory, since two species, *A. stricklandi* Edw. and *A. luteifemur* Edw., which are best included with the unbanded forms, show traces of white rings on one or two segments; they are, however, never likely to be confused with those species possessing true banding, since in the former the rings are only apparent if carefully looked for, while in the latter they are easily visible to the naked eye. In the following key I have included for the convenience of local workers all mainland and Tasmanian species which are inseparable in the female from *Ochlerotatus*. The most easily accessible and constant characters have been used and the arrangement of species is consequently in many instances unnatural.

Key to Australian Species of Ochlerotatus, Banksinella, and Aedimorphus (females).

Species of *Aedes* with the following female characters: ninth sternite small and retracted, cerci long; head with numerous narrow curved scales (except *A. aculeatus* Theo.); claws of at least the fore and mid legs toothed.

1. Tarsi of all legs with distinct white basal banding 2
Tarsi unbanded, or at most with traces of white rings on one or two of the basal segments 10
2. Scutum creamy, with striking black vittae *vittiger* Sk.
Scutum not so adorned 3
3. Head and sides of scutum with flat oval yellow scales *aculeatus* Theo.
Head and sides of scutum with narrow scales 4
4. Wings entirely dark scaled 5
Wings with at least some white scales 6
5. Larger, darker species; femora mottled with white anteriorly
..... *camptorhynchus* Thoms.
Smaller, reddish species; femora not mottled with white anteriorly
..... *rubrithorax* Macq.

6. Lower mesepimeral bristles present; pale scales on wings fairly numerous, scutal integument reddish, wing membrane usually with a dark blotch in middle below costa *flavifrons* Sk.
 Lower mesepimeral bristle absent; scutal integument pitchy, wing membrane without dark blotch 7
7. Wings with numerous large white scales on all veins 8
 Wing scales normal in size and shape, white scales relatively few and mainly along Sc and R₁ 9
8. Pale bands of abdominal tergites nearly straight posteriorly, the dark portions of the tergites usually conspicuously mottled with pale scales, especially posteriorly *theobaldi* Tayl.
 Pale bands of abdominal tergites broad and produced posteriorly into a prominent triangle which forms a broad vitta on segment 6, only a trace of mottling on the dark portions of the tergites form *eidsvoldensis* nov.
9. Medium sized species; the gold scales of the scutum fine and patchy; abdomen with broad white basal bands; last hind tarsal segment with a broad white ring *vigilax* Sk.
 Smaller species; the gold scales of the scutum larger, more numerous and tending to a linear arrangement; abdomen usually with small white basal patches; last hind tarsal segment without, or with very narrow, basal white ring *normanensis* Tayl.
10. Wings extensively mottled with light and dark scales *stricklandi* Edw.
 Pale scales, if present on wing, relatively few and only along anterior border .. 11
11. Scutellum with broad flat white scales *Aedimorphus alboscuteUellatus* Theo.
 Scutellum with narrow scales only 12
12. Lower mesepimeral bristle absent; scutum with a broad margin of yellow scales *Banksinella lineatopennis* Ludl.
 At least one strong lower mesepimeral bristle present 13
13. Scutum with a broad margin of pale scales contrasting strongly with the dark field 14
 Scutum not so adorned 15
14. Numerous large flat scales above and in front of the wing root; abdomen unbanded *andersoni* Edw.
 Large scales above the wing root lanceolate and twisted; abdomen conspicuously basally banded *macleayanus*, n. sp.
15. Hind femora mottled anteriorly with pale scales 16
 Hind femora uniformly pale anteriorly at least on the basal two-thirds 17
16. Mesonotum dark brown to pitchy; mesonotal scales bronzy-brown to creamy white *sagax* Sk.
 Mesonotum reddish; mesonotal scales bright pale golden *cunabulanus* Edw.
17. Fore and mid femora with at least some white scales anteriorly 18
 Fore and mid femora entirely dark anteriorly 19
18. Abdomen with white scales at bases of tergites only; wings entirely dark scaled *nivalis* Edw.
 Abdomen unbanded, fourth and subsequent tergites extensively mottled with dull creamy-yellow scales; wings pale scaled on distal part of C and R₁ *luteifemur* Edw.
19. Venter entirely dark purple scaled *purpureiventris* Edw.
 Venter with numerous pale as well as dark scales 20
20. Abdominal tergites unbanded; scutal integument brownish-black *burpengaryensis* Theo.
 Abdominal tergites with basal white bands; scutal integument reddish *clelandi* Tayl.

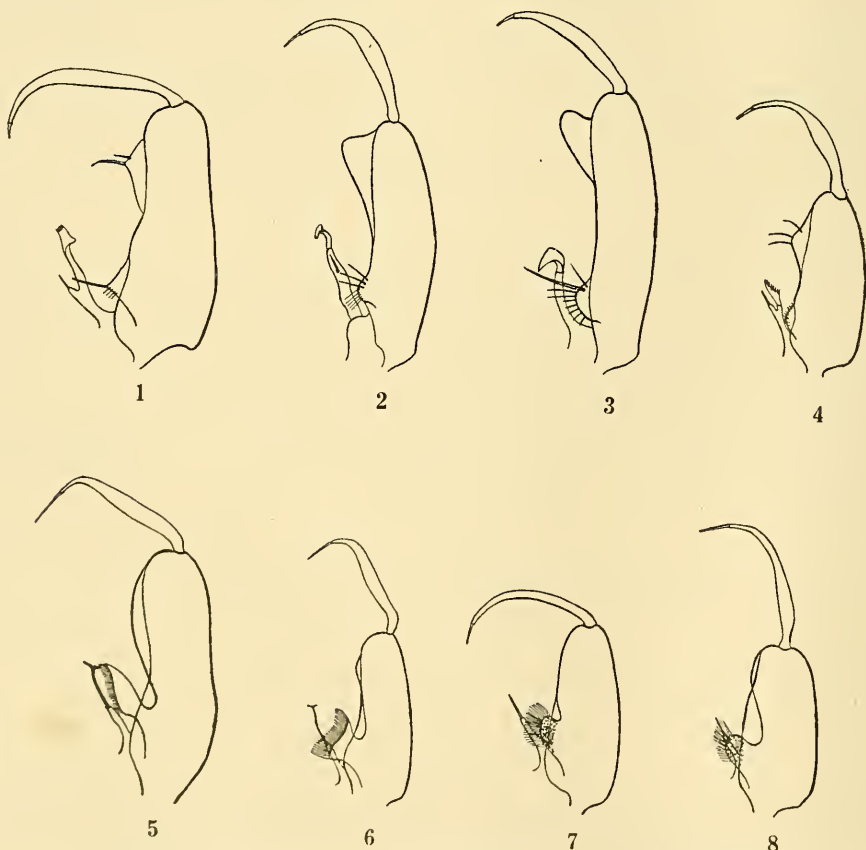
Notes.—This key applies *only* to the females. In the male many characters, which are conspicuous and useful in the female, are ill defined, as is the case with the white scales of the wings, or absent, as may occur with the lower mesepimeral bristles. Except for very distinctive species, a careful comparison with authentic females and an examination of the hypopygium afford the only safe means of identification.

A. nigrithorax Macq. is only to be recognized by hypopygial characters. The female when discovered will probably fall under caption 15.

The following species, not yet known from the mainland or Tasmania, are not dealt with in this paper:—*Aedes* (*Banksinella*) *brugi* Edw., New Guinea; *Aedes* (*Ochlerotatus*) *albirostris* Macq., New Zealand; *Aedes* (*Ochlerotatus*) *antipodeus* Edw., New Zealand; *Aedes* (*Ochlerotatus*) *imprimens* Walk., New Guinea and adjacent islands; *Aedes* (*Aedimorphus*) *vexans* Meig., widely distributed. The last would run down either to *rubrithorax* Macq. or to *vigilax* Sk. in the key; the specimens before me are too abraded to be sure whether there are any white scales on the wings or not. From the former it is readily recognized by its much darker thoracic integument and scales and by its mottled femora, while from the latter it is separable by its shorter proboscis and by the indentation of the abdominal bands, which are straight in *A. vigilax* Sk.

A very distinctive feature of the *nivalis* series is the violet gloss on the abdomen and legs. It is, however, not always present, and when present may occasionally be difficult to detect. It is therefore useless as a key character.

Culex australis Erich. is unrecognizable and must be deleted from the list of Australian *Ochlerotatus*. The name is replaced by *nivalis* Edw.



Text-figures 1-8. Side-piece and appendages of: 1, *A. vittiger* Sk.; 2, *A. flavifrons* Sk.; 3, *A. camptorhynchus* Thoms.; 4, *A. sagax* Sk.; 5, *A. theobaldi* Tayl.; 6, *A. normanensis* Tayl.; 7, *A. vigilax* Sk.; 8, *A. rubrithorax* Macq. All drawn to the same scale.

For the full synonymy and references up to 1924 see Edwards (1924). Subsequent publications on the subgenus and those earlier ones which are directly mentioned are listed at the end of this paper.

GROUP A.—AFFINITIES HOLARCTIC.

The species included here fall into two natural sections on hypopygial characters, those with a sub-basal thumb on the medial aspect of the claspette (*A. vittiger* Sk., *A. sagax* Sk., *A. nigrithorax* Macq., *A. burpengaryensis* Theo.; Text-figs. 1 and 4) and those without such thumb (*A. flavifrons* Sk., *A. camptorhynchus* Thoms., *A. andersoni* Edw., *A. cunabulanus* Edw.; Text-figs. 2 and 3). It will be seen that forms with banded and with entirely dark tarsi occur in both sections. I have, however, used this unnatural but more convenient arrangement, largely because of the difficulty of placing correctly some of the species which are only known from the female.

a. Tarsi with conspicuous white rings.

AEDES (OCHLEROTATUS) VITTIGER (Skuse).

One of the most distinct Australian mosquitoes on account of the scutal adornment. Its hypopygial characters (Text-fig. 1) show its affinities to be with *A. sagax* Sk. and its allies rather than with *A. flavifrons* Sk. and *A. camptorhynchus* Thoms. The claspette is forked and the apical lobe of the side-piece forms a pointed medial projection bearing a strong bristle.

The larva has been described by Cooling (1913) and the larva and pupa figured by Hill (1925a). The combination of short antennae, long frontal hairs, 3-4 branched subantennal hair, relatively long siphon, the presence of some of the pecten spines beyond the siphonal tuft, and the single row of comb scales will separate this from any other Australian larva.

At Eldsvold *A. vittiger* Sk. breeds in clear or muddy waterholes and is very abundant in midsummer in forest country and in the vicinity of the river. It bites by day and is a source of considerable annoyance owing to the persistence of its attacks. In the Sydney district it is rare and frequents the sheltered sandstone gullies.

Distribution.—Coastal Queensland and New South Wales from Townsville to Sydney; also extends west of the Divide. A summer species, most prevalent in south Queensland. Now recorded for the first time from the mountains and from south of Sydney: Barrington Tops, 5,000 feet, January, 1926; Leeton, December, 1926 (K. McKeown).

AEDES (OCHLEROTATUS) FLAVIFRONS (Skuse).

Culicada vandema Strickland.

The types series of *Culex flavifrons* Skuse in the Macleay Museum comprises four specimens, the type male and female which undoubtedly represent one species, another female which is identical with typical *A. vandema* Str., and a third female identical with *A. camptorhynchus* Thoms. With regard to the types, the female differs from typical *A. vandema* Str. in its duller colouration, the rather fewer pale scales on the wing and the markedly fainter blotch on the wing membrane. The two latter characters are somewhat variable in the extensive series of *A. vandema* Str. before me and the colour difference may simply be due to age. A careful comparison revealed no character on which the two could be separated. In the male type the pale scales on the wing are very

few, while the dark blotch has entirely disappeared; lower mesepimeral bristles are absent. A male from Sydney in my collection, which can be allotted without doubt to *A. vandema* Str. also lacks the lower mesepimeral bristle and differs from Skuse's type in its slightly brighter colouration and in the fact that the dark patch on the wing is present though very faint. The hypopygia of the two are identical. I am indebted to Dr. E. W. Ferguson for drawing my attention to the possibility of this synonymy.

A. flavifrons Sk. is easily distinguished in the female by the presence of lower mesepimeral bristles, the numerous pale scales on the wings, the mottled femora, and almost always by the dark patch on the wing membrane. Superficially it bears some resemblance to *A. (F.) occidentalis* Sk. The male (Text-fig. 2) has the apical lobe of the side-piece well developed and projecting distally, while the basal lobe is rounded and bears a row of five fine hairs directed proximo-medially; the claspette has a well developed appendage and bears a single small bristle a little beyond the middle; this appears to be the homologue of the bristle on the medial division in those species in which the claspette is forked.

This species is abundant in Tasmania and appears in considerable numbers in the coastal districts of New South Wales in early spring, where it frequents the sandstone gullies and brush country in company with *A. (F.) alboannulatus* Macq. and *A. (F.) occidentalis* Sk. It is a day biter.

Distribution.—Victoria, Tasmania and King Island (November and December). New South Wales: Blue Mountains (type series); Myall Lakes, Aug. 1, 1922; Woy Woy, Oct. 3, 1925; French's Forest, Sydney, Aug. 17, 1924; Balmoral (Sydney), Nov. 26, 1922; Lane Cove (Sydney), May 31, 1927 (B. Bertram); National Park (Waterfall), Aug. 2, 1925.

AEDES (OCHLEROTATUS) CAMPTORHYNCHUS (Thomson).

To be separated from *A. flavifrons* Sk. by its darker colour, entirely dark wing scales, and absence of any blotch on the wing membrane. The male, unlike that of the previous species, has well developed lower mesepimeral bristles. The hypopygium (Text-fig. 3) differs in the presence of a stout bristle as well as fine hairs on the basal lobe of the side-piece and in the absence of any bristle on the stem of the claspette, the apex of which is differently shaped. The two species are obviously closely related.

In the Sydney district its habits and season resemble those of *A. flavifrons* Sk. It is, however, less common, and its local environment is rather strikingly different in that it is found in the heath on the more level sandstone ridges rather than in the gullies (Mackerras, 1926). In Victoria it appears to replace *A. vigilax* Sk. as the dominant "bush" mosquito (Hill, 1925b).

Distribution.—New South Wales: French's Forest, Sydney, Aug. 17, 1924; Greenwich, Sydney, Aug. 15, 1925 (B. Bertram); National Park (Gundamaian), Aug. 2, 1925; Sutherland, Aug. 7, 1926. Also Western Australia, South Australia, Victoria (abundant), and Tasmania (abundant from October to March).

b. *Tarsi entirely dark, or with only traces of pale rings.*

AEDES (OCHLEROTATUS) STRICKLANDI Edwards.

Easily recognized by the numerous broad pale scales scattered over the wing. In the specimen before me, there are traces of white rings at the bases of the first and second hind tarsal segments only; these might easily be overlooked, but are obvious enough under the binocular. There are two fairly strong lower mesepimeral bristles on one side; the other side is obscured by the legs.

Distribution.—Western Australia and Flinders Island, Bass Strait. Additional locality: Mt. Compass, Oct. 27, 1920 (J. B. Cleland).

Aedes (Ochlerotatus) andersoni Edwards.

Edwards, 1926, p. 112, new name for *Andersonia tasmaniensis* Strickland.

Another striking species, which is easily separated from all except *A. macleayanus* n. sp. by the scutal ornamentation. The abdomen is unbanded. Edwards (1926) describes the male hypopygium as follows: "Lobes of ninth tergite small, with four to six short bristles. Side-pieces with the basal lobes large, flattened, prominent; a row of long hairs along the margin, and two tergally placed bristly spines, one long with slender curved tip, the other short and straight. Apical lobe well developed but practically bare. Claspers not much swollen, slightly tapering, apical spine long. Claspettes with long stem without basal thumb, appendage flattened but not very broad, without angle at base". This description agrees with the hypopygium of *A. camptorhynchus* Thoms. very closely and shows the uselessness of leg ornamentation in phylogenetic studies.

Distribution.—I have seen a number of females from Victoria (Lower Tarwin, biting by day, G. F. Hill) and from Tasmania, October to December. Also recorded by Edwards for January and February in Tasmania.

Aedes (Ochlerotatus) macleayanus, n. sp.

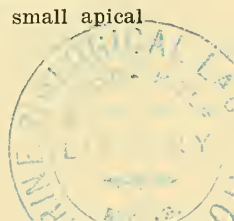
♀. Head with creamy narrow curved scales in the middle, more ochreous ones laterally, and with ochreous upright forked scales; lateral flat scales mostly white, a few violet brown. Antennae dark brown, torus brownish ochreous. Palpi rather long, deep brown. Proboscis entirely deep brown.

Integument of scutum pithy. There is a broad median area of bronzy-brown fine scales which widens suddenly behind the middle of the thorax; lateral to this is a broad creamy zone of larger twisted scales, which are particularly large above the wing roots; this zone of creamy scales extends medially round the anterior margin of the scutum; further laterally there is a narrow zone of bronzy-brown scales at the lateral edge of the scutum. Scutellum and median prescutellar area with creamy white narrow curved scales. Anterior and posterior pronotal lobes with fine bronzy scales above and larger creamy more outstanding ones below. Pleurae brown, with dense flat white scales forming a band across the upper part; there is also a large white patch on the lower part of the sternopleuron. Three strong lower mesepimeral bristles. Wings entirely dark scaled.

Fore and mid femora mottled anteriorly, the pale scales predominating; hind femora entirely white anteriorly except for a narrow apical dorsal zone. Tibiae and metatarsi mottled anteriorly, largely white behind. Tarsi dark. Ungues of all legs toothed.

Abdomen covered with deep brown scales with a slight violet gloss, the tergites basally banded with ochreous scales. The bands are triangular in shape, with the broad base along the base of the tergite and the apex more or less drawn out, on the sixth segment extending to its apex. There is a large lateral basal patch of creamy ochreous scales on the fourth segment and larger white patches at the sides of the fifth and sixth segments. Seventh with a broad median creamy stripe and white lateral margins. Venter white scaled, except for small apical lateral black patches on a few segments.

Length, 7 mm.



Holotype ♀: Launceston, Tasmania, Oct. 1, 1916 (F. M. Littler), in the South Australian Museum.

This is a rather large species which superficially resembles *A. andersoni* Edw., but differs in the absence of flat scales above the wing roots, the darker thoracic integument, the unmottled hind femora, and the banded abdomen. The scutal ornamentation and the leg characters will separate it from *A. cunabulanus* Edw.

AEDES (OCHLEROTATUS) CUNABULANUS Edwards.

Edwards (1912) first mentions this species as a variation of *A. australis* Theo. (i.e. *nivalis* Edw.), but, when describing it (1924), he stated that it was closer to *A. andersoni* Edw. but much smaller in size. The mottling of the anterior surface of the hind femora will separate it from *A. nivalis* Edw., while the reddish thoracic integument and bronzy gold mesonotal scales distinguish it from *A. sagax* Sk. I have seen a single female from Tasmania which I place here with some hesitation. It is not much smaller than *A. andersoni* Edw. and resembles *A. nivalis* Edw. closely in scutal colouration and scaling, but otherwise fits the description fairly accurately. The relationships of *A. cunabulanus* Edw. have been settled by Edwards's (1926) description of the hypopygium of the male as "practically identical in structure with that of *A. andersoni*, the appendage of the claspette appearing a little broader".

Distribution.—Tasmania, November to February. Additional locality: Mount Arthur, Tasmania, December 28, 1915 (F. M. Littler).

AEDES (OCHLEROTATUS) NIGRITHORAX (Macquart).

Only known from the type male and only identifiable on hypopygial characters. It is possible that future discoveries may show the name to belong to one of the species dealt with below. Edwards's (1924) description of the hypopygium runs as follows: "Side-pieces with the basal lobes well developed, hairy; apical lobes slight, bearing two or three rather stout curved spines. Claspers with the basal two-thirds somewhat swollen, apical third slender, terminal spine long. Claspettes with a sub-basal thumb on the inner side bearing a small terminal bristle, somewhat as figured by Cooling for *A. vittiger*; appendage broad and flat, with a retrorse angle at base. Lobes of ninth tergite each with about six short bristles".

Distribution.—Tasmania.

AEDES (OCHLEROTATUS) SAGAX (Skuse).

Culicada wilsoni Taylor.

Edwards (1924) recognizes these as distinct, but Ferguson (1926) gives this synonymy and I believe it to be correct. I have seen females of both forms and there is little to separate them. In typical *sagax* the scutum is covered with brown scales with small patches of white, and the pleurae are spotted with white, whereas in *wilsoni* the mesonotal scales are all or mostly creamy and the pleurae are more densely scaled. There are, however, intermediate forms. The violet sheen of the abdomen is of no value and may be present or absent in otherwise typical *sagax*. Taylor (1918) gives a photomicrograph of the male hypopygium of *A. wilsoni* Tayl.; it is unfortunately not suitable for detailed study, but does not appear to show any essential difference from that of *A. sagax* Sk.

This species is to be recognized by its dark scutal integument and dull scaling, by the mottled hind femora, and by the banded abdomen.

♂. Palpi entirely brown, a little longer than the proboscis, terminal segments swollen and bearing dense long brown hairs; antennae with long brown plumes; one lower mesepimeral bristle; otherwise similar to the female. Hypopygium (Text-fig. 4) with the apical lobe of the side-piece pointed and bearing one small and two larger bristles, basal lobe very small and covered with fine hairs. Claspette with a sub-basal thumb bearing a short bristle and with the appendage serrated along its apico-lateral edge. The resemblance to *A. vittiger* Sk. and to Edwards's descriptions of *A. nigrithorax* Macq. and *A. burpengaryensis* Theo. is remarkable. Allotype ♂: Eidsvold, South Queensland, Oct. 13, 1926 (Mackerras), in the Macleay Museum, University of Sydney.

Distribution.—Widely distributed in Victoria and New South Wales west of the Divide. Now recorded for the first time from Queensland: Eidsvold, June 6, 1926, biting by day (T. L. Bancroft), and October 7-13, 1926, females biting by day and at dusk, male in tussock near a swamp. Taylor records *A. wilsoni* as a source of great annoyance in the Goulburn Valley district, Victoria.

AEDES (OCHLEROTATUS) LUTEIFEMUR Edwards.

Edwards, 1926, pp. 112-113.

This is rather an inconspicuous species, but is readily recognized by the entirely pale hind femora, especially by the numerous pale scales towards the apex of C and R₁, and by the unbanded abdomen which is uniformly dark anteriorly, extensively mottled with ochreous creamy scales in the middle and entirely pale posteriorly.

Distribution.—Tasmania and Victoria (Edwards).—There are specimens in the South Australian Museum from Georgetown, Tasmania, November to March, and from King Island, Bass Strait, November and December, all coll. F. M. Littler.

AEDES (OCHLEROTATUS) NIVALIS Edwards.

Edwards, 1926, p. 112, new name for *A. australis* Theo. *nec.* Macq.

♀. Proboscis and palpi dark scaled, the former with a few white scales. Scutum and scutellum bright reddish to dark purplish brown; clothed with small bright pale golden scales, sometimes tending to a linear arrangement, but without any special ornamentation. A row of three to six lower mesepimeral bristles, usually the larger number. Legs black, with distinct violet reflections in most specimens; fore and mid femora with some scattered white scales anteriorly, hind femora white on basal four-fifths anteriorly, dark apically with some scattered white scales; no pale scales on tibiae and tarsi. Abdomen deep brown, usually with violet reflections, unmottled; all segments with basal white bands of variable extent, sometimes reduced to a single incomplete row of white scales, but never in my experience entirely absent. Venter white, with large apical lateral and small basal median dark patches on all segments. Size variable, some specimens up to 8 mm., the majority about 5-6 mm. The most characteristic features are the scutal and abdominal ornamentation, the markings of the venter, the adornment of the femora, and the violet reflections when present.

This species is exclusively alpine in New South Wales. It was exceedingly abundant and annoying at Barrington Tops in January and February, biting viciously at dusk and for an hour or two after; occasional individuals could be taken biting at almost any time.

Distribution.—New South Wales: Kosciusko; Barrington Tops, 5,000 feet, January and February, 1925. Victoria: In elevated country. Tasmania: Recorded

by Edwards (1926); there is also a single female in the South Australian Museum labelled "Tasmania" without further data.

AEDES (OCHLEROTATUS) BURPENGARYENSIS (Theobald).

This and the two following are to be separated from all others with dark tarsi by the complete absence of pale scales on the anterior surface of the fore and mid femora. The thoracic integument of *A. burpengaryensis* Theo. is described as deep brownish black and the abdomen as unbanded but with white basal lateral patches to the tergites. The venter has yellowish basal bands to the segments. A specimen before me from Myall Lakes agrees very well with the description, the almost metallic violet reflections of the legs being particularly striking. The tergal markings of the abdomen, however, are different and approach *A. clelandi* Tayl.; the second and third tergites are unbanded, the fourth has a very narrow basal band and there are wider basal bands on the fifth to seventh segments. I have no doubt that this specimen should be placed with *A. burpengaryensis* Theo. rather than *A. clelandi* Tayl., but it certainly forms a link between the two.

Edwards (1924) gives the following note on the male hypopygium: "Chiefly differs (from *A. nigrithorax* Macq.) in having the spines on the apical lobe of the side-piece more slender, and the sub-basal thumb of the claspette rather shorter".

Distribution.—South Queensland: Burpengary (type locality). New South Wales: Myall Lakes, Sept. 3, 1922 (A. J. Nicholson).

AEDES (OCHLEROTATUS) CLELANDI (Taylor).

I have examined a paratype and another authentic female in Dr. Ferguson's collection and cannot find anything to separate it from *A. burpengaryensis* Theo. beyond the bright reddish scutal integument, the conspicuous basal banding of the abdominal tergites and the more extensively pale scaled venter. The violet gloss of the legs is slight in these specimens, but both are rather wasted. These characters are hardly, in my opinion, of specific value. I believe it probable that *A. burpengaryensis* Theo. and *A. clelandi* Tayl. will be found to represent the extremes of a continuous north-south range of variation, but the evidence is as yet insufficient and I have decided to let Taylor's name stand for the present.

Distribution.—Bass Strait: Flinders Island, Nov. 21, 1912 (J. B. Cleland); King Island (A. M. Lea).

AEDES (OCHLEROTATUS) PURPUREIVENTRIS Edwards.

Edwards, 1926, p. 113.

I have not seen this species, which should be easily recognized from *A. burpengaryensis* Theo. by the entirely purple scaled venter.

Distribution.—Tasmania.

GROUP B. AFFINITIES NEOTROPICAL.

Tarsi with white rings.

A. aculeatus Theo. stands out as very distinct, but the other species of this group are all closely similar. The characters given in the key will usually be sufficient for their recognition, but the variability of certain species may render separation difficult in the case of extreme specimens. Indeed, out of the hundred odd females of *A. theobaldi* Tayl. and *A. normanensis* Tayl. before me, there are one or two which might be placed with almost equal propriety in either species. Hypopygial characters, however, establish their specific validity.

AEDES (OCHLEROTATUS) ACULEATUS (Theobald).

A very well defined but rare species with the head and sides of the scutum covered with small oval flat yellowish scales. It is the only Australian member of the subgenus without numerous narrow curved scales on the occiput and its affinities are somewhat doubtful.

Distribution.—South coastal Queensland and north coastal New South Wales.

AEDES (OCHLEROTATUS) THEOBALDI (Taylor).

The most striking feature of this rather ornate species is the presence of numerous broad pale scales on all the main veins of the wing. Though somewhat variable in number and size, these scales are always more numerous and distinctly broader than in any other species of the group. The scutum is covered with small densely arranged golden scales mixed with darker ones. The abdominal tergites are basally banded with creamy scales, usually prominent, but sometimes reduced to a narrow incomplete fascia, never, however, forming a posterior triangular prolongation. The dark posterior portions of the tergites show a variable amount of mottling with pale scales, more marked posteriorly; occasionally the mottling is practically absent and the abdomen is indistinguishable from that of *A. normanensis* Tayl., while in some specimens the whole abdomen is mottled and the basal bands are ill defined. The femora are extensively mottled anteriorly with white scales and the last hind tarsal segment is entirely dark or with a narrow basal white ring.

♂. Differs from the female as follows. Palpi brown, slightly longer than the proboscis, with some creamy mottling beneath which extends round the shaft in the middle to form an indefinite pale ring; penultimate segment with a narrow basal white ring; the apical segments slightly swollen and bearing long brown hairs. Antennae with long silky brown plumes. The abdominal bands are definite and there is little or no mottling. The white scales on the wing are scanty and scattered, but are more numerous and broader than in the males of related species. The side-piece (Text-fig. 5) bears an elongate rather hairy apical lobe and a very large characteristically shaped basal lobe covered with fine hairs which form a definite fringe on its medial border. The appendage of the claspette is better developed than in the other members of the group and forks distally to form a striking fluke-like structure. *A. theobaldi* Tayl. helps in some respects to bridge the gap between the two groups. Taylor's (1918) figure of a hypopygium referred here by Edwards (1924) was actually that of *A. wilsoni* Tayl. Described from twelve specimens, all from Eidsvold.

Allotype ♂: Eidsvold, S. Queensland, Oct. 13, 1926 (Mackerras), in the Macleay Museum, University of Sydney.

This species was abundant at Eidsvold from July to October, 1926, though usually a rarity in that district. It is a day and night biting sylvan species, occasionally also taken in the scrubs. The early stages were not discovered.

Distribution.—"An inland species . . . widely spread from Queensland to Victoria and into South Australia" (Ferguson, 1926). Though in general distributed west of the Divide, it appears in the coastal districts in south Queensland.

AEDES (OCHLEROTATUS) THEOBALDI (Taylor) form EIDSVOLDENSIS, new form.

♀. More ornate than the typical form from which it differs in the following respects: the pale scales of the wings, though as numerous, are distinctly narrower;

the thorax is densely covered with small, dull creamy golden scales without darker admixture; abdominal tergites with broad transverse basal creamy bands produced posteriorly to form a prominent median triangle which increases in size on the posterior segments, until on segment six it forms a complete vitta; the mottling of the darker parts of the segments is hardly detectable. This is possibly a distinct species, but I hesitate to treat it as such in view of its closeness to *A. theobaldi* Tayl. and the fact that only one specimen was available for study.

Holotype: The unique female, taken biting by day in forest country at Eidsvold, Oct. 7, 1926 (Mackerras), has been lodged in the Macleay Museum, University of Sydney.

Aedes (Ochlerotatus) normanensis (Taylor).

This obscure and difficult species is very close to *A. theobaldi* Tayl., but is even more likely to be confused with *A. vigilax* Sk. from which it is abundantly different on hypopygial characters. It is distinctly smaller than either and may be separated from both by a collective consideration of the following characters:—

1. The pale scales of the wings are narrow and are only numerous along the anterior border. On the rest of the wing they are very scanty or absent, though a few are almost always present along Cu.

2. The scutum bears relatively large pale golden scales without darker admixture; they are not densely packed and show a tendency to a linear arrangement.

3. The basal pale bands of the abdominal tergites are variable in extent, being occasionally conspicuous and straight edged, but more often reduced to a narrow patch. There is no mottling.

4. There is a variable amount of irregular pale scaling on the proboscis beneath. It shows no sharp demarkation from the distal dark part.

5. The mottling of the femora is relatively inconspicuous and the last hind tarsal segment is devoid of, or with only a narrow, pale ring.

The characters of the male are even less definite than those of the female except for the hypopygium. This structure (Text-fig. 6) shows close affinities with that of *A. theobaldi* Tayl., from which it differs in the smaller but more definite apical lobe and the differently shaped basal lobe of the side-piece.

A. normanensis is a day biting forest species which is numerous at Eidsvold in the later half of summer but is rare earlier in the season. I have bred it from mixed pupae taken in a muddy rock pool and in a waterhole in the bed of a sandy creek. The larvae are extraordinarily elusive and could not be found.

Distribution.—South and Central Queensland.

Aedes (Ochlerotatus) vigilax (Skuse).

A re-examination of Skuse's type leaves no doubt as to the identity of this very abundant and annoying insect. It is also clear that it was correctly recognized by Edwards, despite the fact that he states that the wings are entirely dark scaled. The following notes made from the type will serve to separate *A. vigilax* Sk. from any of its allies; wings with scattered pale scales of normal form, fairly numerous along the anterior border, some scattered ones on the other veins, particularly along Cu; scutum with fine scales, mostly dark brown, but interspersed with numerous irregularly arranged bronzy golden ones; pale bands of abdominal tergites white, about one-fourth the width of the segments and straight edged; pale area on ventral side of proboscis conspicuous and with

sharply defined apical limit; femora mottled with numerous pale scales anteriorly; last hind tarsal segment with a broad prominent basal white ring; lower mesepimeral bristle absent. In over 100 females from various localities the range of variation is slight, being practically limited to the amount of pale scaling on the wing; the white scales may be completely limited to the anterior border, or may be so numerous as to approach the condition seen in *A. theobaldi* Tayl. The apical lobe of the side-piece of the male (Text-fig. 7) is not apparent and the basal lobe is large, rounded and covered with numerous hairs, the pigmented bases of which give it a dark appearance; the claspette is small and bears a simple straight apical bristle representing the appendage.

The larvae have been described by Cooling (1924) and Brug (1924) and the larva and pupa figured by Hill (1925a). Their most characteristic features are the short broad siphon, the arrangement of the comb scales in a patch, the short antennae, and the short frontal hairs.

A. vigilax Sk. is the most important of the Australian "bush" mosquitoes. It is exceedingly abundant in the vicinity of estuaries where there are any mud flats or mangrove swamps which appear to be its principal breeding grounds and the dominant factor governing its local prevalence. In such localities as the Hawkesbury River it may settle on one in clouds and make life unbearable. It has, however, a wide range of flight and may be quite numerous several miles from its breeding grounds. It bites both by day and by night. Its habits and the question of its control in the Sydney district have been dealt with elsewhere (Mackerras, 1926); they do not appear to differ materially in other parts of its range.

Distribution.—Widespread round the coast of Australia. Though almost exclusively coastal in distribution, I have taken a few specimens well away from salt water, one at Barrington Tops, N.S.W. (January, 1925) at 5,000 feet elevation and 40 miles from the coast, and several at Eidsvold, S.Q. (December, 1922, April, 1924, and October, 1926). It appears certain that it was breeding in the latter locality if not in both. The season is from October to April, the greatest prevalence being in the middle of summer.

AEDES (OCHLEROTATUS) RUBRITHORAX (Macquart).

A relatively rare species which is easily recognized by the entire absence of pale scales on the anterior aspect of the femora and on the wings, and by the reddish scutum which is covered with fine bright golden scales. The male hypopygium (Text-fig. 8) resembles that of *A. vigilax* Sk., differing only in the broader, more rounded side-piece bearing a more prominent basal lobe which is not darker in colour than the rest of the side-piece.

Edwards (1924) queried *Culex procax* Skuse as a synonym, an opinion which was confirmed by Ferguson (1926) who also pointed out that one or two weak lower mesepimeral bristles may be present. These findings are confirmed by a re-examination of Skuse's type and the study of a fair series of the species commonly known as *A. rubrithorax* Macq. The bristles may be present on one side and absent on the other; when present they are small but quite conspicuous. The fact that *Culex rubrithorax* Macq. was described from Tasmania need not affect the determination, since it is now known that many species described as from Tasmania in Macquart's 4th Supplement actually came from coastal New South Wales. His description fits an abraded specimen reasonably well and it seems preferable to use his name rather than Skuse's, although the latter can be

definitely recognized and the type is in good condition. In the same work Edwards also queries *Culex occidentalis* Skuse as a synonym. The type of this species, is, however, a *Finlaya* and is in my opinion identical with *A. (F.) queenslandis* Strick.

Distribution.—A coastal species extending from South Queensland to Sydney, New South Wales; also recorded, almost certainly erroneously, from Western Australia and Tasmania. Specimens are before me from the following localities: Eidsvold, S.Q. (February and April); Stradbroke Is., S.Q. (September); Myall Lakes, N.S.W. (August); North Harbour, Sydney (October); Balmoral, Sydney (November). Purely a bush species and a day biter.

References.

- BRUG, S. L., 1924.—Notes on the Dutch-East-Indian Mosquitoes, *Bull. Ent. Res.*, xiv, 4, pp. 433-442.
- COOLING, L. E., 1913.—Report on Mosquito work in Brisbane, *Ann. Rpt. Commissr. Pub. Hlth. Qld.*, to 30th June, 1913. Appendix J, pp. 55-64.
- , 1924.—The larval stages and biology of the commoner species of Australian Mosquitoes, with the biology of *Aedes pecuniosus* Edwards. *C'wlth. Aus. Hlth. Dept. Serv. Publn. (Trop. Divn.)*, No. 8, pp. 1-40.
- EDWARDS, F. W., 1912.—A key to the Australian species of *Ochlerotatus* (Culicidae). *Ann. Mag. Nat. Hist.*, ser. 8, ix, pp. 521-537.
- , 1922a.—A synopsis of the adult Oriental Culicine (including Megarhinine and Sabethine) Mosquitoes. Part II. *Ind. Jl. Med. Res.*, x, 2, pp. 430-475.
- , 1922b.—A revision of the Mosquitoes of the Palaearctic Region. *Bull. Ent. Res.*, xii, 3, pp. 263-351.
- , 1924.—A synopsis of the adult Mosquitoes of the Australasian Region. *Bull. Ent. Res.*, xiv, 4, pp. 351-401.
- , 1926.—Mosquito Notes.—VI. *Bull. Ent. Res.* xvii, 2, pp. 101-131.
- FERGUSON, E. W., 1926.—Mosquitoes of New South Wales. *15th Rpt. Microbiol. Lab., N.S.W., for 1924*, pp. 187-191.
- HARRISON, L., 1927.—The Composition and Origins of the Australian Fauna, with special reference to the Wegener Hypothesis. Presidential Address to Section D, *Aust. Assn. Adv. Sci.*, Perth, 1926 (in press).
- HILL, G. F., 1922.—Notes on the Habits and Distribution of some North Australian Culicidae. *C'wlth. Aus. Hlth. Dept. Serv. Publn.* No. 21, pp. 1-40.
- , 1925a.—The distribution of Anopheline Mosquitoes in the Australian Region, with notes on some Culicine species. *Proc. Roy. Soc. Vict.*, n.s. xxxvii, pp. 61-77.
- , 1925b.—Mosquitoes of Australia. *Vict. Naturalist*, xlii, 2, pp. 45-46.
- MACKERRAS, I. M., 1926.—The Mosquitoes of the Sydney District. Presidential Address. *Aust. Naturalist*, vi, 3, pp. 33-42.
- TAYLOR, F. H., 1918.—Contributions to a knowledge of Australian Culicidae. No. iv. *Proc. Linn. Soc. N.S.W.*, xliii, pp. 826-843.