SIMULIIDAE (DIPTERA) FROM QUEENSLAND

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(Plates 1-2)

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Summary

Eight species and one subspecies of Simuliidae are now known from Queensland, five of which are new. The life-histories of eight are recorded in this paper.

Only two of the species are known to attack man and domestic animals, and only one is a serious pest. This has been separated from *A. bancrofti* (Tayl.), with which it had been confused, and described as *A. pestilens* n.sp.

A. pestilens breeds in fast, turbulent, muddy water during the height of the floods in inland streams. It is predominantly associated with *Melaleuca* spp. in the stream beds, the early stages attaching to the submerged fronds, and the adults congregating in the exposed parts of the trees.

This and other inland species must possess a drought resistant stage, probably the egg.

Keys and figures are given for identification of adults, pupae, cocoons, and larvae.

I. Introduction

Prior to the present investigation, little was known of the Queensland Simuliidae. Taylor (1918) had described *Simulium bancrofti* Tayl., and this was the only Queensland species recorded by Tonnoir (1925), who placed it in the genus *Austrosimulium,* which he created for Australasian species with ten-segmented antennae. Taylor (1927) described *Simulium faheyi* on a single specimen from Innisfail, and subsequently (though on dubious grounds) recorded *Simulium ornatipes* Skuse as a pest in south Queensland (Taylor 1944). The pest species was generally known as *A. bancrofti* (Tayl.).

Nothing was known of the biology of the Queensland forms, but Mr. D. J. Lee (personal communication) had found the early stages of *S. ornatipes* in central Queensland, while Tonnoir (unpublished data) had worked out the life-histories of *A. bancrofti* and *S. ornatipes* in streams near Canberra, and Drummond (1931) had published an account of the same two species from Western Australia. Roberts (1940) has given some notes on the damage caused to stock by the pest species.

This work was undertaken primarily to elucidate the life-history of the pest species and to establish its identity, since somewhat conflicting statements had appeared about its morphology. The uncertainty proved to be due to the confusion of two species with very similar adults, which are quite distinct in the larval and pupal stages, and also have different habits in the adult stage. In all, eight species (one *Cnephia,* three *Simulium,* and four *Austrosimulium*) have been taken in south Queensland, and description of the adults, pupae, and larvae are given below.

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II. Materials and Methods

During the period February to June 1947, many creeks and rivers were visited, and abundant material was usually found in those portions of the streams where there was a steady flow of water. Larvae and pupae were transported to the laboratory in 1-quart "Agee" jars, or in large enamel basins. They were found to stand motor transport fairly well, especially when they were placed with water weeds in large, shallow basins with a relatively small amount of water. The larvae of some species survived journeys lasting up to 7 hours. The jolting and consequent movement of the water was apparently beneficial in promoting aeration. Pupae were more easily handled in jars without water, the wet leaves or stones to which they were attached serving to keep the atmosphere fairly moist. Development and emergence proceeded normally under these conditions for at least 3 days in summer and 6 days in winter.

Adults of both sexes were taken in a muslin net by sweeping bushes along the banks. This method was not very productive, except for *A. pestilens*, which, during its short periods of abundance, clustered so thickly on the leaves of the *Melaleuca* and other shrubs that many hundreds could be captured with each sweep of the net.

Females were also taken ovipositing on rocks, logs, or other objects just awash. All collected in this way proved to be *S. ornatipes*.

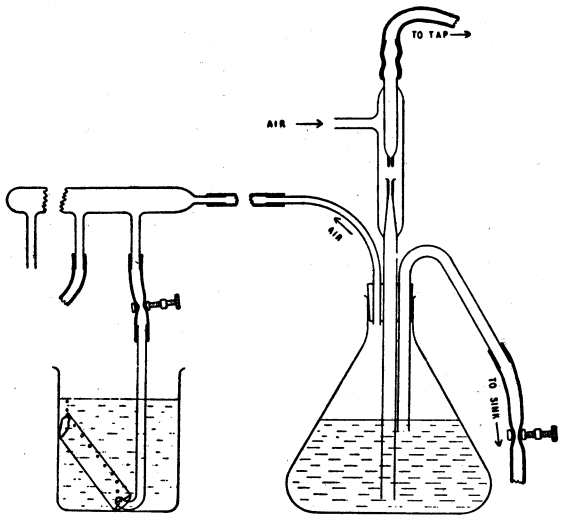

Fig. 1.—Diagram of the equipment used for breeding Simuliidae in the laboratory.

In the laboratory, aeration was provided by a reversed suction apparatus, designed and made by D. Mackerras, and known conveniently as "the bubbler" (Fig. 1). A powerful air pressure was developed in this apparatus, sufficient to bubble air rapidly through at least eight jars. A short, wide, glass cylinder, open at both ends, was placed obliquely in each breeding jar, and the

stream of bubbles directed into it. This device created a current of water, and larvae rapidly found the optimum conditions and arranged themselves inside the cylinder on each side of the stream of bubbles. Other favoured sites were the edge of the cylinder, both top and bottom, and the sides of the glass breeding jar where the bubbles impinged. Small quantities of water were removed daily, and replaced by water from an aquarium containing much microscopic life.

Two species, *S. ornatipes* and *S. nicholsoni*, did fairly well under these artificial conditions, and the former was reared from egg to adult in the laboratory. Other species were not so adaptable; well-grown larvae usually pupated successfully, but small larvae invariably died.

Adults were removed from breeding jars by a suction apparatus, and kept for several hours or days before being killed and pinned. Some survived for 5 days on a diet of raisins or apple.

The descriptions are based on a variety of material, but have been checked in every instance from single bred series; the adults were always described as soon as they were killed, and before shrinkage or other changes could occur. The females are described before the males, and have been selected as the holotypes of the new species, because they are more easily recognized.

The three genera (*Cnephia* End., *Simulium* Latr., and *Austrosimulium* Tonn.) in which the Australian species have been placed by Smart (1945), following Edwards (1931), are accepted here provisionally, a discussion of their status being reserved for another paper. Mention may be made, however, of the occurrence within the genus *Simulium* of an interesting group of species which have a conspicuous patch of bright, creamy or golden scales on the membranous prealar area. They are also distinguished by possessing numerous small, but easily seen, hairs on the "mesosternal" area. This group seems to be essentially northern in distribution, extends to New Guinea (R. H. Wharton), and is probably related to Edwards' (1934) Sub-group C from the Netherlands East Indies. Though the adults are homogeneous, the pupae are diversified, and it is difficult to say whether it is a natural assemblage or not.

III. General Biology

The abundance and wide distribution of several species in Queensland has been surprising, and that they have attracted so little attention is evidently due to the fact that the majority of species do not attack man or domestic animals, the adults being extremely inconspicuous.

Only two species have been taken biting man at all frequently, namely *A. bancrofti* (Tayl.) and *A. pestilens* n.sp. *A. bancrofti* has occasionally been taken biting horses in Queensland and man in the Australian Capital Territory, and Drummond (1931) reports that it bites viciously in the Darling Ranges, Western Australia, particularly in spring and summer. In Queensland it is certainly not troublesome, whereas *A. pestilens* attacks man and domestic animals viciously over a wide area of country. Fortunately it has only a short season each year, and then apparently disappears entirely for long periods.

Of the remaining species, only *S. nicholsoni* took human blood occasionally. This, to judge by the prevalence of larvae, is an abundant species, but the even more abundant *S. ornatipes* has never been seen to bite at all. Taylor's (1944) record of it as a pest would appear to have been a misidentification. We have no idea what these and the rarer species feed on; it is certainly not man nor domesticated animals, and there is a little experimental evidence to suggest that *S. ornatipes* may be able to mature eggs without a feed of blood at all.

The normal resting places of the adults are also obscure. Tonnoir (1925) had some success with southern and New Zealand species by sweeping the bushes along the streams where the early stages were found, and we have mentioned the association of *A. pestilens* with *Melaleuca* in the creek beds. In a search of bushes and other likely and unlikely situations near breeding grounds, we have found a few *S. ornatipes, S. nicholsoni,* and *A. bancrofti,* but the numbers taken were meagre in the extreme as compared with the abundance of larvae and pupae nearby. Their haunts are either very cryptic, or dispersal is immediate and wide. The latter view was held by Taylor (1944), and is supported by finding *A. bancrofti* in brigalow scrubs at Eidsvold at considerable distances from running water (T. L. Bancroft).

The early stages occurred in a wide variety of situations, and were not restricted to permanent water, nor to mountain streams; in fact, they were more prevalent at low than at higher altitudes. After the wet season, *S. ornatipes* colonized many little, temporary streams, and even roadside gutters, while there was a steady flow of water. All the species studied were facultatively herbicolous or lapidicolous. *S. clathrinum, A. furiosum,* and *A. mirabile* were only found in perfectly clear water; *S. ornatipes* also seemed to prefer clear water; but *S. nicholsoni* and *A. bancrofti* tolerated considerable degrees of muddiness, while *A. pestilens* was only found in very muddy streams.

The species also showed definite preferences in the speed of water in which the larvae lived. Of the coastal species breeding in clear water, *S. clathrinum* and *A. bancrofti* preferred the fastest, *S. nicholsoni* not so fast and with a wider range, and *S. ornatipes* the slowest. Inland, where the gradient varies little and all streams are senile, this relation to speed of water (and perhaps also to muddiness) resulted in a definite succession of species following the floods. While the creeks and rivers were in flood, *A. pestilens* bred in almost pure culture, thriving in the turbulent, muddy water, which seemed unsuitable to other species. As the rate of flow diminished and the water cleared somewhat, other species appeared, and displaced *A. pestilens* entirely. *A. bancrofti* and *S. nicholsoni* thrived at this stage, and to a lesser extent *S. ornatipes,* which, however, alone remained when the stream was reduced to a mere trickle.

How these inland species survive the long, dry summer, when all watercourses cease to flow is at present a mystery. Larvae die rapidly when removed from water, and it seems unlikely that pupae could survive the heat and dryness associated with a dry creek bed. Among the countless pupal shells left by the

receding flood, there is always an appreciable number containing unemerged adults. Most of those recently exposed probably emerge (as they do in the laboratory), but those long exposed appear to be completely desiccated, and showed no sign of reviving when placed in the "bubbler." The adults appear to be short-lived, and the most plausible theory seems to be that there is a resistant egg stage which tides the organism over to the next wet season. We have so far experimented only with S. *ornatipes*, and have not yet succeeded in hatching dried eggs in the laboratory.

IV. Keys to Species of Simuliidae

(*a*) *Adults*

1. Antennae 11-segmented 2
   Antennae 10- (sometimes 9-) segmented (*Austrosimulium*) 5
2. Large species with strongly humped, orange scutum, fawn to yellowish fore legs and antennae ..... *Cnephia tonnoiri fuscoflava* n. subsp.
   Smaller, darker species; scutum of normal form and with dark integument; neither fore legs nor antennae entirely pale (*Simulium*) 3
3. Prealar area bare; legs banded conspicuously with creamy-yellow ..... S. *ornatipes* Sk.
   Prealar area with conspicuous pale scales; legs not as above 4
4. Frons of female one-seventh of head width, abdominal segments 2 to 9 entirely black dorsally; male with upper eye facets more enlarged than usual; scutum in both sexes with indefinite golden median and dorsocentral lines, and veins of wing-root very dark ..... S. *clathrinum* n.sp.
   Frons of female one-fourth of head width, at least tergites 5 to 8 of the abdomen with conspicuous pale lanceolate scales dorsally; male with upper eye facets normally enlarged; scutum in both sexes without trace of median and dorsocentral lines, and veins of wing-root yellow to brownish ..... S. *nicholsoni* n.sp.*
5. Wings with three dark spots behind costa; antennae long, with fourth to sixth segments orange ..... *A. mirabile* n.sp.
   Wings unspotted; at most basal two segments of antenna paler than rest 6
6. Abdomen entirely dark dorsally ..... *A. furiosum* (Sk.)
   Abdomen of female with median and sublateral ashy patches dorsally; of male with shiny, ashy, sublateral patches which are visible in dorsal view 7
7. Antennae 10-segmented; third segment in female little larger than second ..... *A. pestilens* n.sp.
   Antennae 9-segmented; third segment in female markedly larger than second ..... *A. bancrofti* (Tayl.)

* The unique female of S. *faheyi* Tayl. would run nearest to S. *nicholsoni* in the key, but it is distinguished by its brown and gold rather than black and creamy coloration, and by possessing small teeth on the claws.

(*b*) *Early Stages*

Larvae old enough to show a pupal gill-spot and pupae may be recognized more easily from Figures 5 and 8 respectively than from a key. Larvae which do not show a gill-spot may be tentatively placed by means of the following key.

1. Anal sclerite without backwardly-directed strut (*Cnephia* and *Simulium*) 2
   Anal sclerite with backwardly-directed strut (*Austrosimulium*) 5
2. Ventral papillae absent 3
   Ventral papillae present (rectal gills simple) 4
3. Rectal gills compound ..... S. *clathrinum* n.sp.
   Rectal gills simple ..... *C. tonnoiri fuscoflava* n. subsp.
4. Head pattern "positive" type*; robust, dark species ..... S. *ornatipes* Sk.
   Head pattern "negative" type*; more delicate, yellowish species ..... S. *nicholsoni* n.sp.
5. Ventral papillae present 6
   Ventral papillae absent 7
6. Chitinous rod encircling tip of abdomen ventral to anal sclerite ..... *A. mirabile* n.sp.
   No such rod present ..... *A. furiosum* (Sk.)
7. Anal sclerite stout, angle between anterior limbs usually less than 90°; submental teeth reduced to 7 ..... *A. bancrofti* (Tayl.)
   Anal sclerite delicate, angle between anterior limbs usually greater than 90°; submental teeth 11 ..... *A. pestilens* n.sp.

V. The Genus Cnephia End.

Cnephia tonnoiri fuscoflava n.subsp.

Simulium tonnoiri Drummond, 1931, p. 6. (typical subspecies)

Larva

The full grown larva measures 6.5 to 7 mm., and is robust, usually grey or brown in colour and distinctly darker towards the tip of the abdomen, which is particularly stout. Head capsule usually heavily pigmented, pattern on dorsum (when detectable) as in Figure 2c. Submentum and antennae as in Figures 2a and 2b; base of cephalic fans dark; ventral notch of head capsule wide and shallow.

Gill-spot (Fig. 2d) broad, irregularly L-shaped, with the horizontal limb directed backwards. The arrangement of the filaments is unusual, in that, having turned posteriorly once (forming the right-angle of the L), they fold back on themselves ventrally and anteriorly, so that the tips of the filaments come to lie along the anterior face of the vertical limb of the L. In the species of *Simulium* studied, the filaments are coiled posteriorly.

Rectal gills simple; anal armature as in Figures 2e and 2f; no ventral papillae, but slight ventrolateral swellings are present as in S. *clathrinum*. The posterior

* Edwards (1934) defines the markings of the head-capsule as "positive" when the insertions of the muscles are darker than the surrounding chitin, "negative" when they are paler.

circlet is armed with about 120 rows, each row containing about 15 spines, which are relatively long, so that the circlet appears wide.

Pupa

Length 3 to 3.5 mm. Head and thorax smooth; thoracic hairs scanty, rather stiff and curly. Gill filaments (Fig. 2g) branched, variable in number, usually 15 to 20 being present. There are three main trunks (dorsal, ventral, and lateral) arising from a very short common stem; these give rise to other branches, which in turn may branch again. Abdominal armature (Fig. 2h) distinctive in having numerous, well-developed, backwardly-directed, sub-basal spines on the dorsal surface of segments 5 to 9, and in possessing a pair of stout, terminal hooks, which curve upwards and forwards.

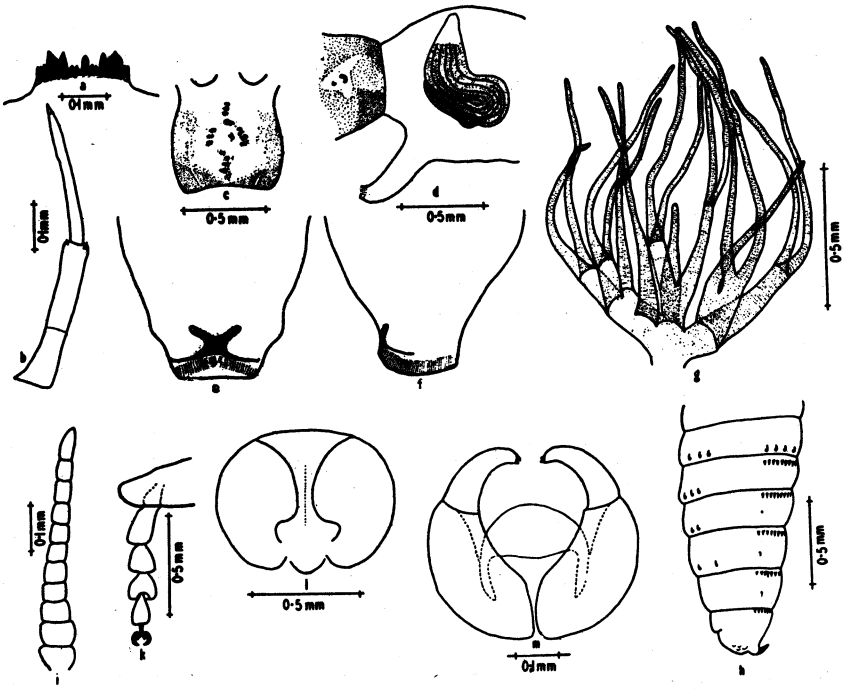

Fig. 2.—*Cnephia tonnoiri fuscoflava* n.subsp.

Larva: a. submentum; b. antenna; c. head (dorsal view); d. gill-spot; e. dorsal view of anal armature; f. same, lateral view. Pupa: g. gill filaments; h. lateral view of abdominal armature. Adult: i. antenna of female; k. hind tarsus of female; l. head of female; m. hypopygium of male.

Cocoon

Tough, coarsely woven, with foreign matter incorporated in it; soft, and completely lacking the precise form and clear outlines of the cocoons of other Queensland Simuliidae. In shape it is a narrow bag, with a pointed, V-shaped closed end, and an irregular opening, through which more or less of the gill filaments project. The cocoons are frequently obscured by filamentous algae.

Female

Length: 3 to 3.5 mm., wing 2.5 to 2.8 mm.

Head: Frons dark grey, about one-tenth of head width at narrowest point (Fig. 2l), with fine, pale golden hairs, which become denser and longer towards the occiput; face dark grey, with pale golden hairs. Antennae (Fig. 2i) almost uniformly fawn coloured, perhaps slightly darker towards base of third segment, with coarser hairs on the basal three to four segments than in other Queensland species. Palpi and mouth-parts black.

Thorax: Scutum strongly arched, orange, covered with fine, pale golden hairs, which are denser in front of scutellum, which is also orange. Pleurae fawn coloured, anterior spiracles ringed with black, mesosternum dark grey. There is the upper mesepimeral hair tuft seen in all species, but no propleural, prealar, or mesosternal hairs.

Wings: With yellowish veins and two dark spots, one around the transverse vein at the root of the wing, and the other at the fork of R (and including r-m). Chaetotaxy normal, with a single row of long macrotrichia on the upper surface of the distal part of Rs. Distinct spiniform macrotrichia on costa but not on R_1. Cu_1 gently sinuous. Halteres uniformly creamy-fawn.

Legs: Fore legs fawn, darkening towards tips of tarsal segments; mid legs fawn, suffused with dark grey; hind legs almost entirely dark grey, but with an underlying brownish suffusion. Calcipala very large, blackish; pedisulcus small but quite distinct; claws with a strong basal tooth (Fig. 2k).

Abdomen: Dark, greyish-brown, covered fairly densely with pale creamy-gold hairs. Genital fork similar to the species of *Simulium*.

Male

Slightly larger than female, but otherwise similar, except for the large, holoptic eyes, darker mid and hind legs, and almost black ground colour of the abdomen. Hypopygium as in Figure 2m.

Taxonomic Notes

Holotype female, allotype male, and morphotype pupa and larva, from Dunwich, Stradbroke Island, S. Queensland, 10.x.47, in collection of the Division of Economic Entomology, C.S.I.R., Canberra.

This species was discovered by Miss E. N. Marks after the body of the paper had been completed and the figures prepared for publication. It has therefore been necessary to treat it separately, which is not inappropriate as it stands widely apart from other known Queensland members of the family. It is closely related to *C. aurantiacum* (Tonn.) from south-eastern Australia and Tasmania, but still nearer to *C. tonnoiri* (Drum.) from Western Australia. From the former, it is to be distinguished in the adult by lacking propleural hairs and possessing a well-defined dark spot on the wing, in the pupa by its markedly coarser, less numerous gill filaments, and in the larva by its somewhat narrower gill spot (cf. Fig 6A in Tonnoir 1925) and larger, less numerous teeth in the posterior circlet (about 15 as compared with 30). Its differences from typical *C. tonnoiri* are minor but apparently constant. The adults are distinctly darker, especially the mid and

hind legs, but we could find no structural differences; the gill filaments of the pupae are a little coarser and fewer (15 to 20 as compared with 20 to 30 in the typical form); and the gill-spot of the larva is somewhat broader, and the teeth of the posterior circlet somewhat fewer (18-24 in typical *C. tonnoiri*). Incidentally, the cocoons of *C. aurantiacum* often show some approach to a definite form, whereas those of the other two are little more than shapeless bags.

The presence of propleural hairs in the adults of *C. aurantiacum* is a definite specific character, but no such clear distinction could be found between our material and typical *S. tonnoiri*, of which, thanks to Dr. A. J. Nicholson, we had a good series for comparison. Nevertheless, we can distinguish consistently between the two, and so feel that subspecific rank would best indicate their relationship.

Biology

Eggs were not found, but larvae of all ages were abundant in clear, moderately fast, somewhat peaty water flowing in a narrow, man-made channel, and in a small, sunlit, natural stream on the narrow coastal flat just before it ran out onto the beach. They were attached to vegetation, to submerged sticks and logs, and especially to long grass blades just beneath the surface. Pupae were found in the same situations, crowded together, often overlapping one another, and frequently so matted with filamentous algae as to be difficult to detect. Pupae kept out of water in moist jars continued to emerge for 3 to 4 days after being collected.

Adults were not observed in the vicinity of their breeding places, and none was taken by sweeping. This species has not been recorded as attacking man or domestic animals in the nearby settlement.

Distribution

Dunwich, Stradbroke Island, 28.ix.47 (E. N. Marks), 10.x.47 (authors).

VI. The Genus Simulium latr.

Simulium ornatipes Skuse

Simulium ornatipes Skuse, 1890, p. 595; Tonnoir, 1925, p. 232; Drummond, 1931, p. 6; Taylor, 1944, p. 213.

Egg

Pear-shaped, approximately 0.2 mm. by 0.13 mm., laid side by side, with long axis at right angles to the substrate and the narrower end pointing upwards. The eggs are glued securely together and to the leaf or stone on which they are deposited.

Larva

Length of full-grown specimens 6 to 6.5 mm. Body creamy, grey, or greenish, irregularly mottled with darker patches. Melanic individuals are frequent. Pattern on dorsum of head variable, often as in Figure 3. Antenna and submentum as in Figure 4a. Gill spot large, black, conspicuous (Fig. 5). Rectal gills consist of three simple digitations. Anal armature as in Figure 6. Ventral papillae present. The posterior circlet ("sucker") is armed with about 60 to 70 rows of spines, 10-20 spines per row.

Pupa

Length 2.5 to 3 mm. Head covered fairly evenly with small flat tubercles, cephalic hairs fine and short; thorax similarly covered, thoracic hairs fine, simple, inconspicuous. On the dorsum of the abdomen, the second segment bears a row of hairs, the third and fourth each carry 4 forwardly-directed strong hooks on each side of the midline, the seventh and eighth segments have 5 or more backwardly-directed, flat, sub-basal spines on each side of the midline, and the terminal segment bears a pair of small, strong hooks. On the ventral surface, the fourth segment bears a pair of forwardly-directed hooks, the fifth, sixth, and seventh each 2 pairs, those on the fifth segment being placed close to the midline, whilst the others are more or less widely spaced; the hooks are usually bifid.

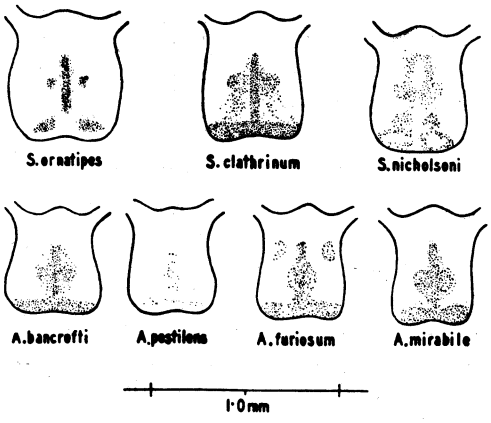

Fig. 3.—Larvae. Dorsal view of heads.

The respiratory organ on each side consists of a short wide stem, from which spring four long, wide, thin-walled tubes or filaments. These filaments are arranged in a characteristic way in life, one limb of the external pair being directed upwards and inwards and crossing its fellow from the opposite side, and the other limb, which is the longest of the four, pointing directly forwards. The limbs of the inner pair are directed upwards and forwards.

Two forms of *S. ornatipes* have been observed, which differ only in the length of the gill filaments. In one, the filaments taper gradually to a blunt point, and measure 2.5 to 3.0 mm.; in the other form they are short, wide tubes which measure 1.4 to 2.0 mm. (Fig. 7). Both forms vary considerably, but intermediates difficult to place in either category are uncommon. The two forms have been taken together in many localities, often on the same blade of grass, but we have occasionally taken only one of them. For example, in a small stream at Brookfield, only "long horned" forms were found at numerous examinations from February to June; whereas, in fast running water in Heifer Creek in March, only "short horned" forms occurred (one examination). We have the impression that the "long horned" forms are better adapted for survival when the flow of water

is reduced. It would clearly be unwise to give these forms any taxonomic status until a great deal more is known about them.

Cocoon

Wall-pocket type (Fig. 8), rather coarsely woven, with an irregular margin which projects anteriorly to a variable degree in the mid-dorsal line. The sides of the cocoon do not meet below the head of the pupa, in contrast to the cocoons of the Western Australian forms, which often have a distinct collar (Drummond 1931). The ventral wall of the cocoon is incomplete, only covering the abdomen of the pupa.

Female

Length: 2.7 mm. to 3.3 mm.; wing 2.1 mm.

Head: Frons narrow, one-seventh head width (Fig. 9), with greyish tomentum and unevenly distributed, white, lanceolate scales, which extend behind the occiput, where they become more golden. Face similar, but tends to be more silvery. Antennae (Fig. 10a) with first two segments brownish-yellow, remainder dark brown with short, shining, white hairs. Mouth-parts and palpi greyish-brown, with paler hairs.

Thorax: Scutum brownish-black, with inconstant traces of paler median and dorsocentral lines; covered for the most part with black lanceolate scales, and much more conspicuous white and golden ones, which are somewhat irregularly arranged. There is a zone of whitish scales above the lateral and anterior margins, irregular golden dorsocentral patches posteriorly, and a rather dense paler zone in front of scutellum. Scutellum black, with golden hairs; metanotum dark brown. Pleurae grey, without prealar patch of scales.

Wings: Clear; R with macrotrichia above. Halteres with knob and most of stem pale cream, base somewhat darker.

Legs: Fore coxae entirely cream, rather densely covered with whitish hairs anteriorly. Mid coxae cream, with more or less greyish suffusion. Posterior coxae grey, creamy towards tips. Femora creamy-yellow, with narrow blackish zone apically (very narrow on anterior legs, wider on posterior legs). Fore tibiae creamy-yellow, with darker zone at base and apically; mid tibiae with dark subbasal area, creamy-yellow proximal half, and dark distal half; hind tibiae mainly dark, with a creamy-yellow band extending from one-quarter to half the tibial length from the base. Fore and mid metatarsi entirely dark, hind creamy-yellow on basal three-fourths, dark apically. Subsequent tarsal segments of all legs dark, except base of hind second tarsal which is pale. Calcipala, pedisulcus, and claws as in Figure 11a.

Abdomen: Brownish-black dorsally, light yellowish-brown ventrally, the two areas being divided about the mid-lateral line. First visible segment has usual fringe of pale hairs, and subsequent segments have zones of conspicuous large pale scales, which tend to form an indefinite pattern of a median stripe and transverse bands towards the apices of segments. Genital fork as in Figure 12a.

Male

Darker and more slender than female. Antennae with basal two segments yellow; remainder dark brown, fading towards tip. Proportions of segments much as in female, but third segment relatively slender (Fig. 10h). Mouth-parts and palpi darker than in the female. Scutum black, covered dorsally with black and dark bronzy lanceolate hairs. Lateral margins and whole of sublateral areas anteriorly with relatively dense, whitish, lanceolate scales, darkening to gold posteriorly; very indefinite dorsocentral and median lines of golden scales, and dense paler ones on front of scutellum. Wings with veins darker than in female; halteres with knob creamy-yellow, stem and base brown. Legs as in female, but pale portions a darker yellow.

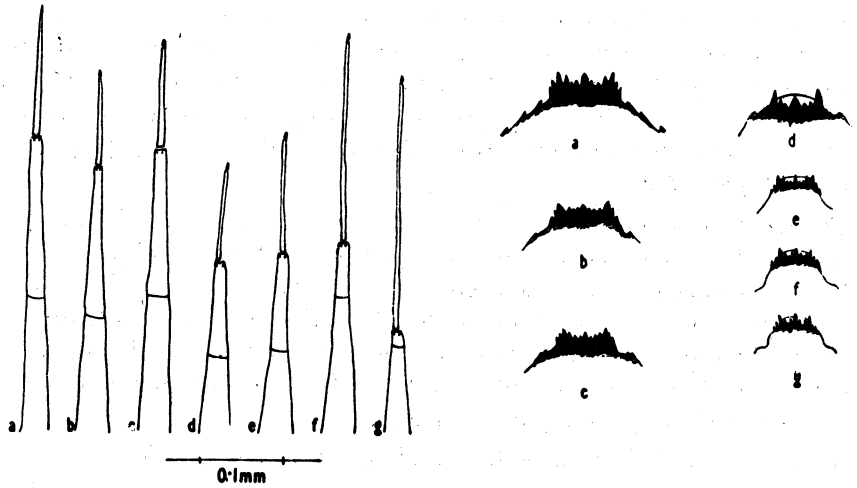

Fig. 4.—Larvae. Antennae (left) and submental teeth (right) of: a. *Simulium ornatipes* Sk.; b. *S. clathrinum* n.sp.; c. *S. nicholsoni* n.sp.; d. *Austrosimulium bancrofti* (Tayl.); e. *A. pestilens* n.sp.; f. *A. furiosum* (Sk.); g. *A. mirabile* n.sp.

Abdomen black dorsally, except for the second segment, which is extensively grey in the sublateral region. Venter pale brownish-yellow, with the dark colour of the dorsum tending to extend a little more ventrally on the posterior segments than in the female. Fringe of pale hairs on basal segment very conspicuous laterally, creamy at base, silvery towards the tip. Paler hairs on dorsum forming a very indefinite central golden stripe on most segments in some specimens, while in others the golden patches are more extensive and tend to form apical bands. Conspicuous pale gold to silvery patches on segments five to nine. Hypopygium as in Figure 13.

Taxonomic Notes

The description of all stages was based on specimens from Brookfield, near Brisbane. *S. ornatipes* is very distinctive in the Australian fauna by reason of its leg markings and pupal respiratory filaments, but it was thought wise to describe

the local form in some detail, as it is possible that subspecific differentiation may exist in different parts of the extensive range of the species.

Biology

We know nothing of the natural feeding habits or resting places of the adults, the only specimens taken in the field being ovipositing females. In the laboratory, the adults were strongly phototropic; they fed fairly readily on raisins or fresh fruit, but refused, in the few trials made, to take human blood. They survived up to five days in small jars, and considerable development of the ovaries occurred on the fruit diet. Over 150 follicles were present in each ovary.

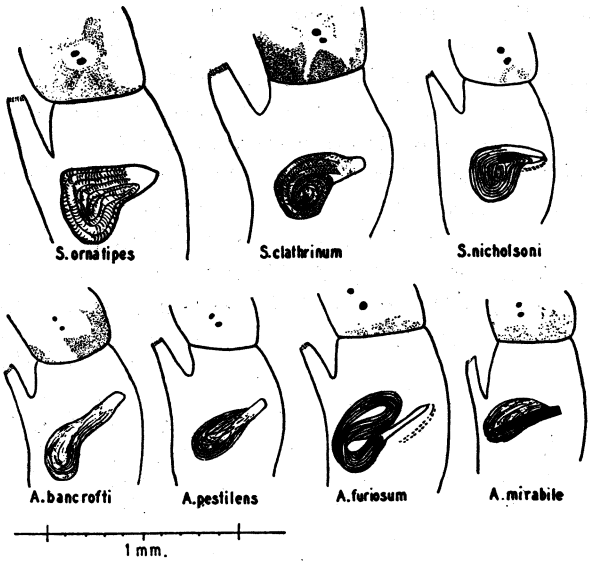

Fig. 5.—Larvae. Lateral view showing gill-spots.

The breeding grounds were widespread and varied, hardly a running stream from the New South Wales border to Rockhampton failing to harbour the early stages at one place or another. They were found most frequently alone in smaller, grassy streams with a moderate flow (Plate 1, Fig. 1); but they also occurred in faster water in company with *S. nicholsoni* or *S. clathrinum* and occasionally with *A. bancrofti*. At the other extreme, they were found in mere temporary trickles in road-side gutters. Always they were in fairly to quite clear water.

Females have been observed in several localities ovipositing on logs and rocks in a fairly fast current (Plate 1, Fig. 2). They were active in the morning about 9 a.m., and also in the afternoon, especially towards sundown. Sometimes only single individuals were seen, but more often there was a little cloud of perhaps a dozen or so apparently competing for the favoured spot. The females hovering a few inches above the water would settle, often two or three at a time, on the exposed surface of the object, and then back down until they could deposit their eggs at the very edge of the water. They were not seen deliberately to crawl

under the water. Females in the act of ovipositing clung tightly to their support, and were often not carried away even though a wave washed right over them. When they were washed off, or dislodged by other females, they would quickly return to the spot and soon settle again. The result is that each large sheet of eggs is a mosaic of the ovipositions of many females, each one contributing several small groups of eggs, separated from one another by groups laid by other females, and the whole cemented together into an even, uniform sheet. Sometimes a rock a foot in width would be ringed by a band of eggs perhaps two inches wide.

It is curious that throughout the work this is the only species that we saw ovipositing, and the only one of which we found the eggs.

On rocks and logs, the eggs were frequently found in the sheets described, though sometimes in small batches (about a centimetre in width) which may have been the product of a single female. On grass, on the other hand, they were generally in small, separate batches, but sometimes the patches were two or three centimetres long, again suggesting the work of more than one female. When freshly laid, the eggs were white, and they gradually developed a light brown shade, with dark brown tips. The brown colour hid them on rocks and logs, but made them conspicuous, easily found objects on grass.

In the laboratory, the duration of the egg stage was about 5 days in late summer, when the temperature of the water varied from 24° to 29°C.

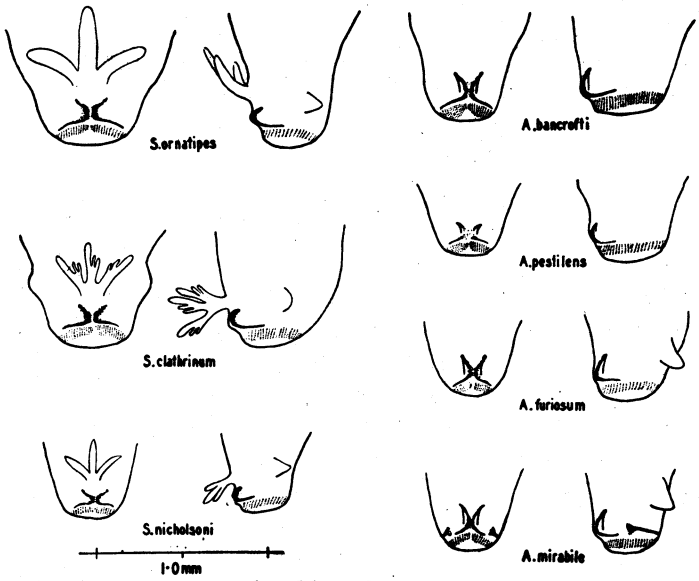

Fig. 6.—Larvae. Dorsal and lateral views of terminal segments.

In the field, the larvae occurred in all the situations mentioned above, and also in artesian bore drains at Cunnamulla (T. Greaves). They favoured clear water, but could tolerate suspended matter at least to the degree of opalescence.

They showed the typical Simulium habit of spacing themselves so that each one was a little apart from its neighbours, and they reacted to intruders by vigorous striking movements with their heads. Most commonly they were attached to blades of grass, or other vegetation, within an inch or so of the surface, but were also frequent on stones. As the water level fell, they would move downwards, and could sometimes be found on stones and dead leaves when there was only just sufficient water to cover them and the flow was reduced to a mere trickle.

Pupae were found with the larvae, but showed some tendency, though not as marked as with some other species, to concentrate in situations a little protected from the direct force of the current.

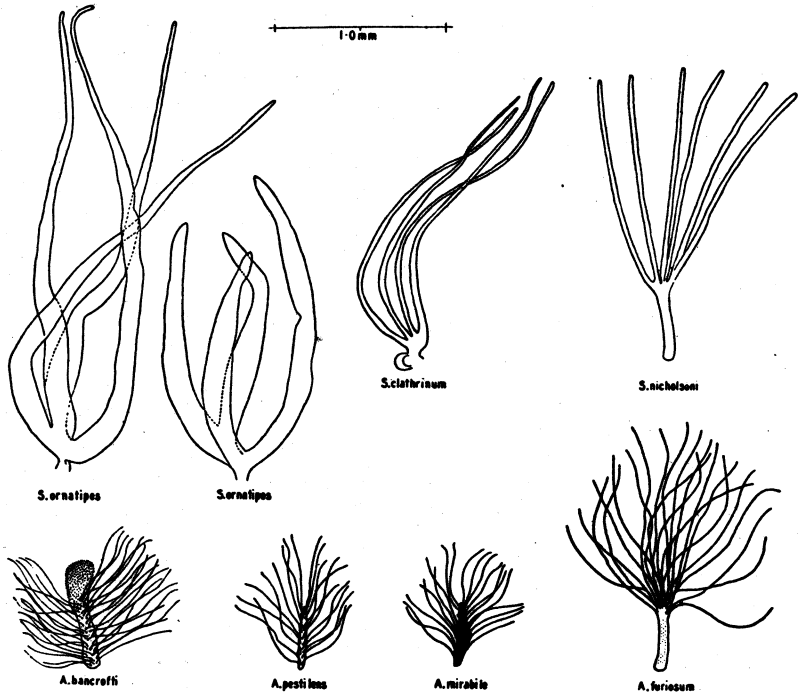

Fig. 7.—Pupae. Lateral view of breathing horns. *Note*: For the sake of clarity not all the gill filaments are shown in *A. bancrofti, A. pestilens,* and *A. mirabile.*

In the laboratory, some of the newly hatched larvae began feeding at once, others floated away still attached to the egg site by a silken strand issuing from their mouths. These strands became entangled in water weeds etc., and enabled the larvae to get a grip in a fresh place. They fastened themselves by their posterior circlet, and fed in exactly the same way as the large larvae. Larvae required a clean surface to fasten themselves to, and perished rapidly if the glass jars became slimy. The majority of these larvae required over 3 weeks for their development, the minimum larval periods recorded in two batches being 20 and 22 days. This is probably considerably in excess of what is required in the field

under ideal conditions. We strongly suspect that neither the food nor the composition of the water in the jars remained satisfactory for long. The really favourable situations, too, seemed to be limited, and very great variation in rate of growth was observed, some larvae being still tiny when others had reached full size.

When ready to pupate, larvae frequently moved about for some time, apparently seeking a suitable spot, but seldom moving out of the current. They usually began cocooning rather intermittently, and in the intervals of resting could be readily distinguished from feeding larvae by the position of their mouth brushes, which were not extended. They required about half an hour to complete the cocoon. The larva then let go its hold by its posterior circlet, and, lying transversely across the mouth of the cocoon, assumed a U-shape with the loop of the U within the cocoon. It then kept up a to-and-fro, semi-rotary movement, until the larval skin burst. This usually required from 3 to 10 minutes. As the pupa extracted itself from the larval skin, the abdomen was pushed down into the cocoon, and the thorax with expanding gill filaments filled the mouth of the cocoon. For several minutes the pupa continued to fidget about within the cocoon, sometimes rotating completely round. This movement served to entangle the abdominal hooks in loose strands of silk and so hold the pupa firmly in the cocoon. Meanwhile the gill filaments uncoiled and gradually took up their characteristic positions. Tonnoir (1923) has figured the process clearly in a New Zealand species, *Austrosimulium tillyardi.*

Newly formed pupae were pale yellow, but very rapidly the imaginal head with its reddish eyes became differentiated, the thoracic appendages became visible, and the whole insect darkened. On the third day, the pupa was very dark, and began to make intermittent, slow, writhing movements. A layer of air was then secreted under the pupal skin, giving it a silvery appearance. When the pupal skin split, the fly quickly freed itself from the old skin, and, still enclosed in its bubble of air, rose to the surface. Although the wings frequently contained some yellow fluid at this stage, the insect could usually take off successfully straight away from the surface of the water. The pupal period lasted 3 days in late summer at 24° to 27°C., and 7 days in winter, when the temperature of the water varied from 9° to 22°C. in the 24 hours.

Summarized, the developmental periods observed in summer were:

egg — 5 days
larval — 20 days (minimum)
pupal — 3 days.

The first and the third are probably fairly accurate, the 3-day pupal period in particular being supported by numerous observations on pupating larvae collected in the field, and apparently being normal for several species. Judging by the growth of larvae of various ages collected in the field and set up fresh in the "bubbler," we would guess at the normal developmental period from oviposition to adult as between two and three weeks.

S. ornatipes is adapted to survive great reduction in flow, but it disappears when flow stops. Whether it survives in a few streams that continue to trickle; and recolonizes the others after rain, or whether it has a drought-resistant stage, we do not yet know. Eggs which had not been dried, hatched in still as well as in circulating water, but in the former the larvae quickly died; there was no evidence of suspended development in still water. Owing to the habit of the female of laying at the water edge, large sheets of eggs were often found in situations which would assuredly be dry next day, owing to the rapid fall in water level as the floods subsided. This suggested that the eggs might be resistant to drying, but dried eggs did not hatch when subsequently wetted, although they swelled and split, and dead larvae protruded from the openings.

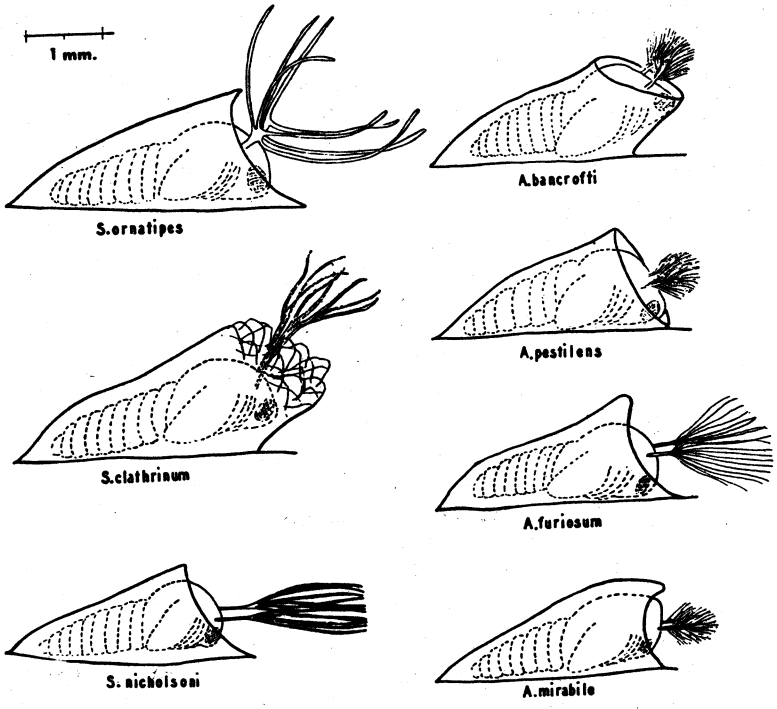

Fig. 8.—Cocoons. Lateral view.

Distribution

Brisbane district—Brookfield, February to June, absent from August to November; Moggill Ck., June 29; South coast—Mudgeeraba Ck., March and May; Springbrook, March; Mt. Tamborine, March; Samford district—Dawson Ck., April; South Pine R., April; Southern Tableland—Heifer Ck., March; Stanthorpe, March; Dalby—Back Ck., April; Chinchilla—Charley Ck., April; Cunnamulla, November 1946 (T. Greaves); Brisbane R., Wivenhoe, April; Blackbutt Range, April; Nanango, April; Kilcoy (Sheep Station Ck.), May; Goomeri (Barambah Ck.), May; Gayndah (Barambah Ck. and Reed's Ck.), May; Eidsvold (Burnett

R. and numerous creeks in district), April and May; Dawson R. (Camboon Woolshed, Theodore), April; Dee R. (Rannes), April; Don R. (Calliungal), April; Callide R. (Calliungal), April, May; Mt. Morgan, April; Rockhampton, April.

SIMULIUM CLATHRINUM n.sp.

Larva

Length 5.7 to 6 mm. Body greyish or greenish, irregularly mottled with darker areas. Head usually heavily pigmented, bases of the cephalic fans and mouth-parts all darker than in S. *ornatipes*. Pattern on the dorsum of the head variable; a common arrangement is shown in Figure 3. Submentum darker than in S. *ornatipes*, with 5 to 7 stout, dark spines on each side; arrangement of teeth as in Figure 4b; antennae as in Figure 4b (left). Gill spot rather small, pear-shaped (Fig. 5). Rectal gills compound, each of the three main divisions subdivided into three, occasionally four, unequal processes (Fig. 6). Anal armature as in Figure 6. Ventral papillae absent. Posterior circlet consists of about 90-95 rows of spines, with 12-16 spines per row, the whole appearing as a wide, closely set band.

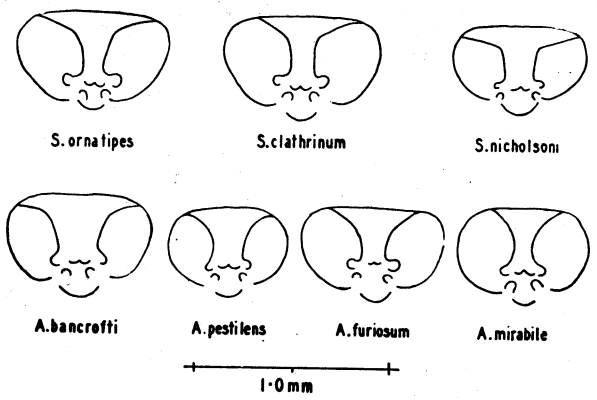

Fig. 9.—Adults. Front view of heads of females.

Pupa

Length 2.5 to 3 mm. Head smooth, cephalic hairs fine, longer than in S. *ornatipes*. Anterior part of thorax smooth, except for a row of small, flat tubercles on each side of the suture line; posterior part of dorsum covered with small tubercles. Thoracic hairs fine, simple, moderately long. Abdominal segments armed similarly to S. *ornatipes*, except that the venter of the fourth segment bears a pair of stout hairs instead of hooks. There are four slender gill filaments arising from a narrow, dark stem on each side (Fig. 7). Each filament tapers to a fine point. The stem and filaments are covered by irregular interlacing rows of minute, black spines, which give them a dark appearance.

Cocoon

Shoe-shaped (Fig. 8), rather coarsely woven, anterior margin produced into a number of interlacing loops, which narrow the opening and give a lattice-like appearance, from which the name is derived (*clathri* - lattice). The gill

filaments, which only protrude a little through the opening in life, are usually bunched together, with the filaments intercrossing.

Female

Length: 2.3 to 2.9 mm.; wing 2.5 mm.

Head: Frons narrow, about one-seventh head width (Fig. 9), brown, with greyish reflections; lanceolate scales down either side, leaving a narrow tomentose strip in middle. Face with grey tomentum, rather densely covered with similar pale scales. Antennae with basal two segments brownish-yellow, extreme base of third brownish-yellow, remainder almost black, with very fine white hairs, form as in Figure 10b. Mouth-parts and palpi blackish.

Thorax: Scutum black, covered for the most part with black lanceolate scales; with a zone of creamy ones along each lateral margin and across front of the scutum, and three somewhat indefinite golden stripes occupying the median and dorsocentral lines; area in front of scutellum rather densely covered with dark golden scales, and a small, dark golden patch anteriorly in each sublateral area. Scutellum black, with dark golden scales. Pleurae dark grey, with a conspicuous prealar patch of white, lanceolate scales, and a small tuft of black upper mesepimeral hairs.

Wings: Costa black, R_1 dark brown, remaining veins light brown. The stem vein and other veins making up the triangle at the base of the wing, including the alular area, are almost black, and the membrane in this area appears to be suffused with grey, so that, in the live specimen with the wings held back, there is quite a conspicuous broad black band across the body behind the silvery sheen on the posterior part of the scutum. This contrasts quite strongly with the appearance in *S. ornatipes* and *S. nicholsoni*. Halteres with knob pale lemon-yellow, stem and base dark brown.

Legs: Appear to be entirely dark, except for basal four-fifths of hind metatarsi, which are dull creamy-yellow. Fore legs—coxae covered anteriorly with conspicuous white hairs; femora with dense, white to creamy-yellow scales, extending half way down the femur anteriorly and to the apex posteriorly; tibia with dense, conspicuous, lateral zone of white scales on basal four-fifths; remaining segments entirely dark. Mid legs—basal two-thirds of femora with white to creamy scales anteriorly, remainder dark; a lateral pale zone on basal four-fifths of tibia extending partly round anterior and posterior aspects; metatarsus with lateral patch of white scales on basal half; remaining segments dark. Hind legs—coxae lacking the conspicuous white hairs of other legs; dark apical fourth of femur better defined; knees yellowish; dark apical portion of tibia also better defined; basal four-fifths of metatarsus with pale scales on all sides; second tarsal narrowly pale at extreme base; remaining segments dark. The zones of silvery scales on the tibiae are more extensive, denser and more conspicuous than in *S. nicholsoni*. Hind tibiae distinctly swollen, and somewhat angulated in distal fourth. Calcipala, pedisulcus, and claws as in Figure 11b. As in *S. nicholsoni*,

some specimens show quite conspicuous pale markings on legs underlying the scales described above.

Abdomen: Completely black dorsally, except for the fringe on the first segment, which forms a narrow transverse white line across the base of the abdomen, and a lunulate grey zone at base of second segment. Second to fourth segments and sublateral part of fifth segment covered with black lanceolate scales, remaining segments rather shiny. Lateral margin with conspicuous zones of white hairs on second to seventh segments, most clearly defined on the second, third, and fourth. Venter brown, much darker posteriorly, the colour extending up the lateral aspect of the second segment. Genital fork as in Figure 12b.

Male

Face with ashy tomentum and silvery lanceolate scales. Colouration of antennae similar to female, except that the basal two segments are streaked longitudinally with dark brown. Mouth-parts and palpi black. Scutum black, covered with black and dark bronze scales across the central zone; anterior, lateral and posterior zones covered with dark golden scales, and there are indefinite median and dorsocentral stripes of dark gold; the golden hairs of the lateral zone show almost creamy in certain lights. Scutellum black, with dark gold hairs. Pleurae dark grey, with creamy zone in front of wing-root; prealar patch of scales as in female. Wings and halteres as in female, except that knob of halter is darker yellow. Legs darker than female, and zones of cream or silvery scales more restricted, forming a patch only on basal third of mid and hind tibiae, and being absent from mid metatarsus.

Abdomen black dorsally, except for a conspicuous ashy patch sublaterally on second segment. Most of the dorsum is covered with velvety tomentum, except the sublateral areas of the fifth, sixth, seventh, and eighth segments, which are quite conspicuously shining. Lateral margins with only a trace on the third to fifth segments of the silvery hairs which are so prominent in the female. Venter dark brown, paler at the base. Hypopygium as in Figure 13.

Taxonomic Notes

Holotype female, allotype male, morphotype pupa and larva, from upper Mudgeeraba Ck., near base of Springbrook Mt., 16.iii.47, in collection of Division of Economic Entomology, C.S.I.R., Canberra.

S. clathrinum is a very dark species, which may be taken as representative of the group with prealar scales. The golden lines on the scutum, and bare distal abdominal segments sufficiently distinguish the adults from other members of the group; the pupal gill filaments are much more slender than those of *S. ornatipes* (the only other local species with four filaments), the fenestrated cocoon is quite distinctive, and the larvae are equally distinctive by reason of their compound anal gills.

Biology

Adults have not been taken in the field, and the eggs are unknown. The larvae were restricted to fast moving, clear streams, in which they attached themselves

to stones, grass blades, and occasionally logs. They concentrated where the torrent was most powerful. Pupae occurred, occasionally in quite dense masses, in the same situations.

Distribution

Mudgeeraba Ck., March and May; Little Nerang R. (foot of Springbrook Mt.), March; Mt. Tamborine, March; Albert R., June; Logan R., June (E. N. Marks); Moggill Ck., June; Dawson Ck. (lower slopes of Mt. Glorious), April; South Pine R., April; Brisbane R. (Wivenhoe), May; Gayndah (Barambah Ck.), May, Eidsvold (The Brook, Burnett R.), May.

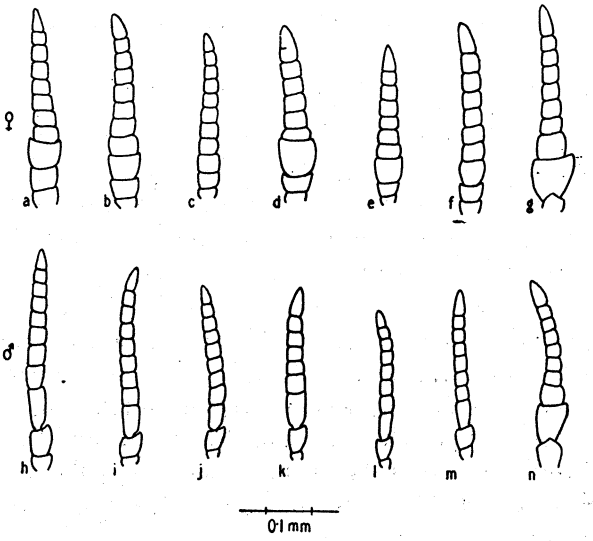

Fig. 10.—Adults. Antennae of females (top row): a. *Simulium ornatipes* Sk.; b. *S. clathrinum* n.sp.; c. *S. nicholsoni* n.sp.; d. *Austrosimulium bancrofti* (Tayl.); e. *A. pestilens* n.sp.; f. *A. furiosum* (Sk.); g. *A. mirabile* n.sp.
Antennae of males (bottom row): h-n in same order as females above.

SIMULIUM NICHOLSONI n.sp.

Larva

Length 4.7 to 5 mm. Body smooth, frequently with a yellow or greenish tint, and faintly mottled with brown or grey markings, head rather pale. Pattern on dorsum of head variable; a frequent arrangement is seen in Figure 3. Submentum with 4 or 5 spines on each side, submental teeth and antenna as in Figure 4c. Gill-spot small, pear-shaped (Fig. 5). Rectal gills consist of three simple digitations. Anal armature as in Figure 6. Two ventral papillae present. Posterior circlet consists of 60 to 70 rows of spines with about 10-12 spines per row.

Pupa

Length 2.5 mm. Head and thorax covered with small flat tubercles, cephalic and thoracic hairs fine, simple, inconspicuous. Abdominal armature essentially

the same as in *S. ornatipes*, except that a few backwardly-directed, flat, sub-basal spines are present on the dorsum of the sixth segment, and that the ventral surface of the fourth segment bears two pairs of simple hooks.

The gill filaments are six in number, and arise from a short, slender stem on each side (Fig. 7). They are narrow, thin-walled tubes, which taper very slightly to a rounded tip. The stem is covered with very minute spines.

Cocoon

Wall-pocket type, finely woven, the anterior margin thickened to form a narrow but definite rim. The sides of the cocoon do not meet anteriorly, and the ventral wall is incomplete, covering only the abdomen of the pupa (Fig. 8).

Female

Length: 2.0 to 2.4 mm.; wing 2.0 to 2.2 mm.

Head: Frons one-quarter head width, with grey pubescence and lanceolate creamy scales (Fig. 9); face similar. Mouth-parts brown; palp with penultimate segment black, terminal segment dark greyish-brown. Antennae with first two and base of third segment brownish-yellow, remainder deep brown, with fine white hairs; form as in Figure 10c.

Thorax: Scutum densely covered with lanceolate scales, predominantly golden in centre, more silvery towards sides; with dorsocentral, rather broad lines of black scales, which converge sharply in anterior quarter and diverge gradually towards scutellum. These lines are often vague and ill-defined. There is an incomplete transverse dark line behind shoulders, and darker markings in posterior part of sublateral areas. Scutellum black, with pale golden hairs on disc and black marginal fringes. Pleurae dark grey, with a conspicuous prealar patch of silvery scales.

Wings: Costa dark brown, remaining veins yellowish-brown. The stem vein and other veins of the wing-root are light brown in colour. Halteres with stem brownish, knob creamy to lemon-yellow in fresh specimens.

Legs: Almost black, with yellowish-brown knees, most conspicuous posteriorly; some suffusion of yellowish-brown underlying the white scales on hind tibiae, and more definitely on basal four-fifths of hind metatarsi. Anterodorsal surfaces of femora, basal two-thirds of tibiae, and basal four-fifths of hind metatarsi densely clothed with silvery lanceolate scales. Fore and mid metatarsi and all distal tarsi black. In some specimens the paler colouration, especially of the hind legs, is more marked and suggests *S. ornatipes*, but the silvery scale patches are distinctive. Calcipala and pedisulcus as in Figure 11c. The base of the claw is humped, but there is no tooth.

Abdomen: Black dorsally, bearing numerous but rather irregularly disposed large, pale, lanceolate scales, which tend to form apical bands on some of the segments; these pale scales are rather dense and conspicuous laterally. First segment yellowish-brown apically, with pale fringe, the lighter colour sometimes suffusing the whole segment. Venter dark brown. Genital fork as in Figure 12c.

Male

Face with silvery tomentum and conspicuous, pale creamy scales. Mouthparts and palpi brown. Antennae (Fig. 10j) with basal two segments dark brown, somewhat fulvous on inside, remaining segments brown, covered with minute, shining, pale pubescence. Thorax densely covered with almost black scales, mixed with bronzy ones over the greater part of the disc; with patches of gold on each side of the midline anteriorly and in front of scutellum, becoming almost ashy white on anterior, lateral and posterior margins of scutum. Scutellum dark brown, with blackish hairs. Metanotum deep brown. Pleurae pale grey, rather shining; prealar scales conspicuous, silvery. Wings normal. Halteres with stem fuscous, knob lemon-yellow.

Legs with all coxae black, covered with silvery scales anteriorly. Femora black, with some suffusion of brownish-yellow posteriorly, especially on the hind legs, and with rather dense but speckled covering of shining, white scales. Knees brownish-yellow. Tibiae with paler colouration underlying the dense, white scales on the basal half, most conspicuously on the hind legs. Fore and mid metatarsi black; hind with basal four-fifths somewhat indefinitely brownish-yellow beneath the covering of white scales. Remaining tarsal segments entirely dark.

Abdomen velvety black dorsally, brownish-yellow ventrally, with the black restricted by rather shining, grey, sublateral patches on the fifth to the seventh segments (similar to *A. bancrofti*, but not so conspicuous). These patches are sometimes extensive enough to reduce the black areas on 5th and 6th segments to large, median, isolated patches. There is a fringe of golden hairs apically on 1st segment, and rather indefinitely at the sides of subsequent segments. Hypopygium as in Figure 13.

Taxonomic Notes

Holotype female, allotype male, and morphotype pupa and larva, from Brisbane R., Wivenhoe, April 1947, in the collection of Division of Economic Entomology, C.S.I.R., Canberra.

S. nicholsoni is a smaller, more silvery species than *S. clathrinum*, lacks the golden lines on the scutum, and has the distal abdominal segments fully covered with scales. The pupae and cocoons are quite distinctive, while their distinctly yellowish colour usually makes the larvae easily recognizable in the field. The differences between *S. nicholsoni* and *S. faheyi* are noted below.

Biology

This is a wide ranging and abundant species, but we know little about the habits of the adults. Miss Marks has taken two specimens biting at Springbrook, in April, and we obtained a small series, mostly males, by assiduous sweeping of *Melaleuca* spp. in the bed of Barambah Creek, near Kilcoy, and one male on *Melaleuca* in the Callide River near Calliungal. Females have not been observed ovipositing, and the eggs are unknown. In the laboratory, two bred females took human blood fairly readily, but none of the bred adults survived for long, and

circumstances have so far prevented us from following up this initially encouraging observation.

Larvae and pupae occur in the larger, moderately fast streams, sometimes in company with *A. bancrofti*, sometimes with *S. clathrinum*, and sometimes with *S. ornatipes*. Occupying an intermediate position in relation to speed of water, they are found more often in company with another species than alone, though they do occur alone in water that is not fast enough for *A. bancrofti* and not clear enough for *S. ornatipes*. They seem to be equally at home in inland, fairly muddy waters as in clear, coastal streams. They will attach to any hard, clean surface, though they are perhaps most frequent on twigs, broken branches, and dead leaves caught on obstruction within about 6 inches of the surface in places where the water is flowing freely.

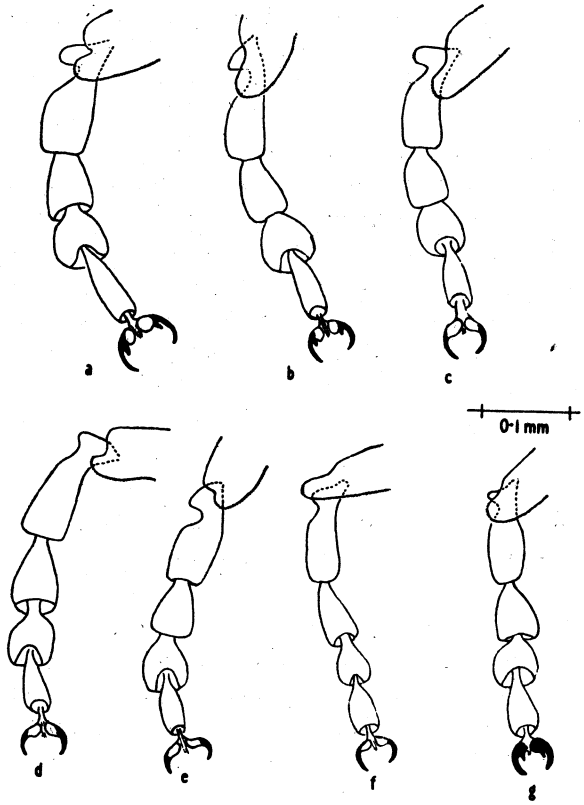

Fig. 11.—Adults. Tarsal segments of females of: a. *Simulium ornatipes* Sk.; b. *S. clathrinum* n.sp.; c. *S. nicholsoni* n.sp.; d. *Austrosimulium bancrofti* (Tayl.); e. *A. pestilens* n.sp.; f. *A. furiosum* (Sk.); g. *A. mirabile* n.sp.

In the laboratory, the pupal stage lasted 2 to 3 days in summer. Flies emerged normally from pupae which were removed from water and allowed to become almost completely dry. In one instance, we even got emergence from pupae

formed on the moist vegetation by larvae which were clinging to it when it was taken from the stream. There seems little doubt that pupae left exposed by falling water levels would complete their development normally in the field.

Distribution

Brisbane district—Brookfield, March; South Coast—Mudgeeraba Ck., March; Albert R., June; Springbrook, April (E. N. Marks); Logan R., June; Dalby district (Back Ck.), April; Brisbane R. (Wivenhoe and Murrumba Crossing), April, May; Nanango, April; Goomeri (Barambah Ck. and Boonara Ck.), April and May; Gayndah (Burnett R. and Reed's Ck.), April and May; Eidsvold (Burnett R. and many creeks in district), May; Dawson R. (Theodore and Joe's Ck.), April; Dee R., Rannes, April; Don and Callide Rs., Calliungal, April and May; Mackenzie R., June (J. L. Wilson).

SIMULIUM FAHEYI Taylor

Simulium faheyi Taylor, 1927, p. 71.

Female

Head: Frons dark grey, with creamy scales; tapering from about one-third head width at vertex to about one-sixth above antennae. Palpi and mouth-parts dark brown. Antennae with basal two segments light creamy-brown, third bright brown, remainder dark brown.

Thorax: Scutum deep brownish-black, covered with bright, pale golden scales, which shine a little silvery on the shoulders; indefinite dorsocentral bronzy stripes, similarly arranged to the darker ones of S. *nicholsoni*. Pleura varying from brown to dark grey, with an ashy sheen extending down below anterior spiracle; prealar scales golden, conspicuous.

Wings: Veins brown and macrotrichia black. There is some darkening of the concentration of veins at the wing-root, and the membrane in this area is distinctly clouded. Halteres light brown throughout, with very little darkening towards base of stem.

Legs: Normal, except for knees, basal half of hind tibiae, and basal five-sixths of hind metatarsi, all of which are creamy in colour. Pale scales on legs golden, except on paler areas mentioned, where they also show paler reflections. Hind tibiae with smoothly curved contour. Calcipala normal (i.e. a little longer than wide), covering about half the second tarsal segment; pedisulcus a well-marked notch. Claws with a minute tooth forming little more than a pointed apex to the basal thickening.

Abdomen: Somewhat twisted and shrunken. First segment brown, with bright golden-brown fringe; remaining segments deep brown, with pale golden scales across the disc of the fifth and subsequent segments. Laterally, the patches of bright, pale golden scales occur on the third and subsequent segments, and are most conspicuous on the third. Venter hidden.

Taxonomic Notes

The above notes were made during a rather brief examination of the type in the School of Public Health and Tropical Medicine. No parts were mounted for detailed study. It may be mentioned that this specimen is labelled "Allotype," although it is unique, and that it is a female, although Taylor (1927) was uncertain of the sex. The type of *A. bancrofti* (a female) is also labelled "Allotype," and it appears that, at one stage, Taylor used "Holotype" for male and "Allotype" for female types, irrespective of whether or not he had the other sex.

S. faheyi is close to *S. nicholsoni*, but we believe that it is distinct by reason of its general rich brown and golden, rather than black and silvery to cream, adornment, golden rather than creamy prealar scales, and presence of a tooth (though minute) on the claws. There must necessarily remain some doubt, until the early stages are discovered.

Distribution

Innisfail, North Queensland (F. H. Taylor), a female taken while sweeping with a net along a creek bank. We also, with some hesitation, place here a female taken by one of us at Lawn Hill, west of Burketown, in May 1931.

VII. The Genus Austrosimulium Tonnoir

Austrosimulium bancrofti (Taylor)

Simulium bancrofti Taylor, 1918, p. 168; 1927, p. 70 (part).
Austrosimulium bancrofti (Taylor), Tonnoir, 1925, p. 241 (part); Drummond, 1931, p. 8.

Larva

Length about 5 mm. Body creamy, with darker mottling. Head usually fairly heavily pigmented. Pattern on the dorsum of head very variable, a common arrangement being shown in Figure 3. Submental teeth reduced in number, arranged as in Figure 4d; antennae as in Figure 4d (left). Gill-spot elongate, club-shaped, as in Figure 5. Rectal gills three simple digitations. Anal armature as in Figure 6. Ventral papillae absent. The posterior circlet consists of over 90 closely-set rows of spines, with 20 to 30 spines per row.

Pupa

Length 2.5 mm. Head covered with small, irregularly-disposed tubercles. There is a row of tubercles on each side of the suture line of the thorax, and laterally the thorax is covered with tubercles arranged in tiny rosettes, an area on each side of the midline being left bare. Cephalic and thoracic hairs fine, simple. The hooks on the dorsum of segments three and four of the abdomen are widely spaced; four pairs of similar hooks also occur on the fifth, sixth, and seventh segments, and two pairs on the eighth segment. There are no dorsal, backwardly-directed, flat spines, nor ventral hooks, such as are present in *Simulium*.

The respiratory organ on each side consists of a broad, flat, spatulate, basal horn, covered with small spines, which are particularly conspicuous towards the tip. Very numerous, fine filaments originate from the whole of the outer surface

of the horn, except for the distal fourth (Fig. 7); they are about the length of the horn itself or a little shorter, and are transversely banded.

Cocoon

Shoe-shaped (Fig. 8), fairly closely woven, with a conspicuous anterior collar, but without a thickened rim. The ventral wall is incomplete posteriorly, the whole of the abdomen usually resting on the substrate.

Female

Length: Variable, 2 to 3 mm.; wing 2 to 2.5 mm.

Head: Frons about one-third head width (Fig. 9), covered with grey tomentum, with pale creamy hairs showing dull yellowish in some lights; occiput similar. Face with ashy white tomentum and creamy-white hairs. Palpi and mouth-parts dark brown. Antennae 9-segmented (Fig. 10d); basal segments creamy-yellow, remainder brownish-black. The third segment is nearly twice as long as the second and distinctly expanded dorsoventrally, the ninth is large, conical, about twice as long as the eighth, and often with a notch or groove near its middle.

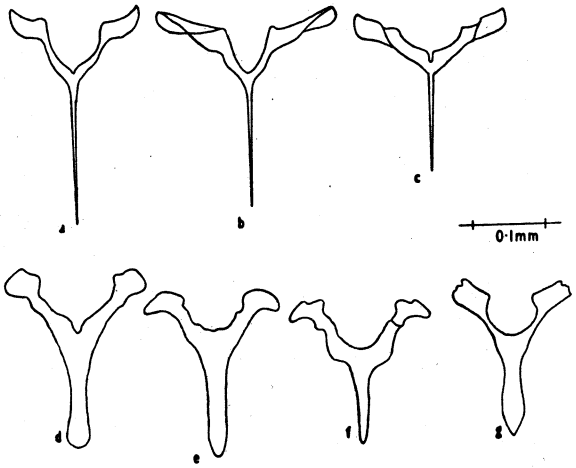

Fig. 12.—Adults. Genital forks of females. Order as in Figure 13.

Thorax: Scutum covered with dark grey tomentum and fairly dense short hairs, which are dull golden over most of the disc, but show silvery on the lateral and anterior margins. Area in front of scutellum with longer, rather creamy hairs. Scutellum black, with similar hairs, and a line of long, darker hairs along apex. Metanotum black, with some ashy reflections. Pleurae covered with ashy tomentum.

Wings: Veins pale fawn, hairs on main veins black. Halteres with basal part of stem dark, distal part of stem and knob pale creamy-yellow.

Legs: Dark grey, with considerable pale fulvous suffusion and silvery hairs, the fulvous colour being distributed as follows: Fore leg—knee, tip of tibia

ventrally; mid leg—base of femur, knee, tip of tibia, basal half of metatarsus, base of second tarsal and trace on base of third tarsal; hind leg—base of femur, knee, portion of ventral aspect of tibia, narrowly on tibio-metatarsal joint, narrowly on basal part of second tarsal segment. Calcipala about half width of metatarsus and about as long as wide (Fig. 11d). The claws are not toothed.

Abdomen: Predominantly ashy, forming a conspicuous pattern, the velvety black ground colour being reduced to a lateral zone on second, third, and fourth segments, which is broken into two dark stripes on fifth, sixth, and seventh segments. These dark markings on each side are joined by narrow basal dark bands on all the segments. There are also small ventrolateral basal brown patches on fifth, sixth, and seventh segments, and the venter is light fulvous, which colour extends more widely beneath the basal four segments than the ensuing three. Genital fork as in Figure 12d.

Male

Antennae (Fig. 10k) with all segments dark, except for traces of yellow on the first and second; third segment not as broad as in female, but broader than is usual in males; ninth olive-shaped, nearly twice as long as eighth. Mouth-parts and palpi dark brown, almost black.

Scutum covered with jet black tomentum, mixed with dark golden and black hairs, the gold being less dense than in female. Shoulder and lateral margin to wing-root with ashy tomentum and paler hairs. Scutellum jet black, with long black hairs. Metanotum black, with some ashy reflections. Pleurae covered with grey tomentum. Wings as in female. Halteres with stem dark brown, knob brilliant lemon-yellow.

Legs dark grey, with diffuse pale fulvous markings as follows: fore leg—on posterior aspect of femur, knee, inner aspect of tibia; mid leg—similar, but also includes basal part of metatarsus and extreme base of second tarsal segments; hind leg—more extensively pallid on anterior face of femur and tibia, but metatarsus all dark, base of second tarsal segment pale.

Abdomen jet velvety black dorsally, and brownish-fulvous on venter, with a conspicuous patch of brilliant ashy tomentum laterally on fifth and sixth segments; this involves also the apical quarter of the fourth segment, and sometimes part or whole of the seventh. Fringe of first segment dark dorsally, bright silvery and conspicuous laterally. Hypopygium as in Figure 13.

Taxonomic Notes

There has been much confusion about the identity of *A. bancrofti*, Taylor maintaining that it had nine-segmented antennae, and Tonnoir that it normally had ten. The type series consists of nine females, all bearing a printed label "Eidsvold, Queensland, Dr. T. L. Bancroft" evidently affixed by Taylor. The type specimen is labelled "Allotype," and has nine-segmented antennae, with a large, broad third segment as illustrated by Taylor (1927) in his Figure 2. A specimen labelled "Paratype" has ten-segmented antennae of the form shown in Taylor's Figure 1. Of the others, one has nine-segmented antennae, and six have ten-segmented

antennae. Thus, the type series comprised two *A. bancrofti* and seven *A. pestilens*! Tonnoir also had both forms before him in 1925, but later (MS.) correctly placed this species and prepared notes on its life-history. Drummond (1931) also recognized it correctly, and, incidentally, designated an allotype male, which he lodged in the collection of the Division of Economic Entomology, C.S.I.R., Canberra.

Adults of *A. bancrofti* can be immediately distinguished from all other species of the genus, except *A. pestilens*, by the abdominal markings in both sexes. From *A. pestilens*, it is only separable by the antennal characters, although the larvae and pupae are quite distinct.

Biology

The adults of *A. bancrofti* in Queensland are obscure, unobtrusive creatures. The few specimens captured by Bancroft (and ourselves in earlier visits to Eidsvold) were taken biting either man or horse. During a recent visit to the district, we were not bitten once by *A. bancrofti*, though we did collect a few individuals by sweeping *Melaleuca* in the stream-beds. The situation was very remarkable and instructive. Breeding of *A. pestilens* had ceased, but there were countless thousands of larvae and pupae of *A. bancrofti* in the river, and adults must have been emerging in very large numbers. Every individual of the many we bred out had nine-segmented antennae, and yet every one of the few adults that bit us had ten-segmented antennae! They represented the last survivors of the *A. pestilens* wave we were too late to see in that area. Further south, *A. bancrofti* seems to be more interested in human blood, and there is quite a series in the collection of the Division of Economic Entomology bearing labels that they had been taken biting man in the Australian Capital Territory. Drummond (1931) records it as biting fiercely in south-western Australia.

The early stages were always found in swift, strongly flowing water (about 4 feet per second), sometimes clear, but usually opalescent, and often quite muddy, though neither as swift nor as muddy as was favoured by *A. pestilens*. They attached themselves to any clean substrate, often on smooth, water-worn stones, but especially on broken limbs and logs caught in the current (Plate 2, Fig. 1). They occurred at any depth from the surface down to 15 inches and perhaps further, often alone, but not infrequently associated with either *A. pestilens* or *S. nicholsoni*, depending on the speed and muddiness of the water.

The larvae of *A. bancrofti* showed one habit which we have not seen in any other species except *A. pestilens* (and once in *A. clathrinum* in particularly fast water). They do not spread out in evenly spaced array, but crowd together in dense masses, more like maggots in a carcass than *Simulium* larvae in a stream. In favourable places one can almost pick them up by the handful.

When about to pupate, the larvae of *A. bancrofti* tend to seek out crevices and crannies a little sheltered from the direct force of the water. They usually pupate in little lines and groups, with each pupa having at least some direct hold on the substrate, but sometimes crowd together in a manner reminiscent of *A. pestilens*.

The pupal stage lasted two to three days. Even freshly formed pupae emerged normally when removed from the water.

Distribution

South Coast—Mudgeeraba Ck., March and May, Albert R., June; Dalby district (Back Ck.), April; Chinchilla (Charley Ck.), April; Goondiwindi (McIntyre R.), August, J. L. Wassel; Roma district (Muckadilla Ck.), March, R. A. J. Meyers; Brisbane R. (Wivenhoe and Murrumba Crossing), April and May; Goomeri district (Boonara Ck. and Upper Barambah Ck.), April and May; Gayndah district (Lower Barambah Ck.), April and May; Eidsvold district, Burnett R., Lochaber Ck. (W. J. Roulston), The Brook, Jacky Small's Ck., April and May; Dawson R., near Theodore, April; Dee R., Rannes, April; Don. R. and Callide R., Calliungal, April and May; Mackenzie R., April and June (J. L. Wilson).

Also recorded from A.C.T. (Tonnoir, MS.) and south-western Australia (Drummond 1931). The distribution of *A. bancrofti* is probably much more extensive than our records indicate, but will not be fully known until collections are made of larvae and pupae rather than adults.

AUSTROSIMULIUM PESTILENS n.sp.

Simulium bancrofti, part, Taylor, 1927, p. 70.
Austrosimulium bancrofti, part, Tonnoir, 1925, p. 241.

Larva

Length 4.5 to 5 mm. Body pale, with the usual irregular mottling. Head very pale, appendages lightly pigmented. Head pattern very often inconspicuous, a pattern sometimes observed being shown in Figure 3. Submentum and antenna as in Figure 4e. Gill-spot small, oval, as in Figure 5. Rectal gills three simple digitations. Anal armature slender, as in Figure 6. Posterior circlet consists of 70 to 80 rows of spines, 10 to 12 spines per row. Ventral papillae absent.

Pupa

Length 2.2 to 2.6 mm. Head and thorax covered with small tubercles. Cephalic and thoracic hairs relatively well developed, the most posterior of the dorsocentral row on the thorax being quite stout and forwardly curved. Abdominal armature resembles *S. ornatipes* in the disposition of the hooks on the dorsal surface of the third and fourth segments, but it resembles *A. bancrofti* in the absence of flat, backwardly-directed teeth and ventral hooks. In place of the dorsal hooks of *A. bancrofti* on the fifth to the ninth segments, *A. pestilens* has stout, curly hairs. The terminal pair of hooks is well developed.

The respiratory organ on each side consists of a slender, pointed basal horn, from which numerous fine filaments arise (Fig. 7). The surface of the horn is irregular, and the filaments, which are finely banded, spring from all parts of it. They are a little longer than the horn itself.

Cocoon

Varies a good deal in shape owing to the habit of building them one on top of another. Sometimes it is definitely shoe-shaped, with a well-developed collar, as in *A. bancrofti* but shorter; while in others the sides merely meet in the midline in front (Fig. 8). Fairly closely woven, with a slight rim around the opening, but no central dorsal projection.

Female

Length: Body 2 to 2.5 mm.; wing 1.8 to 2 mm.

Head: Small; frons (Fig. 9) about one-fourth of head width, i.e. a little narrower than in *A. bancrofti,* but variable. Antennae ten-segmented (Fig. 10e); third segment a little larger than second, tenth conical, shorter than in *A. bancrofti;* all segments dark.

Thorax: Similar to *A. bancrofti,* but the ground colour darker, as are the pleurae and legs. Calcipala and pedisulcus as in Figure 11e; claws not toothed. Wings as in *A. bancrofti.*

Abdomen: With segments brown, marginal hairs of first less conspicuous than in *A. bancrofti,* but the pattern is similar. Central ashy stripe hardly visible on second segment, indefinite on third and fourth, becoming more conspicuous on fifth, and expanding on sixth and seventh. Lateral margins with apical, lunulate, ashy patches tapering to a point medially. Genital fork as in Figure 12e.

Male

Antennae entirely dark; third segment half as long again as second but relatively narrower, tenth conical (Fig. 10b). Thorax black, somewhat shiny, with sparse pale golden hairs. Pleurae dark. Legs dark, with silvery hairs externally on femora, tibiae, and metatarsi.

Abdomen black; sides brownish, with the brown extending along apical edge of segments to form a narrow band dorsally. Venter fawn coloured. There is an indication of ashy reflections on some of the abdominal segments laterally, though usually not as conspicuous as in *A. bancrofti.* Hypopygium as in Figure 13.

Taxonomic Notes

Holotype female, allotype male, and morphotype pupa and larva, from Charley's Creek, Chinchilla, April 1947, are in the collection of the Division of Economic Entomology, C.S.I.R., Canberra.

A. pestilens is nearly related to *A. bancrofti,* from which the adults are only to be separated with certainty by possessing ten-segmented antennae. We have examined very many bred specimens of both species, and have not found the number of segments to vary in either, although they are often difficult to count in dried specimens. Moreover, all adults we collected biting in various parts of Queensland during 1947, and all the extensive series submitted by stock inspectors as worrying stock, had ten-segmented antennae. In the female, the form and size of the third antennal segment is rather characteristic (cf. Figs. 10d

and 10e), and the head of *A. pestilens* is distinctly smaller than that of *A. bancrofti* (Fig. 9).

The breathing horn of the pupa is quite different in the two species (Fig. 7), and the cocoons are usually sufficiently distinct to be recognized with a hand lens. Full grown larvae can also be readily distinguished with a hand lens by the form of the pupal gill-spot, which is particularly distinctive in *A. bancrofti* (Fig. 5). Other distinguishing larval characters are the pallor of the head in *A. pestilens*, and its delicate anal armature with more divergent anterior limbs.

Biology

This is the pest Simuliid of inland Queensland. Its original hosts were probably kangaroos and wallabies (*Macropus* spp.), and we have been informed by stock-owners that these marsupials sometimes die from the severity of the worry during a bad sandfly wave. Now they attack man, cattle, horses, sheep, and dogs with equal avidity. Cattle are driven from the waters, and mill slowly round in a mob all day, stirring up a cloud of dust, which gives them some protection. It is said that there is never any need to muster during a sandfly wave, for all the cattle in the paddock will be found in one compact mob. One grazier told us that he had seen a single mob of 7,000 head put together by sandflies in the Dawson River country. Horses crowd into fires for protection, and often get burnt. Sheep mill round, stirring up dust in the same way as cattle. Calves and lambs become separated from their mothers, and this is considered to be the main cause of the deaths that occur. Roberts (1940) has noted that the eyes and nostrils of young lambs may be blocked, and that the flies are sometimes inhaled, which may also be a cause of death.

Adults of *A. pestilens* are closely associated with tea-trees (especially *Melaleuca branchiata*). They shelter in the foliage after they emerge, and return to the trees to digest their blood meal. Dense clouds of hungry females arise from the bushes as one moves through them, and hundreds of flies may be collected with a single sweep of the net. Females are more numerous than males in such swept material, and include unengorged and recently engorged individuals, and specimens showing partial digestion of a previous blood meal. We did not see adults very far from the streams in which they bred, but apparently they follow the stock out, and graziers have recorded them up to ten and twelve miles from the rivers.

A. pestilens would be one of the most dangerous pests of stock in this country, were it not for the fact that its season of activity is extremely short. The fly wave follows flooding in the streams with great regularity about ten days after the waters come down, and lasts only about ten to fourteen days. There is no more worry, unless further flooding occurs, when secondary or tertiary waves may follow. At these times, the whole country is a sea of mud, which gave rise to the widely held opinion that the flies breed in mud. The brevity of the season is quite remarkable. Thus, flies were present in thousands, but larvae and pupae

in reduced numbers, in the Don River at Calliungal on April 13. By April 29 larvae and pupae had disappeared (empty pupal shells in abundance above the now lower water level), males also disappeared, and only a very few engorged females were taken by thorough sweeping of the bushes.

These observations can be related to the restricted habitats of the early stages. Larvae and pupae were only found when the streams were torrential (water speed in excess of 4 feet per second), turbulent, and muddy. Then they were extraordinarily numerous, larvae crowding in masses like *A. bancrofti*, and the pupae too being piled on top of one another, as if there were not enough space to accommodate them all. They would attach to sticks, logs, stumps, and dead leaves caught in a submerged limb, but by far the most favoured situation was on submerged branches and fronds of living *Melaleuca branchiata*. Later, when the level fell and the speed of the water decreased, larvae and living pupae disappeared; we could find no indication of persistant breeding even on a reduced scale, only the masses of empty pupal shells in their cocoons, now feet above the water, to mark the intense proliferation that had occurred (Plate 2, Fig. 2).

Collecting the early stages is a muddy, amphibious operation, so it is perhaps not surprising that they have not been described before, but it is surprising that only Mr. John Mann recognized them and the zone of dried cocoons left after the fly wave disappeared.

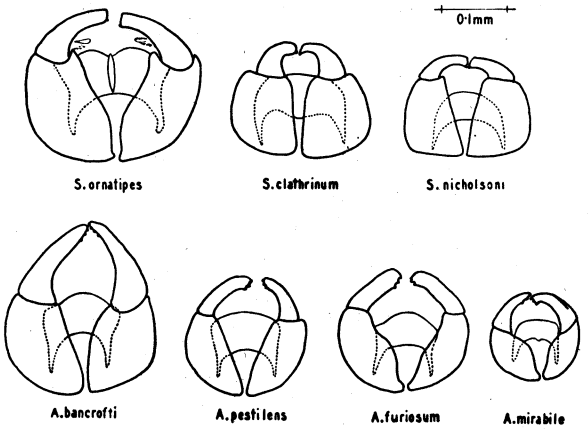

Fig. 13.—Adults. Hypopygia of males.

We have no doubt left in our minds that *A. pestilens* (and also *A. bancrofti*, *S. nicholsoni*, and *S. ornatipes* in the western parts of their range) has a resistant stage in which it lies dormant between waves. What that stage is is not so clear. Time relations of the outbreaks strongly suggest that it is the egg. If development were more or less complete before the egg dried (as in some mosquitoes), then about a week for development of the larvae and two days for the pupae would fit the picture very well. We have, however, not yet found the eggs, and

have no information about the duration of any stage except the pupal, so the sequence is purely conjecture. Much dried material was collected in the field, but so far no living stages have been demonstrated in it.

Control

This is not the place to discuss control at any length, especially as we have no experimental evidence to offer. At pesent, little is done other than to build smudge fires (Roberts 1940) to protect men and horses. These are remarkably effective within their limits, for the flies are extremely sensitive to acrid smoke. One could, for example, work quite comfortably amongst the tea-tree at the river edge, protected by three or four "incense-pots" of burning cow dung, when it would have been quite impossible even to remain there without the smoke.

DDT gives considerable promise for the control of Simuliidae. Fairchild and Barreda (1945) in South America, and Garnham and McMahon (1947) in Kenya, had considerable success by adding DDT to the stream in very low concentrations. This might present practical difficulties in Queensland, for the time to treat would be during the week following flooding, and much of the country is then impassable. Spraying from aircraft delivering a single, long, continuous swathe following the central line of the most turbulent water might be the answer to this difficulty. A third possibility is to use the dips charged with DDT for cattle-tick control to turn the cattle into poison baits for the flies. This also presents the practical difficulty that it may not be possible to handle the stock when dipping would be most effective. Nevertheless, it is felt that all three methods are worth a trial to determine their effectiveness and limitations.

Distribution

Widely distributed in the southern half of Queensland, west of the Dividing Range, and extending as far as the Cooper's Creek basin. East of the Divide, it has only been found in great numbers in the Dawson River area (where it is so abundant that it is widely known as the "Dawson River sandfly") and the headwaters of some tributaries of the Burnett River. We have seen specimens (adults or early stages) from the following localities: Dirranbandi (January), Cunnamulla (March), Wooroorooka (April), Chinchilla (March, April), Roma (April), Charleville (March), Adavale (March), Windorah (March), Boondoomba (March), Cadarga (April), Goomeri (April), Gayndah (April), Eidsvold (May), Theodore (April), Calliungal (April).

AUSTROSIMULIUM FURIOSUM (Skuse)

Simulium furiosum Skuse, 1888, p. 1362.
Austrosimulium furiosum (Skuse), Tonnoir, 1925, p. 239.

Larva

Length about 5.5 mm. Body greyish, with the usual irregular mottling. Pattern on the dorsum of the head very variable, a common arrangement is shown in Figure 3. Submentum and antenna as in Figure 4f. Gill-spot large, S-shaped,

as in Figure 5. Rectal gills three simple digitations. Anal armature as in Figure 6. Posterior circlet consists of 70-80 rows of spines, 10-12 spines per row. Ventral papillae present.

Pupa

Length 2.3 to 2.5 mm. Head and thorax covered with small tubercles. Cephalic and thoracic hairs well developed, the most posterior dorsocentral thoracic pair being stout and forwardly curved. Abdominal armature similar to that of *A. pestilens*.

Respiratory organ on each side consists of a slender stem, from the summit of which about 23 long, fine filaments arise (Fig. 7). The stem is beset with fine spines, and the filaments have bands of minute spines giving them a segmented appearance. Some specimens have filaments about three-fifths the length of the usual type.

Cocoon

Wall-pocket type (Fig. 8), with a low collar formed by the sides meeting in front; coarsely woven, with a definite rim, but no central dorsal projection. Ventral wall absent.

Female

Length: 2 to 2.4 mm.; wing 2.2 mm.

Head: Frons about one-sixth of head width (Fig. 9), dark greyish-brown, with short creamy hairs; face similar. Antennae with all segments dark brown; third to tip darker than first two and covered with short, fine, creamy hairs (Fig. 10f). Palpi and mouth-parts brown. Basal segment of palp darker than the rest.

Thorax: Scutum brownish-black, fairly evenly covered with creamy-gold hairs which do not show much contrasting lustre on sides. Scutellum dark brown, with some small pale gold hairs and dark apical ones; postnotum brown. Pleurae dark brown, with three patches of ashy tomentum, one behind anterior spiracle, one below wing-root, and one just behind wing-root.

Wings: Costa and stem vein dark brown, remaining veins paler brown. Halteres with dark stem and creamy knob.

Legs: Dark brown, suffused with a dull fawn hue, especially on femora; distal sixth of the femora and tibiae very dark, almost black; knees yellowish. Calcipala and pedisulcus as in Figure 11f. Claws not toothed.

Abdomen: First segment greyish-brown, with cream fringe; remaining segments all black, without ashy markings. Laterally the colour is rather a greyish black, but centrally each segment is deep velvety black as described by Skuse. Fifth and subsequent segments with pale creamy hairs, which tend to form an indefinite apical fringe; venter brown. Genital fork as in Figure 12f.

Male

Darker than female. Antennae (Fig. 10m) entirely dark; mouth-parts black. Scutum jet black, with fairly uniform covering of dark golden hairs. Scutellum

black, with a few pale hairs and a black marginal fringe; postnotum black, with ashy reflections. Pleurae dark grey, with ashy suffusion running downwards from below the anterior spiracle. Wing veins and knob of halter darker than female. Legs similar to female, but rather darker. Dorsum and sides of abdomen velvety black, without pale hairs except on first segment, where the fringe is greyish-brown but fairly conspicuous nevertheless; venter grey. Hypopygium as in Figure 13.

Taxonomic Notes

Our Queensland specimens agree very well with a series of larvae, pupae, and bred adults obtained by D. Mackerras at Gosford, New South Wales, Skuse's type locality. The females have also been compared with Skuse's original type series by Mr. R. H. Wharton, who informs us that he could discover no significant differences. Unless other larvae and pupae producing identical adults turn up at Gosford (a not impossible contingency), the identity of Skuse's species may be taken as established.

A. furiosum is easy to distinguish in Queensland, for it is the only known representative of the southern group of species with an entirely dark abdomen in both sexes. Larvae and pupae were collected usually in clear, fast-running water, but in one of the Queensland localities they were present in a mere trickle. The latter probably represented the last residue of breeding in a stream which had previously been more vigorous. Adults have not been seen in nature.

Distribution

Coombabah Ck., near Southport, March; Logan R., near foot of Mt. Barney, June (E. N. Marks); Noosa, September (E. N. Marks); Dalby district, Back Ck., April.

AUSTROSIMULIUM MIRABILE n.sp.

Larva

Length about 4.5 mm. Body creamy, with the usual dark mottling. Head usually heavily pigmented, pattern variable, a common arrangement shown in Figure 3. Submentum and antenna as in Figure 4g. Gill-spot conspicuous by reason of the jet-black basal respiratory horn, elongate oval, with truncated upper end (Fig. 5). Rectal gills consist of three simple digitations. Anal armature includes a conspicuous chitinous rod which extends around the body just anterior to the posterior circlet (Fig. 6). Posterior circlet consists of about 80 rows of spines, 12-15 spines per row. Ventral papillae present.

Pupa

Length 2.2 mm. Head and thorax covered with small tubercles. Cephalic and thoracic hairs well developed, particularly the dorsocentral thoracic hairs, the two posterior pairs being stout and forwardly curved. Abdominal armature consists of the usual four pairs of strong hooks dorsally on segments three and four, and a series of ventral hooks similar to those of *S. ornatipes.*

The respiratory organ on each side consists of a dense, black, spiny, pointed horn, from which numerous fine filaments arise (Fig. 7). The surface of the horn is covered with longitudinal spiny ridges, the filaments springing from the furrows between them. The filaments are finely ringed, and are about as long as the horn itself.

Cocoon

Wall-pocket type (Fig. 8), rather coarsely woven, with a definite anterior rim and a short central dorsal projection. The ventral wall is absent, and the sides do not meet anteriorly below the head. The cocoon is usually very much spread out laterally, so that the outline is nearly circular, and only the central part is raised up sufficiently to accommodate the body of the pupa.

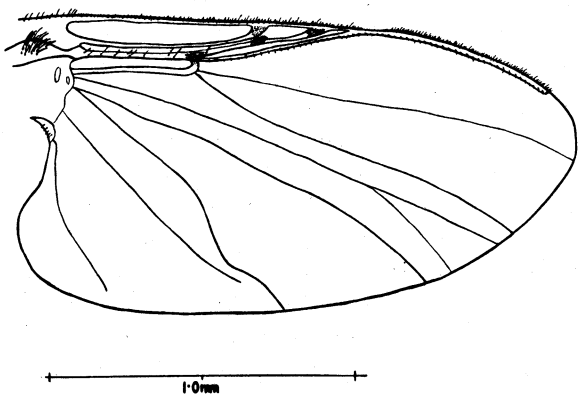

Fig. 14.—Wing of *Austrosimulium mirabile* n.sp., female.

Female

Length: 2.25 mm.; wing 2.25 mm.

Head: Frons narrow (Fig. 9); frons and face silvery; occiput black, with golden hairs. Antennae very long, 10-segmented; first segment large, second very large, more than twice as long as first, third about half as long as second, narrower (Fig. 10g). First three segments black, fourth black at extreme base, remainder of segment orange; fifth and sixth entirely orange; seventh to tenth black. Proboscis dark brown to blackish; palpi dark, except terminal segment, which is pale.

Thorax: Black, with evenly scattered, fine, golden hairs on disc, and a greyish area in front of scutellum. Scutellum black. Pleurae black, with a conspicuous ashy patch of tomentum below edge of scutum and behind pronotal lobes, which bear a silvery pubescence.

Wings: With three conspicuous black spots on R_1, one opposite the origin of Rs, second opposite the tip of Sc and including it, and third spot at the tip of R_1. The macrochaetae on R_1 are concentrated in relation to the spots, and there is

also a patch of thick hairs on base of stem vein (Fig. 14). Halteres with stem dark brown, knob pale creamy-yellow.

Legs: Black; femora and tibiae black, knees narrowly yellowish, tarsi dark brown. Claws strongly toothed. Calcipala very large, three-fourths width of segment and covering the pedisulcus (Fig. 11g).

Abdomen: First visible segment brown, with pale edge and long golden fringe laterally. Second dark brown, with an oblong ashy spot on either side of midline and a velvety black patch in centre. Third and fourth entirely velvety black. Fifth with ashy, T-shaped area in centre; base and arms of T marked with brilliant white scales. Sixth similar, but cross arms much wider. Seventh similar, but pale area expanded so that the black portion is reduced to a triangular patch on each side of midline. Eighth segment ashy, with darker suffusion on each side of midline and silvery scales laterally. Ninth darker, with silvery tip. Genital fork as in Figure 12g.

Male

Head wider than thorax; face black, with large, central, shining patch of ashy tomentum. Mouth-parts and basal palpal segments brownish-black, terminal segment creamy-brown. Antennae (Fig. 10n) with first two segments relatively large, as in female, second markedly expanded dorsoventrally; segments one to three brownish-black, four to six orange-yellow, remainder brown, with some orange suffusion and pale hairs more conspicuous towards the tip.

Thorax as in female, but the golden hair is more dense, and the ashy area in front of scutellum is much larger, more conspicuous, and indistinctly divided in the middle by a median patch of long, golden hairs, which extend backwards over base of scutellum. Pleurae and legs as in female.

Abdomen with fringe hairs of first segment much darker than in female. Second segment velvety black in centre, brownish laterally, with conspicuous ashy tomentose bands along anterior and posterior margins. Third and fourth segments all black (no brownish areas differentiated). Fifth segment black, with ashy tomentose patch laterally, and small bright ashy median spot apically. Sixth and seventh black, with larger ashy median apical spots. Eighth similar, but with ashy distal margin in addition to the spot. Ninth brown. Pale median areas of abdomen have patches of silvery scales as in female, but they are smaller. Hypopygium as in Figure 13.

Taxonomic Notes

Holotype female, allotype male, and morphotype pupa and larva, from Dawson Ck., slopes of Mt. Glorious, April, in collection of the Division of Economic Entomology, C.S.I.R., Canberra.

This is a remarkably distinctive species, by the form and colour of the antennae, the spotted wings, and abdominal markings. Pupa and larva are more normal, but still well differentiated from other species. It is only known from the type series, which was collected on dead leaves caught in rocky crevices in moderately fast, clear water.

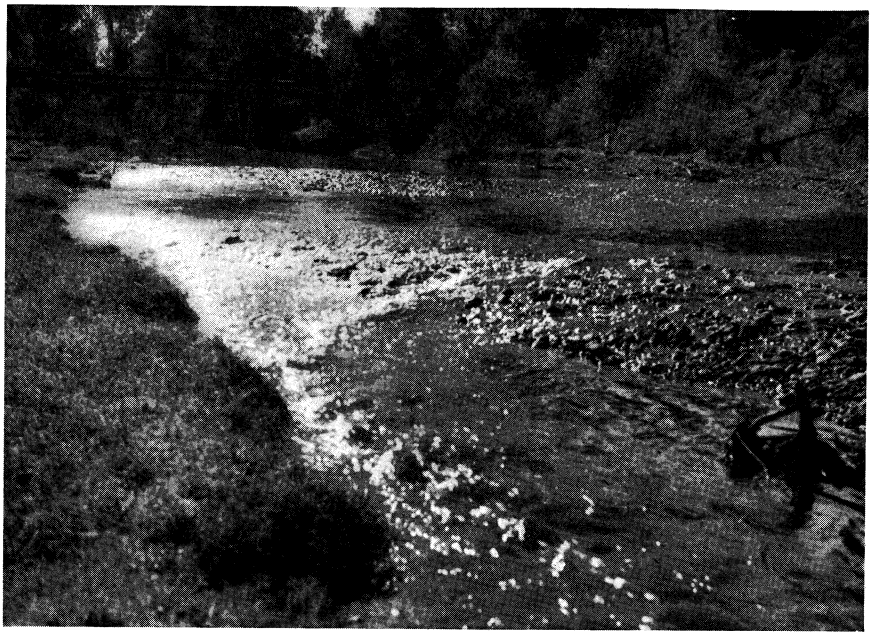

Fig. 1

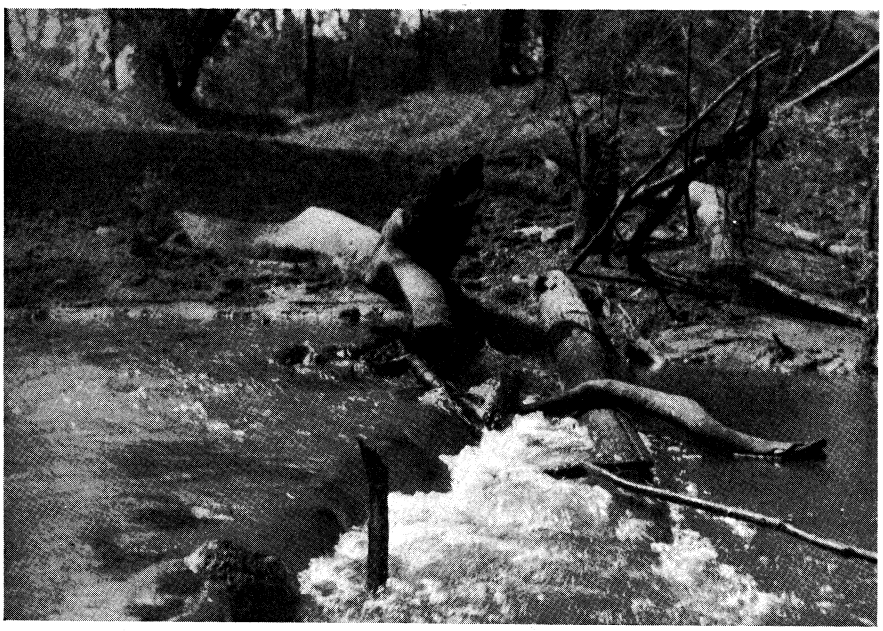

Fig. 2

MACKERRAS and MACKERRAS.—SIMULIIDAE (DIPTERA) FROM QUEENSLAND

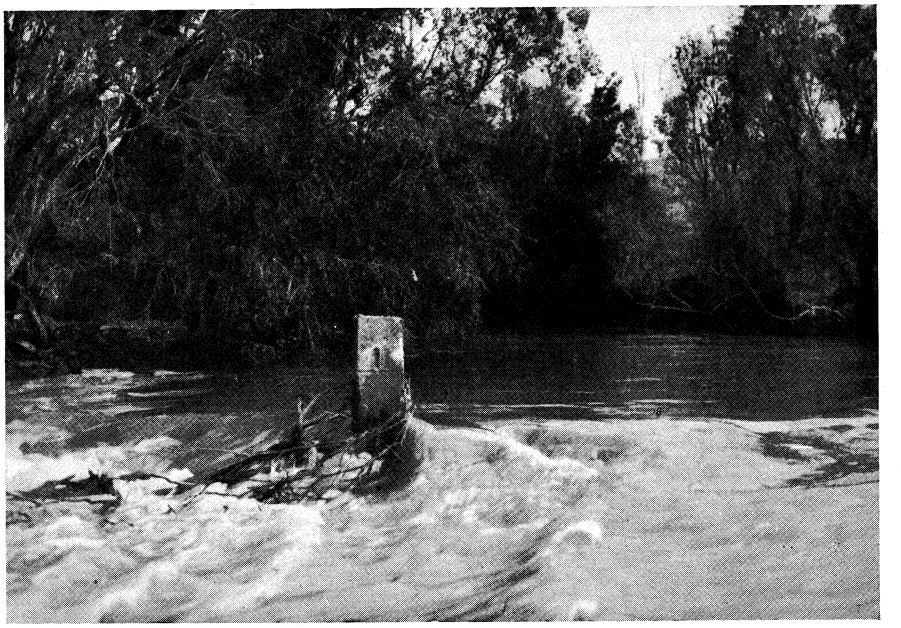

Fig. 1

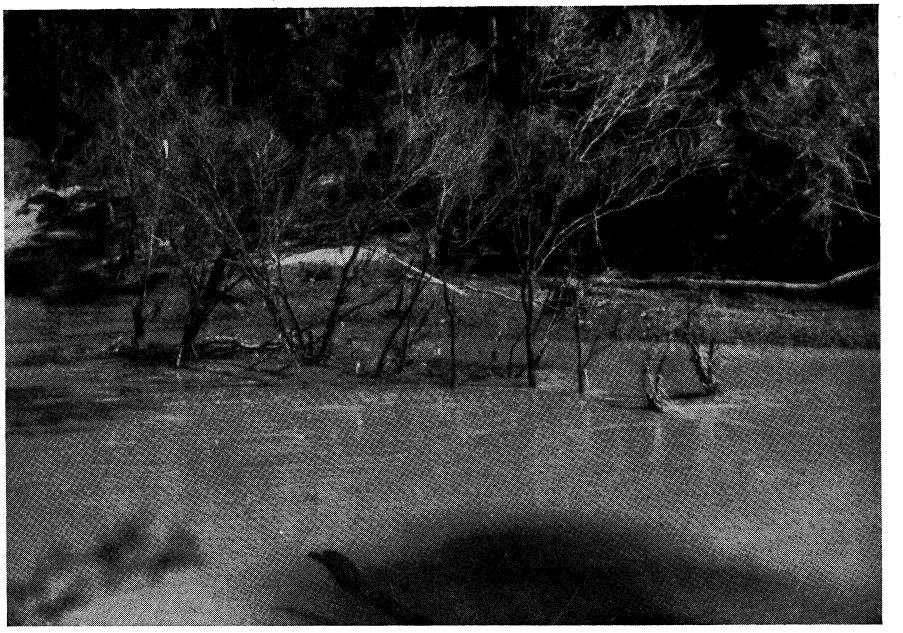

Fig. 2

MACKERRAS and MACKERRAS.—SIMULIIDAE (DIPTERA) FROM QUEENSLAND

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We are grateful, finally, to many friends in the country for accommodation and help during the investigations.

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Explanation of Plates 1-2

Plate 1

Fig. 1.—Breeding ground of *S. ornatipes* and *S. nicholsoni*. Biloela district.

Fig. 2.—Logs on which *S. ornatipes* were ovipositing abundantly, Don R., Calliungal. A former breeding ground of *A. pestilens*.

Plate 2

Fig. 1.—Breeding ground of *A. bancrofti*, Barambah Creek, near Gayndah. Flow almost fast enough for *A. pestilens*.

Fig. 2.—A former breeding ground of *A. pestilens*, Dawson River. These tea-trees were covered with empty pupal shells and cocoons.