NOTES ON THE BIOLOGY OF *SCAPTIA AURIFLUA* DON. (DIPTERA, TABANIDAE).

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(Plate i; eleven Text-figures.)

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Introduction.

Although the early stages of many Tabaninae (*Tabanus* and *Haematopota*) have been discovered in other parts of the world, comparatively little is known of the Pangoniine genera. The larvae and pupae of a few species of the more specialized genera *Chrysops* and *Silvius* have been studied, but *Goniops chrysocoma* Osten-Sacken, which has been fully described by McAtee (1911), is the only generalized Pangoniine of which the breeding habits and early stages are known. Our knowledge of the immature stages of Australian Tabanidae is small, although the family is represented here by more than 250 species. The larvae of four species of *Tabanus* and one Pangoniine, *Silvius notatus* Ric., have been briefly described (Johnston and Bancroft, 1920; Hill, 1921). The discovery of the breeding grounds and early stages of the generalized Pangoniine, *Scaptia auriflua* Don., is, therefore, of considerable interest.

Scaptia Walk. is the dominant Australian Pangoniine genus, nearly fifty species being known (Ferguson, 1926). It is the Australian representative of that group of genera with short, broad, mostly hairy bodies, and with the third antennal segment eight-annulate, of which *Pangonia* (*s.l.*) may be taken as typical. *Goniops* Ald. also appears to belong to this group and, from the information available, seems to possess characters in common with some species of *Scaptia*. It is, therefore, not surprising that the larva and pupa of *S. auriflua*, described below, should show points of resemblance to those of *G. chrysocoma*.

The writer is indebted to Dr. I. M. Mackerras for the identification of the species, for information on the Tabanidae, and for assistance in the preparation of the paper.

The Habits of the Adult.

S. auriflua is a medium-sized, rather ornate species, of which White (1915) has given an adequate re-description. It is distributed along the southern and eastern highlands of Australia, from Tasmania and South Australia to southern Queensland, and is commonly found associated with flowering *Leptospermum* growing in swampy country at high altitudes. In January, 1935, the flies were plentiful on *Leptospermum* flowers on a small plain at the foot of Mt. Coree (4,600 ft.) near Canberra, and were also abundant on the flowers of another species of *Leptospermum* growing along Alpine Creek, Kiandra, and in a swamp

near Yarrangobilly (5,000 ft.). Dr. Mackerras informs me that they were very common on flowering *Leptospermum* at Barrington Tops (4,500 ft.) in the summer of 1925. The flies remained resting or moving about on the flowers for considerable periods, and were not readily disturbed. They frequently rested beneath the flower clusters and among the inner parts of the bushes, with their lower surface uppermost, and were then not readily distinguishable in spite of their bright colouring. Both sexes were present in equal numbers. They were not seen to hover over or alight on the swamps, although other Tabanids, including *Scaptia ruficornis* Macq., had this habit.

Most species of *Scaptia* suck the blood of mammals, and the females are usually taken when attacking the collector; males are rarely seen. *S. auriflua*, however, made no attempt to bite, and has never been recorded as blood-sucking by other observers. It is most probable that both sexes feed exclusively on the nectar of flowers, although the mandibles of the female are not reduced, as they are in the primitive, non-blood-sucking genus *Pelecorhynchus*. Possibly *S. auriflua* sucks the blood of native animals, but no evidence of this was found.

Notes on the Life-History.

Goniops oviposits on the underside of leaves and guards the egg-mass for some days, buzzing loudly at intervals. The breeding habits and the egg-masses of *S. auriflua* have not been discovered, nor is there any evidence to suggest that it might possess similar peculiar habits.

The larvae of *S. auriflua* were discovered in the soil of a restricted area on a small mountain plain beside Mt. Coree (Plate i, fig. 1). The soil, the moisture content of which varied over the period when larvae were found, was never dry nor saturated; in general it was moderately damp. The larvae were just below the surface and frequently well up among the grass roots. They were present in the same situation whenever it was examined from October, 1934, to August, 1935. Many other areas in the locality were examined, but the larvae were not found anywhere else. The surface of the ground was covered with grasses and a small group of willows was close by (Plate i, fig. 2). Between the willows and Coree Creek, which was 65 yards distant, the ground was slightly lower and was covered with marsh grasses, being in places saturated. Since the first larvae found were full grown, it was assumed that they lived in the swamp and moved to higher ground to pupate, but this was found to be incorrect, when later search revealed larvae of all sizes. Moreover, none were found in the wetter soil.

On 7th October, full-grown larvae were present, associated with numerous Tipulid and some Stratiomyiid larvae.

On 13th and 14th October, full-grown larvae in the proportion of 1 to 50 Tipulids were present, the Tipulids being extremely plentiful.

On 11th November, a few large larvae were present, and most of the Tipulids had pupated.

On 17th February, half-grown larvae and no Tipulids were found.

On 24th March, larvae of various sizes from half to full grown and no Tipulids were present. The soil was at its driest.

On 23rd June, very small to nearly full-grown larvae were present, and Tipulids were again found in small numbers.

On 11th August, small to full-grown larvae were present and Tipulids occurred in fair numbers. The soil was wetter than it had ever been previously, due to

the fact that snow had fallen to a depth of six inches or more a week earlier. The larvae were still very close to the surface.

Throughout the whole period, earthworms and cockchafer larvae were present in the soil. The *Scaptia* larvae were always contracted when found, probably due to being disturbed when the soil was turned over. They remained inert and never attempted to move away.

The first larvae collected were kept each in a separate jar of slightly moistened soil and supplied with Tipulid larvae as food. As the larvae were full grown and were not observed to feed, it was assumed that they were at the resting stage prior to pupation. They remained in this state for approximately two months (54 to 65 days) before pupating. The pupal stage lasted 15 to 24 days, and the flies emerged in December and January over a period of three weeks.

As the larvae showed no attempt to attack each other, several were later kept in each jar. Apparently most of the feeding is done in the winter, as larvae collected in March and June disposed of earthworms supplied to them, although actual feeding from a worm was only observed once. The *Scaptia* larva had pierced the worm near the middle and had its head buried in the body, part of which was sucked out. Tipulid larvae placed in the jars were later found damaged and flaccid, but feeding on these was not actually observed. Some larvae have been kept successfully in jars of soil and grass roots for five months. They can withstand starvation, and drying and hardening of the soil for six weeks without being affected. Larvae subjected to such conditions were contracted and darkened, but extended and became normal when placed in moist soil and given food.

The full duration of the life cycle is not known, but the facts that adults are only on the wing for a limited period in summer, and that larvae in various stages of growth occur together, suggest that full development may take two, or even three, years.

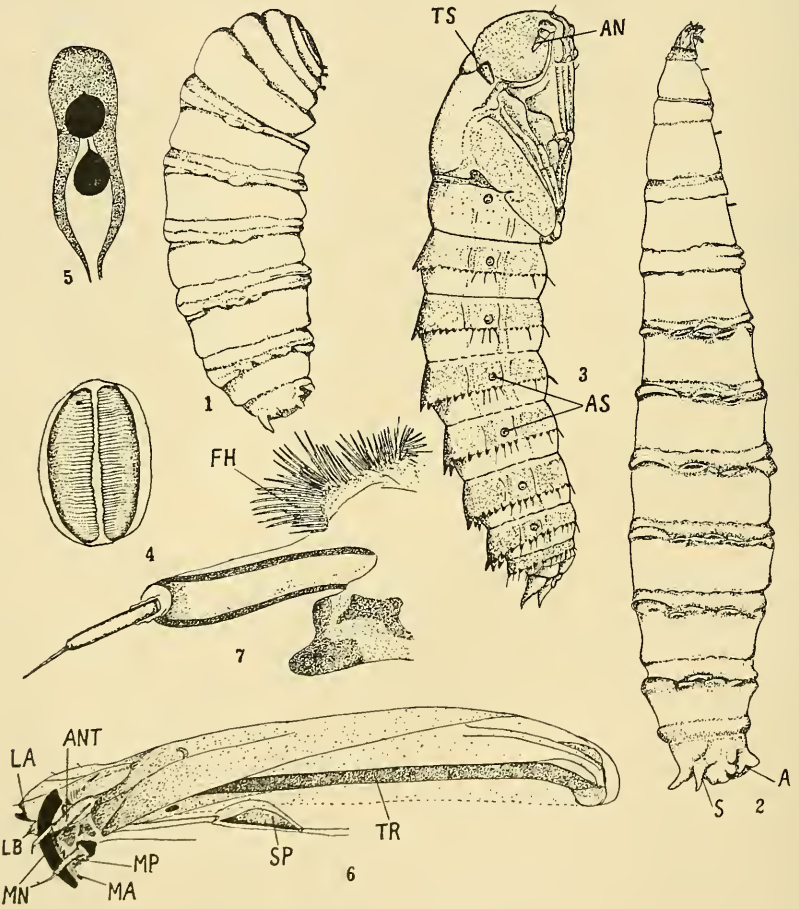
The Larva (Text-figs. 1 and 2).

Larvae from 11 to 26 mm. in length were examined and, except for size, there was no difference in structure between these stages.

The following description is taken from a full-grown larva. The length of the larva when fully extended is 26 mm. The body is pointed anteriorly and, unlike most other Tabanid larvae, truncated posteriorly (Text-fig. 2). It is widest at the 3rd, 4th and 5th abdominal segments. The larva is capable of contracting to half its length when disturbed. When moving actively it has a leech-like shape, but takes on a short barrel shape when touched (Text-fig. 1), the girth increasing by about 2 mm.

As the pigment fades and alters in preserved specimens, the following description of the colour markings is from a live larva. Beneath the thick striated integument, which is itself practically colourless, is a layer of pigment broken up into patches. The pigment is a dark chocolate or purplish-brown, and varies in amount and extent with individual larvae, and with stages of growth. It is brightest in colour near the anterior end, and most continuous and intense on the dorsal surface of the last four abdominal segments. The patches where the pigment is absent are a pale yellowish colour, and it is only through these patches that parts of the internal organs are visible. The unpigmented patches are rounded or elongated-oval in outline. The lateral regions

of the thoracic segments are devoid of pigment, and the junction between segments is colourless, except for an occasional spot between the posterior segments. Down the dorsum of the thoracic and first few abdominal segments there is a long narrow colourless area. On the ventral surface the yellowish patches are more extensive than the pigmented areas, which simply form a network of colour around them. The ventral surface of the eighth segment, and the parts surrounding the anus, are completely devoid of pigment. In general the arrangement of the pigment in this larva gives it a very characteristic mottled or spotted appearance.



Text-figs. 1-7.—*Scaptia auriflua.*
1.—Larva contracted, × 3·6. 2.—Larva extended, × 3·6; *a*, anus; *s*, spiracle. 3.—Pupa, × 3·6; *an*, antenna; *as*, abdominal spiracles; *ts*, thoracic spiracle. 4.—Posterior spiracle, × 80. 5.—Graber's organ, × 144. 6.—Head of larva, × 16; *ant*, antenna; *la*, labrum; *lb*, labium; *ma*, maxilla; *mn*, mandible; *mp*, maxillary palp; *sp*, salivary pump; *tr*, tentorial rod. 7.—Antenna, × 64; *fh*, flexible hairs.

With the exception of the head, the annulus of the first thoracic segment, and certain papillae on the eighth abdominal segment, the whole of the integument is strongly and evenly striated. Between adjacent thoracic segments is a broad annulus. The annulus of the first segment, which is immediately behind the head, is covered with close minute spines directed backwards. On the ventral surface of each thoracic segment are two groups of hairs situated one each side of the centre in the anterior third. Each is composed of four long, light brown setae arising from a common base. There is no division of the thorax into dorsal, lateral and ventral areas, beyond a slight curving of the striae in these regions. No trace of the anterior spiracles is visible on the thorax.

The integument on the posterior border of each abdominal segment is thickened, raised slightly, and somewhat irregularly folded. Just behind the anterior border of each segment the skin is raised all round and folded into a series of small prominences. Dorsally this forms a continuous ridge, slightly curved forwards. Laterally there is a series of small curved ridges with hollows between and among them, and ventrally there are two parallel ridges of integument, one being formed by the anterior border of the segment, and one by the fold behind it. The posterior borders of the segments are more prominent ventrally, making a series of three ridge-like pseudopods. On the ventral surface of each abdominal segment except the last there is a transverse series of six very delicate, colourless hairs in the anterior third.

The eighth segment is entirely different from the others. It is much shorter and does not bear a ring of projections. Two large pointed papillae arise from the dorsal surface at the posterior extremity and project backwards, upwards and outwards. Between them on the vertical face of the segment is the posterior stigma (Text-fig. 4). There is no indication of a siphon, the spiracle lying flush with the integument. It is elliptical in shape, consisting of a single narrow vertical slit with two raised chitinous lips, the edges being finely scalloped. Below the spiracle are two pairs of short rounded papillae. The anus on the ventral surface is surrounded by a fleshy ridge, which bears a pair of blunt papillae projecting downwards and backwards. The four papillae below the spiracles are striated and each bears a short, fine hair. The pointed dorsal projections and the anal ridge are finely rugose.

Graber's organ (Text-fig. 5) is very difficult to discern because of the heavy pigmentation in the posterior segments. It is never visible from the exterior, and can only be detected after the eighth segment is macerated and the pigment scraped out. The organ lies below the integument of the dorsal surface of the eighth segment just anterior to the pair of projections. It is rounded at the anterior end and tapered posteriorly. In the larvae examined, which were all more than half grown, there were only two bodies present. These were large, black and round, occupying most of the space in the sac, and arranged one in front of the other.

The head (Text-fig. 6).—The head capsule is very elongated, only the anterior fifth being visible when extended, the rest being enclosed within the thorax. Of the portion which is external, a smooth thin membrane which grows out from the thorax envelops the posterior half, the mouth parts projecting in front of this. The epicranium is a flat dorsal plate of smooth, brown chitin dividing into three arms anteriorly. The two outer projections curve round forming the lateralia, and the central arm continues forward into the rostrum. The chitin

is darker along the sides of the epicranium, giving the effect of two stripes. Posteriorly the chitin of the dorsal plate becomes thinner and is produced into two lateral arms which curve downwards and fuse with the posterior extremities of the tentorial rods. At the base each of these epicranial arms is joined to the tentorial rod by a short curved bar. Just anterior to the basal membrane the head capsule is completed ventrally by a smooth, flat gular plate lying between the lateralia and extending forward to the posterior end of the labium.

The tentorium consists of a pair of dark brown, hollow chitinous rods, running the length of the head ventrally. These rods end anteriorly just behind the reduced buccal cavity, and take a downward sweep posteriorly to join the tips of the epicranial arms. They are each connected near the anterior end, behind the eye-spot, with the dorsal plate by a curving vertical bar. The eye-spots are small, dark, reddish masses lying internally beneath the lateralia just in front of the basal membrane, and not visible from the dorsal surface. The pharynx, which is chitinized for its whole length, runs below the tentorial rods anteriorly, and then between them, expanding slightly at the posterior end of the head.

The salivary pump lies posterior to the gular plate and below the ventral side of the head internally. It is large, chitinous, and saddle-shaped, having the concave surface uppermost. A duct running forward from its anterior end opens in the front of the labium. From its posterior end a duct runs back to the salivary glands. Valve structures are present in the organ where these ducts enter it.

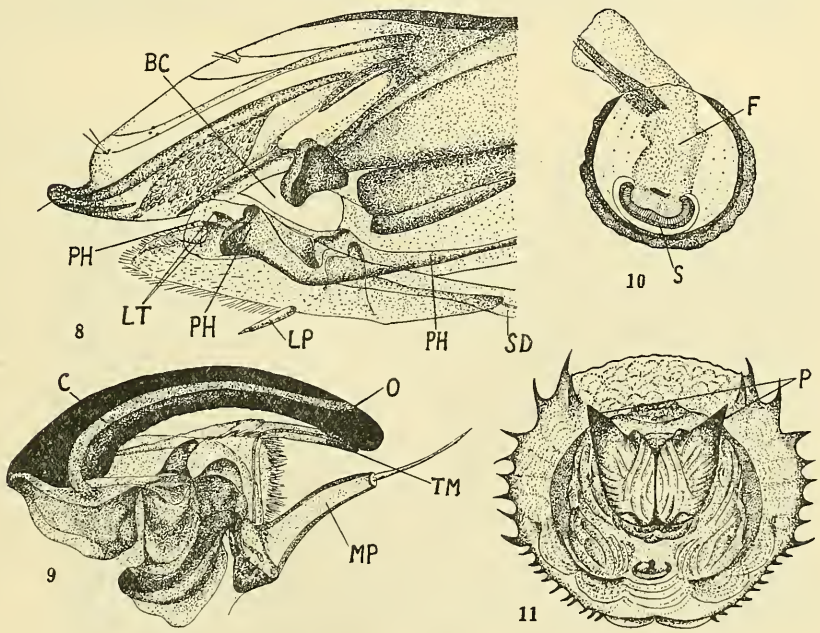
The antennae (Text-fig. 7) arise dorso-laterally from the lateralia, and consist of three segments, the basal one being very elongated, flattened and lying close against the head. Cameron (1934) and Isaac (1925) describe the antenna of Tabanid larvae as two-segmented, considering the apparent basal segment to be a flattened cephalic sclerite. Stone (1930), Boving (1924) and others state that the antenna is three-segmented. In *Scaptia auriflua* the large basal segment is clearly articulated with the head, and readily separated from it. The middle segment projects sideways and is considerably smaller than the basal one, whilst the apical segment is very narrow, pointed and setiform. Between the lateralia and rostrum the chitin is delicate and membranous. Near the base of the mandibles and between the antennae and rostrum on each side is a comb of fine hairs which are hidden when the mandibles are withdrawn. They correspond to the stiff brush of "piercing spines" (Isaac, 1925) in many Tabanids, but are much finer and less conspicuous.

Mouth Parts.—The anterior extremity of the head is occupied by the prominent mouth parts. Dorsally the rostrum ends in the laterally compressed labrum with its up-turned end. Ventrally the two pointed hairy lobes of the labium project forwards. Between these laterally are the large, conspicuous mandibles with their associated maxillae.

The labrum (Text-fig. 8) is narrow and blade-like, with a narrow, sharply up-turned tip composed of hard black chitin. A pair of small setae is present at the end, and two other groups of setae occur dorso-laterally. On the ventral surface and laterally in this region is a large area of close papillae, corresponding, no doubt, to the epipharynx. The labium (Text-fig. 8) is less chitinous than the labrum and does not project so far forward. It is bi-lobed and covered with fine hairs. At its base ventrally are a pair of elongated palps projecting forwards.

Dorsally it is fused with the anterior end of the pharynx, which is strongly chitinous in this region. A pair of lobes from the dorsal wall of the pharynx grow upwards to meet the ventral surface of the labrum, and associated with them is a pair of forwardly-directed, sharp, chitinous teeth arising from the labium. Isaac and Cameron both assert that these structures permanently close the mouth opening, cutting off the reduced buccal cavity from the exterior, the liquid food being taken in through the mandibular canal. This specialization of the labium and pharynx, and the structures connecting the labrum and labium in *Scaptia*, closely correspond with the condition described for *Haematopota pluvialis* by Cameron and *Tabanus rubidus* by Isaac. But in *Scaptia*, although the mouth appears to be closed by the dorsal pouch of the pharynx and the chitinous teeth of the labium, it is possible to separate the labrum and labium-pharynx, thus opening the mouth, by pushing the tip of the labrum upwards or by pressing from the buccal cavity forwards with a needle, none of the parts being torn or damaged in the process. It is quite possible that these parts are not capable of independent movement in the living larva, and the mouth is non-functional as in *Haematopota* and *Tabanus*. Projecting into the back of the buccal cavity is a pair of triangular masses connected with the tentorium.

The mandible (Text-fig. 9) is a strong, black, slightly curved tusk-like structure, with a blunt tip, and slightly expanded at the base where it is



Text-figs. 8-11.—*Scaptia auriflua.*
8.—Labrum and labium, × 52; *bc*, buccal cavity; *lp*, labial palp; *lt*, labial teeth; *ph*, pharynx; *sd*, salivary duct. 9.—Mandible and maxilla, × 52; *c*, canal; *mp*, maxillary palp; *o*, opening of canal; *tm*, tip of maxilla. 10.—Abdominal spiracle of pupa, × 64; *f*, felt chamber; *s*, slit. 11.—Posterior end of pupa, × 12 approx.; *p*, points of aster.

connected with the maxilla. The concave inner edge is finely serrated. There is an opening on the dorsal, convex surface a little behind the tip. This is the entrance to a canal which runs through the mandible and is continued through its base. Isaac states that it then continues as a membranous tube amongst the anterior sclerites of the head, until it ends in the pharynx. The mandible is more strongly developed and larger in proportion to the other mouth parts in *Scaptia* than in the Tabanid larvae described by other workers. The maxilla (Text-fig. 9) is composed of lighter chitin and works in unison with the mandibles. It is a fairly broad flat plate produced to a slender point anteriorly: the end of this projection is hard and black and extends a little beyond the mandible. The lower edge of the maxilla is heavily fringed with fine hairs. The maxillary palp arises near the outer posterior edge and is very large and conspicuous. The basal segment is a short triangular mass of heavy chitin. The second segment is large, cylindrical and well chitinized, whilst the apical segment is fine and slender.

The Pupa (Text-fig. 3).

The pupa is 19 to 22 mm. in length. When newly formed, the thoracic region and all the anterior end, except the eyes, are a creamy colour, and the abdomen is bright chestnut. The colour changes to a general light brown, and before emergence again darkens considerably, the eyes becoming greenish.

The frontal carina is a ridge of light brown, wrinkled chitin with a notch in the median line. Above the carina is a pair of slight prominences of wrinkled chitin, each bearing a fine bristle. Below the carina is a pair of small, but prominent projections placed close together in the median line, and lying between the eyes ventrally. Below and to each side of these is one fine bristle. The antennae are short and curved down over the eye. The thoracic spiracles are short and dark-brown, and do not project much beyond the dorsal surface. The wing sheaths just reach the fore border of the second abdominal segment.

Except for the first and last, the abdominal segments are all similar. The first to the seventh are divided into dorsal, lateral and ventral areas by smooth grooved lines. Each of these segments bears a conspicuous spiracle near the centre of each lateral area. The spiracle (Text-fig. 10) is a round mound with a strong chitinous rim which is incomplete anteriorly. Near the posterior edge of the mound is a curved spiracular slit, opening into a large felt chamber. Every segment except the first bears a girdle of spines near its centre. The part of the segment in front of the ring of spines is marked with a network of raised lines of darker brown than the general surface. The posterior half of the segment is finely rugose. The girdle of spines, which point backwards, is continuous. The spines are dark brown, thorn-like structures, and are largest and strongest on the dorsum, smaller in the lateral areas and very small ventrally. The lateral spines are produced into long, stiff, colourless setae. In the last segment the dorsal spines are absent, whilst all the rest bear setae. In the female pupa there is a median gap ventrally in the ring of spines on the last segment, whilst in the male there is no break in the ring.

The pupal aster (Text-fig. 11) which in all known Tabanid larvae, except *Goniops*, is a series of six large projections on the anal segment, consists of only two noticeable projections, the dorso-lateral pair. These are strongest and most outstanding in the male pupa. The ventral pair are reduced to two small knobs, and the dorsal pair are scarcely distinguishable.

Fig. 1.

Fig. 2.
Areas where larvae of *Scaptia* were found.