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Two New African Species of Drosophila (Diptera, Drosophilidae) Whose Larvae Feed on Simulium Larvae (Dipt., Simuliidae)

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Summary

Two new species of *Drosophila*, with aquatic larvae, are described and named *D. cogani* and *D. simulivora*. *Drosophila gibbinsi* Aubertin is the only previously known *Drosophila* with aquatic larvae. It belongs to the same species group as the two new species. Its description is amplified and the *simulivora* species group (subgenus *Drosophila* S.Str.) is erected to include the three species.

The larvae of the two new species feed mainly on first and second instars of *Simulium* larvae, which are abundant in the fast-water microhabitats patronised by the two *Drosophila* species. Both species are attacked by a parasitoid of the genus *Trichopria* (Hymenoptera, Diapriidae).

Distribution, evolution and niche-separation problems are briefly discussed. The possible role of *D. cogani* and *D. simulivora* in the biological control of *Simulium damnosum* is also discussed.

Zwei neue Drosophila-Arten (Diptera, Drosophilidae) aus Afrika, deren Larven sich von Simulium-Larven (Dipt., Simuliidae) ernähren

Zwei neue *Drosophila*-Arten (*D. cogani, D. simulivora*), deren Larven aquatisch leben, werden beschrieben. Sie gehören zur selben Artengruppe wie *D. gibbinsi*, der bisher einzigen bekannten *Drosophila*-Art mit aquatischen Larven. Deren Beschreibung wird erweitert. Für die drei Arten wird eine neue Artengruppe (*simulivora*-Gruppe, Untergattung *Drosophila* s.str.) aufgestellt.

Die Larven der beiden neuen Arten ernähren sich hauptsächlich von *Simulium*-Larven (1. und 2. Stadium), die in den von ihnen bevorzugten Mikrohabitats mit schnellfließendem Wasser reichlich vorkommen. Beide Arten werden von Hymenopteren der Gattung *Trichopria* (Diapriidae) parasitiert.

Verbreitung sowie Probleme der Evolution und Nischenbildung werden diskutiert. Besprochen wird außerdem die mögliche Bedeutung von *D. cogani* und *D. simulivora* für eine biologische Bekämpfung von *Simulium damnosum*.

The larvae of *Drosophila gibbinsi* Aubertin, which were discovered in the river Nile in Uganda (Smart 1937), are the only aquatic Drosophilids known up to now.

The present paper describes two further species with aquatic larvae, which were collected by one of us, somewhat unsystematically, during a survey of populations of Simuliidae in the forest zone of West Cameroon during 1970 (Disney, in press). It had been observed that the *Drosophila* larvae seemed to be associated with concentrations of *Simulium* larvae. Subsequently it was found, on dissecting some of the preserved *Drosophila* larvae, that the two species were feeding primarily on the *Simulium* larvae with which they were associated in the field. This discovery suggests that the species could be useful in a programme of integrated biological control of *Simulium damnosum* Theobald.

The two new species were discovered mainly in the River Mungo, and its tributaries, in the region north-east of Kumba. One species also occurred in the Bille River, a tributary of the River Meme lying to the west of Kumba. The various sites are shown on maps

elsewhere (Disney 1971 and in press). The site supporting the largest population of both species was the Blackwater tributary of the River Mungo (4° 22' N, 9° 47' E).

The fact that the Blackwater was the main breeding site for the two new species appears to correlate with the observation that this site was atypical in that not only were the conductivity, alkalinity and measured cations higher than other sites surveyed in the region, but also it was the only site which continuously supported large populations of *Simulium damnosum* throughout the year of the survey of blackfly populations (Disney in press). This further emphasises the possible role of these aquatic Drosophilid larvae in the biological control of *S. damnosum.*

In addition to the Cameroon specimens it was subsequently found that some specimens from Liberia, collected by Professor Muirhead-Thomson in 1956, belonged to one of the new species and not, as had been previously supposed, to *Drosophila gibbinsi.*

Taxonomy

Drosophila cogani n.sp. and *D. simulivora* n.sp. are described and compared with *D. gibbinsi* Aubertin, the description of which is amplified. These three species are very closely related, to the extent that they are not easily separated by a conventional key. Examination of the genitalia is always necessary for a sure determination. Nevertheless the arista and palpus, in certain cases, provide useful pointers to the specific identity of a given specimen.

While the adults are difficult to separate larvae and pupae, at least for the sympatric species *D. cogani* and *D. simulivora,* are easier to distinguish; the ventral hooks being much more robust in *D. simulivora.*

The descriptions of the larvae are based on the nomenclature used by Okada (1968) and Tsacas (1969).

Drosophila gibbinsi Aubertin (Fig. 1)

Drosophila gibbinsi Aubertin, 1937, Proc.R.ent.Soc. Lond. (B) 6 (9): 169

This species was described from a series of males and females. To supplement the excellent description by Aubertin we add some details neglected by him, some measurements and drawings of the genitalia.

Male

Head: width of the head: width of the frons = 1,9; frons with a triangular paler spot in its centre; orbits darker than the frons, shining slightly, wide; width: height of the frons = 1,8; orbital bristles normal, or I: or 3 = 0,5; or I: or 2 = 1,2; or 2 nearer to or I than to or 3 and displaced towards the outside, or 3 inserted nearer to or I than to inner vertical bristle; postvertical bristles as long as or I and hardly crossed; arista with 5-6 upper short branches and 2, sometimes 3, lower ones in addition to the terminal fork; carina brown, dorsally whitish, narrow at base of antennae, widening to a triangular form beneath and reaching almost to the epistoma; clypeus scarcely visible, yellowish; peristome with I oral bristle followed by 2 shorter hairs; palpus yellow; cheek wide, ca 1/4 the length of the longer axis of eye, with 2 bristles (one of which is longer than the oral bristle), followed by 3 ± shorter hairs; palpi wide, with four marginal bristles and numerous hairs; eye red brownish, densely short pilose. Mesonotum with 6-8 irregular rows of ac; two pairs of dc preceded by a third pair of smaller bristles; no prescutellar; anterior scutellar bristles crossed in their middle, posterior ones parallel (a; p = 1,03); sterno-index 0,77; 2 subequal humeral bristles. Legs yellow to brownish, the femur lighter in colour, hairy; fore femur with one row of 3 bristles, situated posteroventrally on its distal two-thirds, the middle one longer; a preapical dorsal bristle present on all tibiae, apical present only on middle tibia; the metatarsus of forelegs as long as the other four segments together. Wings with brownish veins, 3rd longitudinal vein (r 4+5) and m parallel; wing indices: length : width = 2,5, c = 3,1, 4v = 0,70, 4c = 0,48, 5x = 1,2, ac = 2,2, c3 fringe = 100%. Abdomen: tergites with a scarcely visible brown ill-defined band: genitalia coloured as preceding tergites.

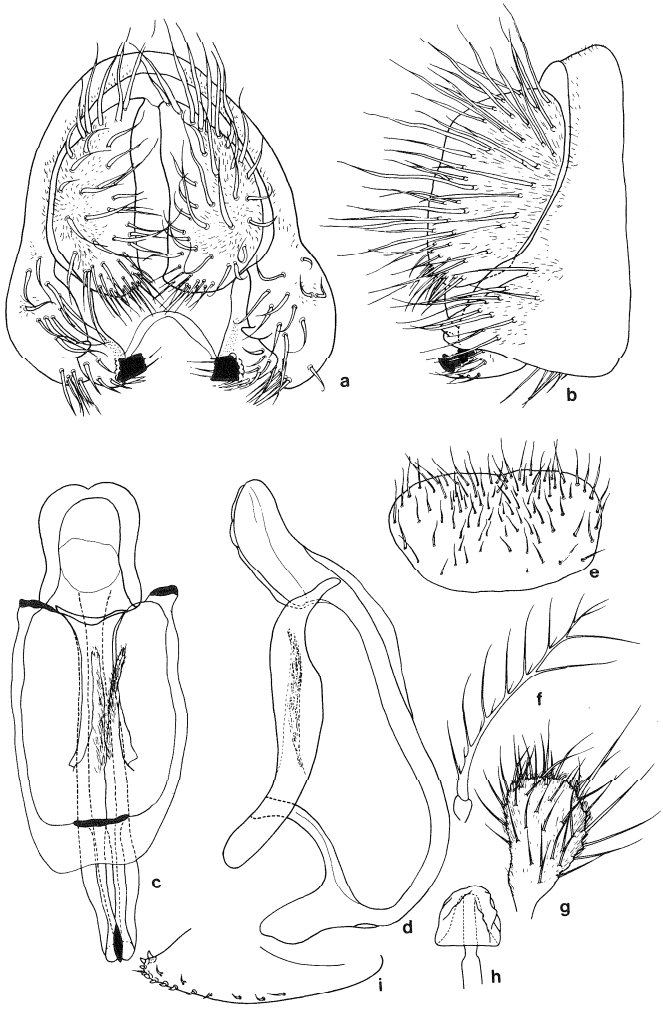

Fig. 1. *Drosophila gibbinsi* Aubertin. a, periphallic organs in caudal view; b, the same in lateral view; c, phallic organs in ventral view; d, the same in lateral view; e, pregenital sternite of ♂, f, arista of ♂; g, palpus of ♂; h, spermatheca; i, ovipositor.

Female

Like the male in colour; egg guide brown, narrow. Indices: head : frons = 1,9; width : height of frons = 1,5; eye : cheek = 4,4; orbitals: or I: or 3 = 0,52; or 1: or 2 = 1,3; sterno-index = 0,82; scutellar (a:p) = 1,05; wing indices: c = 2,8; 4v = 0,66; 4c = 0,52; ac = 2,0; 5x = 1,2.

Body lengths: ♂, 2,8-3,0 mm (pinned specimens), wings 3,2 mm.
♀, 3.0 mm, wings 3.5 mm

Larva and Pupa: have been described by Smart (1937)

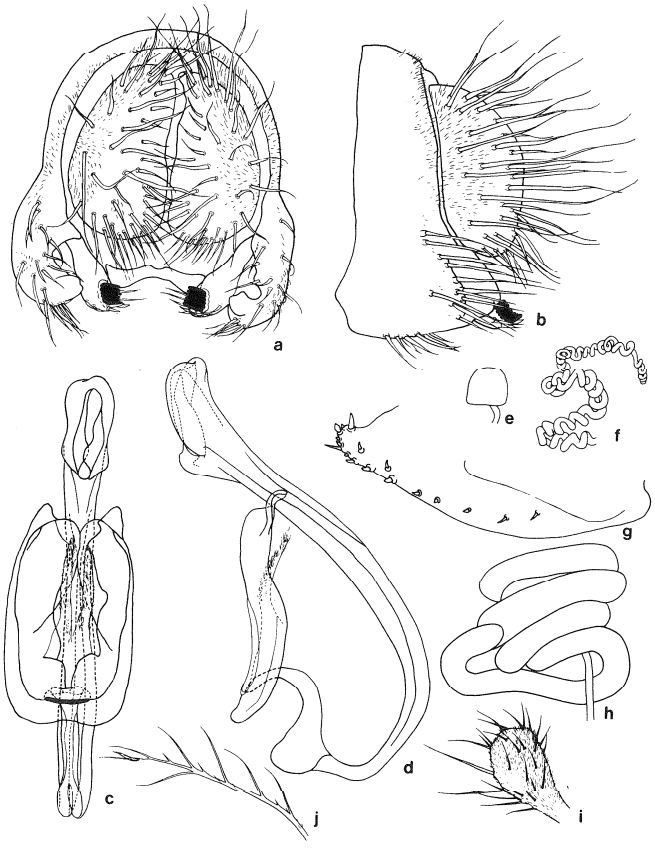

Fig. 2. *Drosophila cogani* n.sp. adult. a, periphallic organs in caudal view; b, the same in lateral view; c, phallic organs in ventral view; d, the same in lateral view; e, spermatheca; f, ventral receptacle; g, ovipositor; h, testis; i, palpus of ♂; i, palpus of ♂; j, arista of ♂.

Distribution:

Uganda, South Africa (Natal).

Holotype, allotype and paratypes, Jinja, Uganda (R. Nile), 4th March 1932 (leg. E.G. Gibbins). British Museum (N.H.), No. B.M. 1934: 259. Other material: 1♂, Shooters Hill, 22-VII-1956, Natal (leg. B. Stuckenberg).

1 ♂, 1 ♀, Kimoro, Madagascar Centre, 1680m. Andringitra, Ambalavao, 19-I-1958 (leg. B. Stuckenberg), the male shows some minor differences in the structure of its genitalia. Lacking further material we have not reached a final conclusion on the identity of these two specimens, they have been labelled *"Drosophila* sp. cf *gibbinsi* Aubertin".

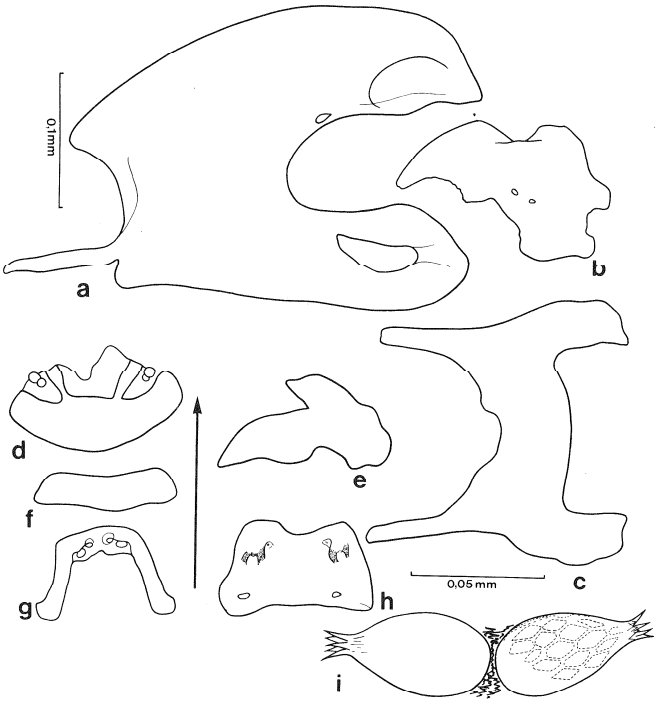

Fig. 3. *Drosophila cogani* n.sp. larva and presumed eggs. a, pharyngeal piece; b, mouth hook; c, median piece; d, interectostomal plate; e, ectostomal sclerite; f, hypostomal plate; g, hypostomal sclerite; h, epistomal plate; i, presumed eggs (see text) – from a drawing by Prof. Muirhead-Thomson. Figs. d-h orientated anterior-posteriorly (arrow).

Drosophila cogani sp. n. (Figs. 2 and 3)

We describe this species by comparing it with *D. gibbinsi* Aubertin.

Male

Head: width of head : width of frons = 2, width : height of the frons = 1,9; bristles and hairs stronger than those of *D. gibbinsi*; no triangular paler spot in the centre of the frons; orbital bristles: or 1 : or 3 = 0,54; or 1 : or 2 = 1,56. Inner vertical bristles longer than or 3; postvertical bristles crossed in their apical third; arista with 5 upper short branches (rarely 4 or 6) and 2 lower ones (rarely 1 or 3), in addition to the terminal fork; carina narrow at the base of antennae widening beneath as in *D. gibbinsi* but so that it is rounded, not triangular, and less protruding; palpus narrower than in *D. gibbinsi,* less pilose; eyes dark red, pilosity shorter than in *D. gibbinsi;* cheek width ca. 1/4 the length of the longer axis of eye. Mesonotum scarcely shining with 8 regular rows of ac, sometimes 6; anterior scutellar bristles a little shorter than posterior (a : p = 0,87); sterno-index = 0,72. Metatarsus of the forelegs a little longer than the other four segments together; fore-tibia with one apical bristle, which is very short but visible. Wings as *D. gibbinsi* but narrower (L : W = 2,7); wing indices: c = 2,90; 4v = 0,67; 4c = 0,5; 5x = 1,20; ac = 2,3; c3 fringe = 100%. Abdomen: lighter in colour than *D. gibbinsi.*

Female

Like the male in colour. Indices: head : frons = 2; frons width : height = 1,3; eye : cheek = 4,7; orbitals: or 1 : or 3 = 0,61; or 1 : or 2 = 1,95; sterno-index = 0,65; scutellars (a:p) = 0,92; wings: c = 2,60; 4v = 0,66; 4c = 0,54; 5x = 1,40; ac = 2,30; c3 fringe = 100%.

Internal genitalia

♂, testes white, with 4-5 outer coils; ♀, spermathecae unsclerotised, ventral receptacle long and tightly coiled.

Periphallic organs

Genital arch (epandrium) broad laterally, yellow, microtrichia along posterior margin; lateral lobe (toe) conspicuous with numerous strong, long bristles along lateral lower margins; clasper with a lateral row of about 7 long obtuse teeth, a median cluster of smaller and less coloured teeth, two thin and elongate and one inferior row of 2-3 teeth similar to those of the median cluster. Anal plate separate from genital arch, brownish, large, dorsally tapering, with long and strong bristles; microtrichia on the anterior 2/3 of the anal plate. Tenth sternum rectangular, narrow.

Phallic organs

Aedeagus slender, long, curved, apically expanded; anterior parameres finger-like, hirsute. Hypandrium narrow, ninth sternum with two free lobes.

Egg guide

Brown, narrow, 14 unequal teeth on the margin, the 1st and 3rd longer; laterally with two other teeth; one subterminal bristle, between the fifth and sixth teeth.

Body lengths

♂ 2,4 mm (pinned specimens); wings 2,7 mm
♀ 2,6 mm (" "); wings 3 mm

Distribution

West Cameroon and Liberia
Holotype ♂, Wowe River, West Cameroon, Cameroon Republic, 23-1-1970. Paratypes I ♂, I ♀ same data; 1 ♂, 2 ♀ River Mungo (near Baduma), West Cameroon, 13-II-1970; 5 ♂, 1 ♀, Blackwater, West Cameroon, 3-VIII-1970; 2 ♂, 2 ♀, same locality, 9-V-1970 (leg. R.H.L. Disney); 1 ♂, 2 ♀, Firestone plantations, Liberia, X. 1956, ex egg mass of *Simulium damnosum* (leg. R.C. Muirhead-Thomson).

Holotype and paratypes in British Museum (N.H.), London; paratypes in Museum National, Paris.

Larva:

The mature larva spindle-shaped (fusiform) and narrowing anteriorly, measures 4,5-5 mm in length (for larvae preserved in alcohol) and about 1 mm in width. The integument is a pale brownish colour with a dorsal velvety covering. Ventrally it is covered with minute papillae. The anterior spiracles on the first thoracic segment are retractile inside the body of the larva, their stalks are long with numerous branches. The abdominal segments have ventral pads armed with brown or black hooks arranged in 3 double rows on each segment – the two antero-lateral rows face anteriorly and the median-posterior row faces posteriorly (cf. Plate IIb); the hooks vary in shape and length). The last segment (caudal segment) is narrower than the last but one and ends in a small siphon into which the peduncles of the caudal spiracles withdraw. On its ventral surface opens the anus, surrounded by a row of hooks and surmounted caudally by 3 lobes. Around the caudal siphon exist many small tubercules (as described in pupa).

Cephalopharyngeal skeleton about 1 mm in length. Mouth hooks joined dorsally, broad, strong, with one obtuse ventral tooth; ventral process, at a level more than two-thirds from the anterior end, small and obtuse. The mouth hooks of this species seem to correspond to the type B as defined by Okada (1968). Median piece (hypostomal sclerite of Okada) short, its transverse bar broad and arched, posterior arms short, anterior ones tapered. Ectostomal sclerites elongate with a ventral pointed protuberance; between them there is an odd interectostomal plate, its shape being roughly an arch with the concave side forwards. The epistomal plate (epipharyngeal sclerite of Okada 1968) a vague trapezoid, with two posterior foramena and two anterior sensillae. The hypostomal plate is in shape of a transverse band, its sclerites being fused into a single arched sclerite with the lateral arms pointing backwards. Pharyngeal piece short and solid, its basal piece broad, with short superior and inferior branches, the latter with a broad foramen; no differentiated sclerotised arch (latticed process of Okada).

Pupa:

The ovoid pupa measures about 4 mm in length, the ventral surface remains flat. Its colour is light brown. The puparium is formed by the integument of the larva and exhibits all its external features (as described above). The anterior spiracles are evaginate, horn-index = 8,3, the number of branches is about 57, with 4 much shorter centrals, and they are variable in length. The tips of the branches are club shaped (clubbed type of Okada). These branches occupy the entire surface of the head of the stalks. Their arrangement on the stalk is not easy to recognise but is probably assignable to the type Y of Okada (1968).

Caudal tubercules in about 5 pairs: 2 dorsolaterals, 4 laterals and 4 ventrals. The posterior spiracles close together, pale, tubular, wider than long.

Egg

We did not find eggs in nature. All the females dissected, being freshly reared, were without mature eggs in their ovaries. However Professor Muirhead-Thomson found some eggs in an egg mass of *Simulium damnosum* in Liberia, alongside the immature stages of *D. cogani.* These eggs are illustrated in Fig. 3i. They are not of the usual Drosophilid type and so their identity must remain tentative. The circumstantial evidence suggests they belong to this species.

Drosophila simulivora sp. n. (Figs. 4 and 5)

This species is very close to the two preceding species and it is therefore described by comparison with them.

Male

Head: width of head: width of frons = 1,97; frons width : height = 1,34. Bristles of head strong as in *D. cogani;* periorbits paler; orbital bristles: or 1 : or 3 = 0,76; or 1 : or 2 = 2,2; frons darker in its anterior part; postvertical bristles hardly shorter than inner vertical bristles; antennae brownish, arista with 5 (4-6) upper very short branches and 2 sometimes 1 lower in addition to the terminal fork; face paler than frons; carina narrower between the bases of the antennae than in *D. cogani,* widening abruptly beneath, with parallel sides, pale dorsally; palpi brownish with marginal bristles shorter than in *D. cogani;* cheek wide – ca. 1/6th the length of the longer axis of eye.

Mesonotum with the longitudinal markings better defined than in *D. gibbinsi;* acrostichal hairs in 6 rows; anterior and posterior scutellar bristles of equal length (a:p = 1); 2 sternopleural bristles, sternopleural index = 0,65. Legs yellow, metatarsus of forelegs shorter or equal to the other four together; tibiae with apical and preapical bristles as in *D. cogani.*

Indices of the wings: length : width = 2,7; c = 3,0; 4v = 0,6; 4c = 0,5; 5x = 1,1; ac = 2,1; c3 fringe = 100%.

Abdomen: tergites apically and laterally brownish, apical bristles long particularly on the last tergite.

Female

Like the male in colour. Indices: head : frons = 1,99; width : height of frons = 1,32; eye : cheek = 5; orbitals: or 1 : or 3 = 0,64; or 1 : or 2 = 2,0; sterno-index = 0,67; scutellars (a:p) = 1,0; wings: length : width = 2,5; c = 2,76; 4v = 0,64; 4c = 0,52; 5x = 1,5; ac = 2,2; c3 fringe = 100%.

Internal genitalia:
♂, testes white with 5 outer and 5 inner coils; ♀, spermatheca unsclerotised, longer than in *D. cogani,* ventral receptacle long, less tightly coiled than in *D. cogani.*

Periphallic organs:

Genital arch yellow, slightly broader laterally; lateral lobe (toe) with three bristles, anterior lobe (heel) with a group of five bristles; microtrichia along posterior margin, except its lower part; only primary claspers present with a row of 12-13 teeth and a second row of 7 bristles. Anal plate wide, separate from genital arch, yellowish, with long bristles.

Phallic organs:

Aedeagus curved, broad, broadly rounded apically. Two rounded processes with three minute sensillae present are probably the anterior parameres. Caudal margins of ninth sternum deeply notchend and without spines.

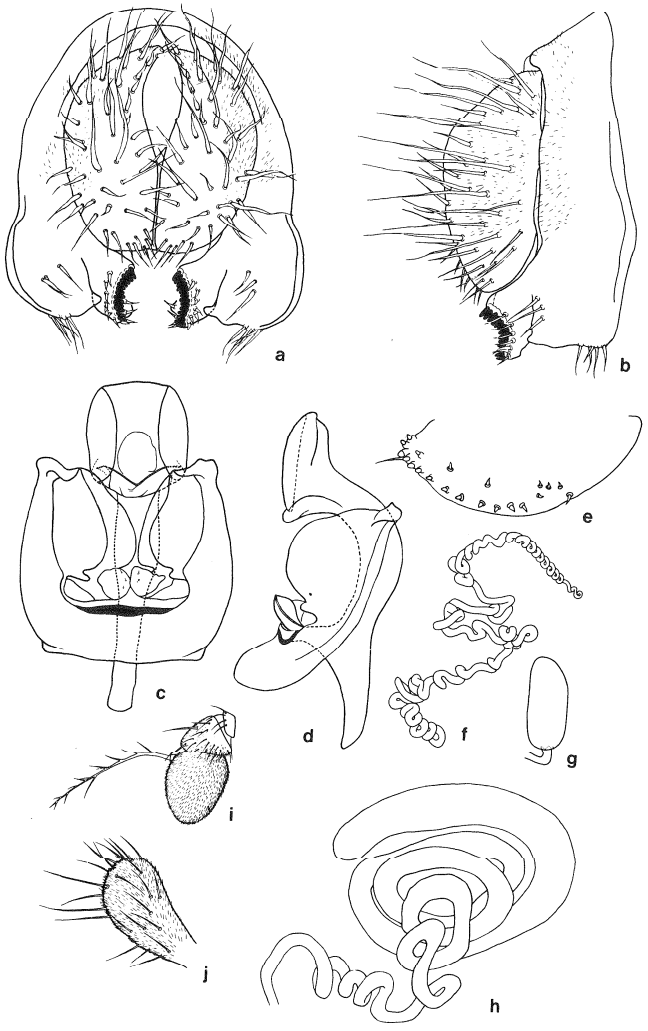

Fig. 4. *Drosophila simulivora* n.sp. adult. a, periphallic organs in caudal view; b, the same in lateral view; c, phallic organs in ventral view; d, the same in lateral view; e, ovipositor; f, ventral receptacle; g, spermatheca; h, testis; i, antenna of ♂; j, palpus of ♂.

Egg guide:

Brown, broader than in *D. cogani;* 14 unequal teeth on the margin, seven other teeth laterally one subterminal bristle between the third and fourth teeth.

Body lengths:

♂ 2,1 mm (pinned specimens); wing: 2,7 mm.
♀ 2,3 mm (" "); wing: 2,6 mm.

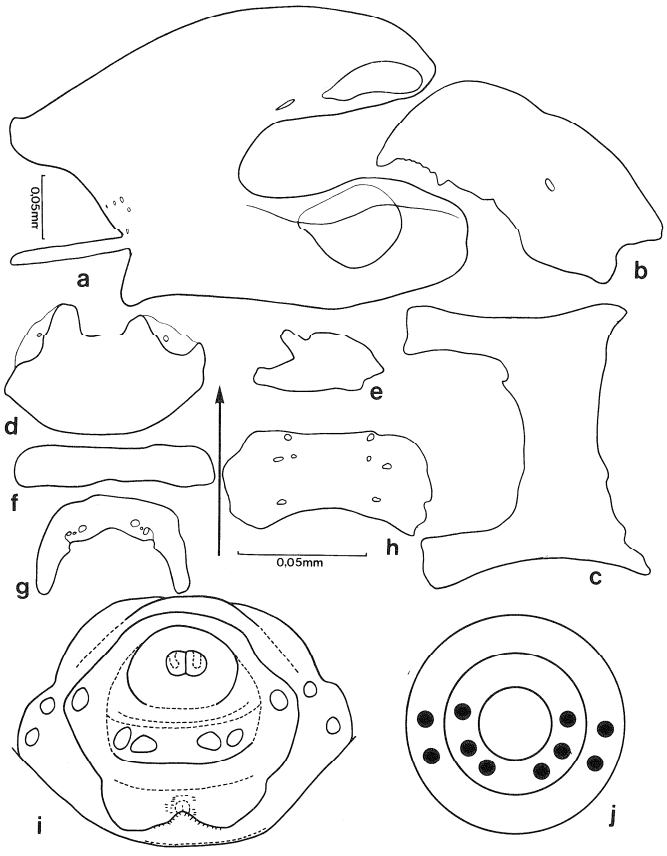

Fig. 5. *Drosophila simulivora* n.sp. larva and pupa. a, pharyngeal piece; b, mouth hook; c, median piece; d, interectostomal plate; e, ectostomal sclerite; f, hypostomal plate; g, hypostomal sclerite; h, epistomal plate; i, caudal view of puparium; j, disposition of caudal tubercles of puparium. Figs. d-h are orientated anterior-posteriorly (arrow).

Distribution:

West-Cameroon.
Holotype ♂, Blackwater, West Cameroon, Cameroon Republic, 3-VIII-1970, 6 ♂, 8 ♀; same date; 1 ♂, 1-V-1970, 5 ♂, 9-V-1970 (leg. R.H.L. Disney). Holotype and paratypes in British Museum (N.H.), London; paratypes in Museum National, Paris.

Larva

The larva of *D. simulivora* looks very similar to that of *D. cogani* except that the hooks of the ventral pads are black in colour and much more robust. By contrast the mouth parts of the two species are very different, apart fom size. Mouth hooks joined dorsally, rectangular in shape with the distal tooth small and the ventral process very small and close to it. Between them there is a roughened region representing a first stage in the differentiation of the teeth (type C? of Okada). Median piece short, with the transverse bar broad and straight, the posterior arms are rudimentary and the anterior ones enlarged apically.

Ectostomal sclerites broader with a small, ventral, obtuse protuberance; the interectostomal plate is comparable to that of *D. cogani.* The epistomal plate is roughly rectangular in shape, broader than long and with 8 foramena arranged in two lateral groups. The hypostomal plate is in the shape of a transverse band, its sclerites are fused into a single arched sclerite, with the lateral arms pointing backwards. Pharyngeal piece as that of *D. cogani* but without anterior apophysis.

Pupa

Similar to that of *D. cogani.* The hooks of the ventral pads are much stronger than those of the latter species. Horn-index = 9,7. Number of branches of anterior spiracles about 97, of which 2 are shorter centrals.

Egg

Not known.

Relationships

The three species dealt with in this paper form a very homogeneous group. That this group belongs to the genus *Drosophila* is not obvious at first sight. The form of the frons (wide and short) as well as the small spines of the fourth costal section, which run along its whole length, bring it closer to the genus *Microdrosophila.* The conformation of the arista, very unusual in *Drosophila,* recalls some species of *Scaptomyza.* The external morphology, therefore, leaves some room for doubt as to the generic position of this species group.

On the other hand the study of the genitalia reveals characters showing unquestionable affinities between this species group and *Drosophila.* In fact the structure of the epandrium, and above all of the phallic organs, is typical of the subgenus *Drosophila* s. str. With regard to the internal organs the ventral receptacle is of a type very common in this subgenus. On the other hand the testes are of a type rather rare in *Drosophila* s. str.

Within the subgenus *Drosophila* it is impossible to place these species in one of the existing species-groups. At most they show some superficial similarities with the *polychaeta* group, especially with regard to the dorso-centrals. It is therefore considered that the three species, *D. gibbinsi, D. cogani* and *D. simulivora,* are peripheral members of the subgenus *Drosophila* s. str. and that they form a new species-group within this subgenus. This group can be briefly defined as follows:

Species-group *simulivora* sp. gr. n.

Medium-sized flies, light brown in colour; abdomen brownish apically. Two pairs of dorso-centrals preceded by 1 or 2 much smaller pairs, posterior dc very long. High costal index ($> 2{,}5$), C3 fringe = 100%. Branches of arista short.

Some characters make it difficult to fit the adults into the system established for the genus *Drosophila.* The same applies to the pre-imaginal instars. In fact if we disregard such obviously adaptive characters as the development of the abdominal hooks these species still exhibit some unusual features – both for the genus *Drosophila* and for the family Drosophilidae.

Our knowledge of the larvae and pupae of this family is still very fragmentary. Thus it would be premature to draw conclusions from the following review of noteworthy characters:

1. Oral hooks: We know of no other case, in the Drosophilidae, of a dorsal fusion of these structures.

2. Interectostomal plate: This recalls the "Unterlippenstück" of Muscidae (Schumann 1963). It is also known that carnivorous larvae tend to have a greater number of sclerites in their mouthparts. This underlines the predatory habits of the larvae of the *simulivora*-group.

3. Anterior spiracles: Such a large number of branches is unique in the Drosophilidae – *D. cogani* 57, *D. simulivora* 97 and *D. gibbinsi* 33 (as indicated in the figure by Smart 1937). Clearly such a large number tends to obscure the underlying pattern of their arrangement. For *D. cogani,* however, their arrangement appears close to the Y type of Okada (1968).

4. Posterior spiracles: These are of the closed type (parallel) but they are peculiar in having the ratio length/width (in dorsal view) smaller than in the open (divergent) type (cf. Okada 1968, p. 165).

5. Locomotory pads: These are very well developed and bear very robust hooks. We interpret this as an adaptation that enables the larvae to contend with strong currents in the rivers where they live. These hooks recall similar structures described by Vaillant (1951, 1953) in some larval Empididae which also feed on Simuliidae.

6. Caudal tubercles of the pupa: These are notable for their reduced size and number. They are consequently difficult to discern. Only the dorsal and anal tubercles seem entirely absent, the lateral, sublateral, ventral and subventral being present. Such reduction is exceptional in Drosophilidae.

Natural History

Larvae and pupae of *Drosophila cogani* and *D. simulivora* were first obtained on palm fronds set in rivers as a device for collecting *Simulium* larvae and pupae (Disney 1972). At the Blackwater site there was always settlement of larval Chironomidae and *Simulium* on these fronds, with *S. damnosum* being one of the principal species. In addition regular settlement of the two species of *Drosophila* occurred, especially on parts of palm-frond leaflets which developed a mat of algal filaments, *Simulium* salivary-threads and so on. While the larvae were always fully immersed the pupae were around the water line. These *Drosophila* pupae were thus either immersed or just above the water line and were always very firmly adhering to the surface of the palm-frond leaflets.

Having procured larvae and pupae on these palm-fronds a search was made for the normal substrata. It was soon found that 'equivalent' situations were being patronised – that is the 'normal' substrata favoured by *Simulium damnosum* were the preferred substrata of the *Drosophila* species. In particular trailing root-mats (at the end of aerial roots descending from overhanging trees) were particularly favoured. It is evident that the larvae, although living in a situation characterised by fast flowing water, manage to avoid dislodgement by the current. They achieve this partly by seeking cover amongst the fibre/filament mat covering the substratum but also through the effective anchoring achieved by the hooks on the ventral pads (Plate II c and d).

The dissection of larvae, which had been preserved in alcohol, showed that both species are carnivorous. The most frequent item that was recognised in the stomach contents proved to be young larvae of *Simulium* (Plate I c). The characteristic cephalic fans, hypostomium and posterior circlet of a larval *Simulium* are readily distinguished if the gut contents are mounted in Berlese's Gum Chloral Fluid on a glass slide. Typically first instar (evidenced by the egg tooth) or second instar *Simulium* larvae are eaten. They are consumed in large numbers. Thus one larva of *D. simulivora,* which measured just under 3 mm in length, contained nearly 150 distinguishable items in its gut. At least 140 of these could be confidently identified as first and second instar larvae of *Simulium.* The remain-

ing items were too digested for certain identification, with the exception of the 'husk' of what we believe to be a *Simulium* egg (Plate I a).

There is little doubt that the dominant item in the diet of both *Drosophila cogani* and *D. simulivora* is young *Simulium* larvae. The two species thus resemble *D. gibbinsi* in feeding on aquatic Diptera larvae in that Smart (1937) wrote of this species that the "gut contained a very large number of dipterous larval head capsules which appeared to be those of small chironomids". The preference of larvae of *D. cogani* and *D. simulivora* for *Simulium* larvae would seem to be a feature distinguishing them from *D. gibbinsi.*

Table 1 summarises the records of the two species in Cameroon. This indicates that both species were collected in the period from 1 January – 3 August 1970. In addition *D. cogani* was recorded in Liberia in October 1956. It would seem, therefore, that the species are to be found throughout the year. It is clear that the two species live side by side in the same situation. The time elapsed between the collection of pupae (or larvae) and the hatching of the adults ranges from 5-19 days in the two species. This appears to be longer than one might have expected for a Drosophilid in tropical temperatures. More precise records are required.

Parasitism

When hatching adults from pupae of *D. cogani* and *D. simulivora* in the laboratory it was found that many had been attacked by a parasitoid Hymenopteran. One wasp emerged from each parasitized *Drosophila* pupa. One species only was involved and this has been identified as *Trichopria* sp. of the family Diapriidae. The taxonomy of African Diapriidae is in such a state that further designation is not possible. Plate 1 d shows a parasitised puparium of *D. cogani.*

An unidentified species belonging to the genus *Trichopria* has previously been reported as a parasite of *Drosophila* sp. in Hawaii, under experimental conditions (Dresner 1954). This is therefore the first time that a species of this genus is cited as a parasite of a Drosophilid under natural conditions. Judging from the parasitised pupae we were able to study the *Trichopria* larva is a true endoparasite that lives inside the body of the pupa, always as a single larva, in both *D. cogani* and *D. simulivora.* A careful examination of parasitised puparia did not reveal the site of oviposition or point of penetration by a young larva. It is possible that oviposition takes place on the mature larva when it leaves the water prior to pupation. The emergence hole of the adult wasp, in both *Drosophila* species, is always situated in the antero-dorsal part of the puparium.

The *Trichopria* was recorded from three localities (Blackwater, Bille and the Mungo near Baduma). It therefore seems widespread in the Kumba area of Cameroon. It is probable that more systematic collecting would have shown it to be in all sites supporting populations of the *Drosophila* species. The parasitised pupae were collected between 1-IV-1970 and 1-VI-1970. This period corresponds to the period when the largest number of specimens were collected and reared in the laboratory. Almost certainly both the parasite and its hosts can be collected throughout the year. The collections were too unsystematic to reveal the percentage of pupae parasitised, but the numbers while not very high are nevertheless sufficiently numerous to suggest that the attacks of *Trichopria* might constitute a significant factor in the regulation of the *Drosophila* populations.

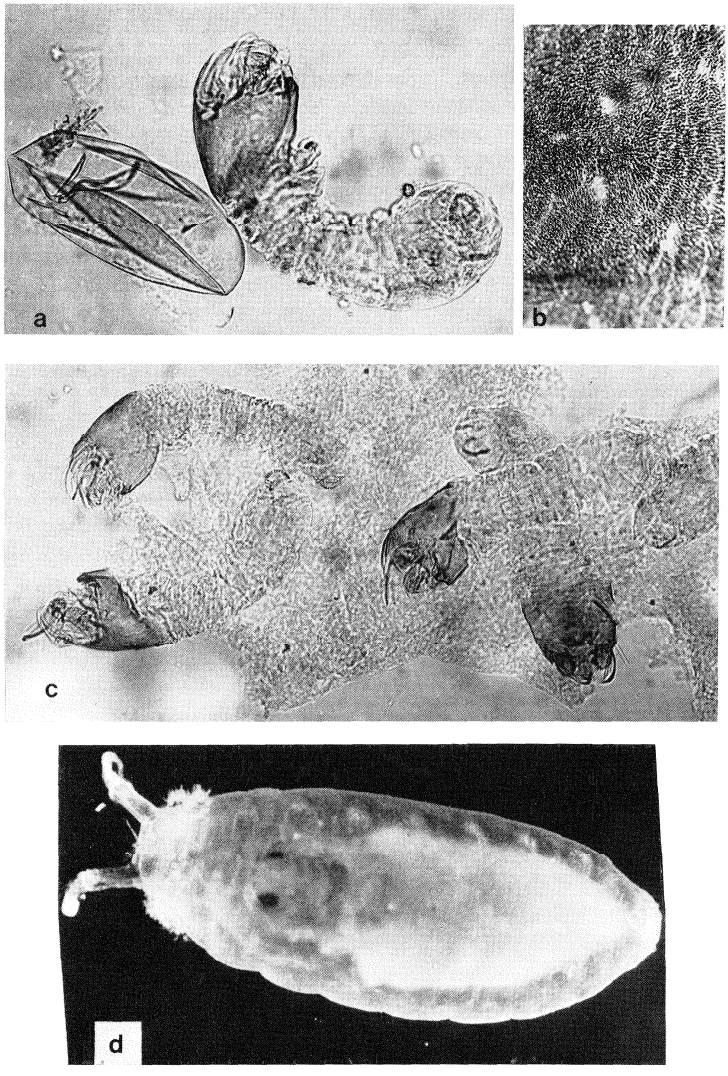

Plate 1. a, simuliid egg and larva found in the stomach of *Drosophila simulivora* n.sp.; b, dorsal view of larval integument of *D. simulivora;* c, gut contents (*Simulium* larvae) of *D. simulivora;* d, puparium of *D. cogani* n. sp. containing a pupa of the parasitoid *Trichopria* sp. (Hymenoptera, Diapriidae).

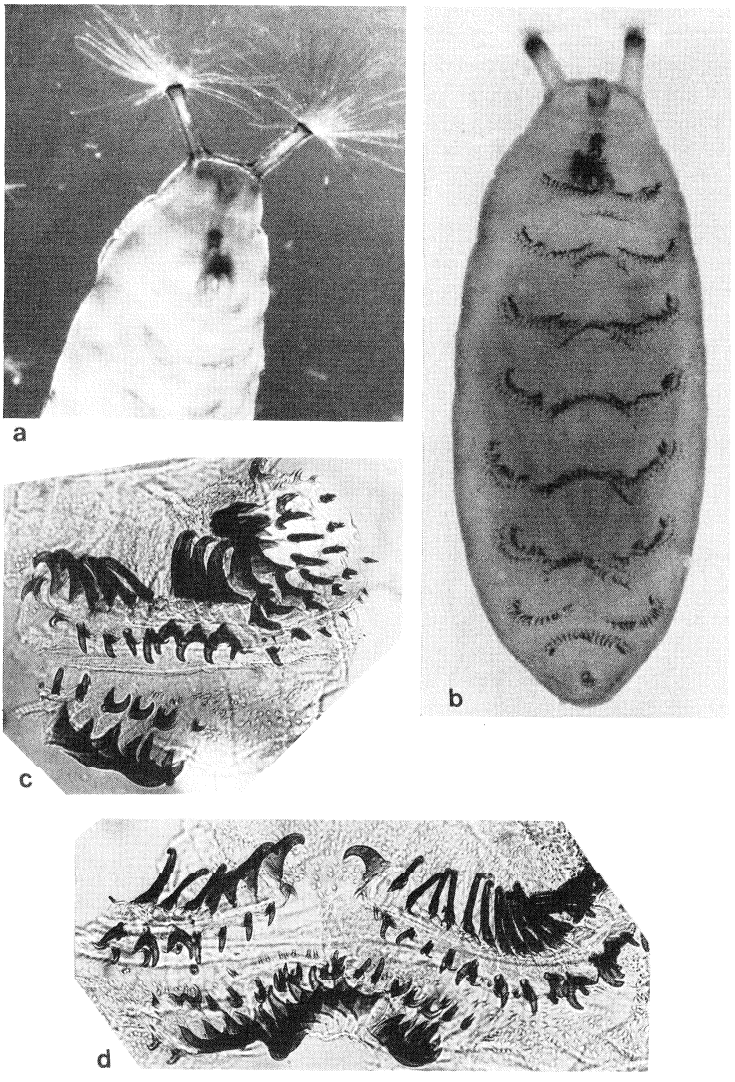

Plate 2. a, *Drosophila cogani* n. sp. pupa – dorsal view of anterior part; b, ventral view of pupa of *D. simulivora* n. sp. c, ventrolateral pad of *D. simulivora* larva. d, ventral pads of *D. simulivora* larva.

Distribution and Evolution of the Simulivora-group

The geographical distribution of the *simulivora*-group is insufficiently known to be able to relate it to any of the 'standard' beiogeographical patterns. Thus while what is known (Fig. 6) recalls the Victorian areotype of Sharpe (1893) the latter was regarded as being exclusively applicable to mountain faunas. The available evidence indicates that *D. simulivora* and *D. cogani* are forest-zone species and *D. gibbinsi* is a savanna-zone species.

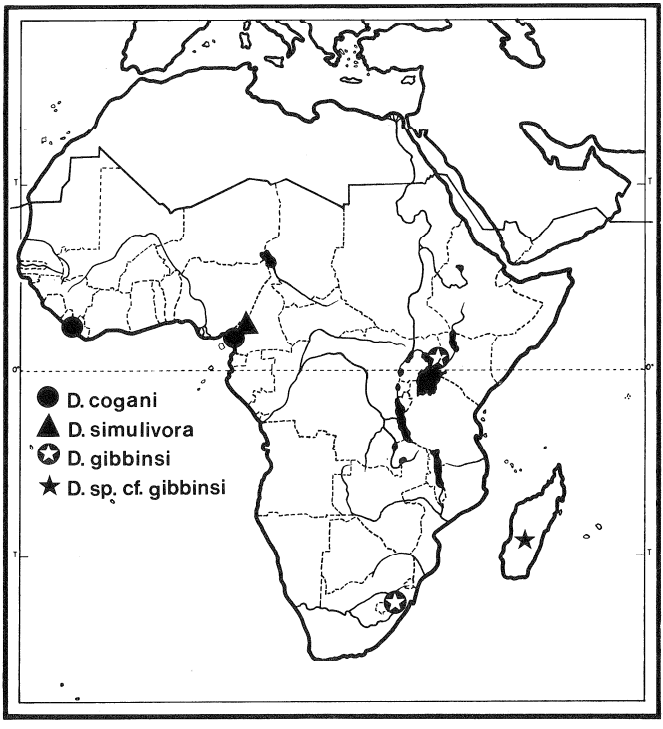

Fig. 6. Distribution of the species of the *Drosophila simulivora* species-group.

The *simulivora*-group is doubtless monophyletic and it is therefore interesting to note that the sympatric *D. cogani* and *D. simulivora* exhibit considerable differences in their genitalia. On the other hand the genitalia of the allopatric *D. gibbinsi* and *D. cogani* are very similar. Thus it would seem that a more rapid differentiation has occurred during speciation between the two sympatric species than between the two allopatric species. This phenomenon is even more marked with regard to the malagassy form, the differentiation of which appears to have not yet reached the specific level.

Present knowledge does not indicate whether the divergence of *D. cogani* and *D. simulivora* was the result of sympatric speciation or not. The two species are now (at least) sympatric in the narrowest acceptance of the term. It is not unusual to find pupae of the two species side by side on the same support. Both species feed on Simuliidae, as is proven by larval gut contents. It is thus difficult to perceive any niche separation or mechanism of speciation. It is possible, however, that the two species utilise slightly different

Table 1. Details of collections of *Drosophila cogani* and *D. simulivora* from West Cameroon in 1970. (Reared adults, with associated pupal pelts, are indicated in brackets.)

Localities (Rivers)	Dates		specimens preserved	Species
	Collection (larvae/pupae)	Emergence of adults		
Blackwater	6 Jan.	–	pupae	*D. cogani*
"	14 Mar.	–	larvae, pupae	*D. cogani, D. simulivora*
"	1 Apr.	18 Apr.	pupae (adults)	*D. cogani, D. simulivora, Trichopria*
"	"	19 Apr.	pupae (adults)	*D. simulivora, Trichopria*
"	"	20 Apr.	pupae (adults)	*D. simulivora, Trichopria*
"	"	22 Apr.	pupa (adult)	*Trichopria*
"	"	–	pupae (adults)	*D. cogani, D. simulivora, Trichopria*
"	4 May	–	larvae	*D. simulivora*
"	9 May	13 May	pupae (adults)	*D. cogani, D. simulivora*
"	"	14 May	pupae (adults)	*D. cogani, D. simulivora*
"	"	–	larvae, pupae (adults)	*D. cogani, D. simulivora, Trichopria*
"	1 Jun.	–	pupae	*D. cogani, D. simulivora, Trichopria*
"	3 Aug.	–	(adults)	*D. cogani, D. simulivora*
Mungo, north of Baduma	13 Feb.	–	pupae (adults)	*D. cogani, Trichopria*
Bille	23 Feb.	–	pupae	*D. cogani*
Menge	7 Apr.	–	pupae	*D. cogani*
Okia	19 May	21 May	pupae (adults	*D. simulivora*
Kobe, near Ikiliwindi	4 Jun.	–	pupae	*D. cogani*

feeding sites in relation to the current. The size difference in the ventral hooked pads of the larvae suggest this possibility. This would place *D. simulivora* in the stronger current and *D. cogani* in the weaker. There could also be a difference in their ability to hunt larger-sized prey. The inadequate information available suggests that *D. cogani* might be feeding more extensively on eggs and the smallest *Simulium* larvae. Unfortunately at the time the collections were made it was not appreciated that two species had been collected. It is perhaps not without significance that the specimens collected in Liberia by Professor Muirhead-Thomson were from an egg mass of *Simulium damnosum.* They were all *D. cogani.* He also found the possible eggs of *D. cogani* in this situation (see above).

The problem of niche separation and speciation in the *simulivora*-group will only be illumined by further observations.

Possible Role in Biological Control of Simulium damnosum

Although numbers of aquatic invertebrates have long been known to prey upon larval *Simulium*, including larval Diptera of the families Empididae and Dolichopodidae (Vaillant 1951. 1953). none of these have been animals that are both principally feeding on *Simulium* as well as being (at least potentially) relatively abundant. Crosskey (1973) rightly concluded in his review that "up to now no means for the biological control of black-flies have been discovered".

Larval Trichoptera are an example of common predators on the aquatic stages of *Simulium.* In West Africa they undoubtedly destroy large number of *Simulium* larvae (Burton and McRae 1972), but the evidence indicates that this is essentially non-selective, opportunistic predation. Because of this these predators are never likely to play a significant role in a programme of integrated biological control. However recent observations on the genus *Orthotrichia* (of the family Hydroptilidae) indicate that some West African species may be specialised, selective predators on the aquatic stages of *Simulium* – in particular on the eggs and pupae (Disney 1973). Some observations in Ghana (Burton and McRae 1972) back up the observations made in Cameroon. If these are indeed specialised predators on *Simulium* then this combined with their relative abundance in West African rivers indicates that they may have a potential in biological control. We suggest that the two species of *Drosophila* described in this paper exhibit a similar, or greater, potential for the biological control of *Simulium damnosum.* We believe the evidence for this view is sufficient to justify extensive studies to explore this possibility. Perhaps the *Trichopria* are partially regulating the populations of the *Drosophila.* If so then it might be necessary to first control the *Trichopria* populations (perhaps by mass releases of sterilised males) in order to trigger a population explosion of *Simulium*-eating *Drosophila* species in an African river.

With a control problem as formidable as that posed by *Simulium damnosum* it seems likely that the use of specialised predators is only likely to constitute the first stage of a programme of integrated biological control. Having reduced populations of pre-adult *S. damnosum* to manageable proportions it seems likely that one will then need to bring in additional weapons – microsporidian Protozoa, mermithid Nematodes, sterilised or non-anthropophilic genetic strains of *S. damnosum* and so on. While chemical control programmes can be most effective for freeing small, more-or-less self-contained sites (such as a dam and its environs) from *S. damnosum* the available evidence suggests that chemical control on a regional scale is likely to be expensive, ultimately ineffective and environmentally unacceptable. The environmental damage is likely to be vast and largely un-

predictable due to our very inadequate knowledge of African ecosystems. Our ignorance of the faunas of African rivers is particularly striking. The observations reported above highlight the probability that large-scale, chemical control programmes might only serve to blindly obliterate the organisms that could have provided the means of long-term control through a programme of integrated biological control.

The two species of *Drosophila* described in this paper certainly merit detailed study by medical entomologists as well as by those aroused by the intrinsic interest of these unusual aquatic Drosophilids and problems of niche-separation and speciation.

A c k n o w l e d g e m e n t s

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We are indebted to Dr. B.R. Subba Rao and Dr. Z. Boucek (British Museum – Nat. Hist.) for identification of the Hymenopteran parasitoid.

We are most grateful to Professor R.C. Muirhead-Thomson for allowing us to freely use his notes on *Drosophila cogani* and for letting us reproduce his drawing of the strange eggs he found.

Lastly we would like to thank Mr. P.K. Tatason who made daily checks on the containers of *Drosophila* pupae brought into the laboratory.

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BUCHBESPRECHUNGEN

Becker, Y.: **The Agent of Trachoma.** Recent Studies of the Biology, Biochemistry and Immunology of a Prokaryotic Obligate Parasite of Eukaryocytes. (Monographs in Virology, Vol. 7) 1974. VIII, 99 pp., 12 figs., 5 tabs. (S. Karger Verlag, Basel.) Bound DM 61,–

Anhand der Originalliteratur (16 Seiten Literaturverzeichnis) hat der Autor mit Kompetenz folgende Probleme des Trachomerregers abgehandelt: Definition und Klassifikation, Isolierung und Vermehrung, Biologie (Entwicklungszyklus und Morphologie), chemische Zusammensetzung, molekulare Aspekte des Entwicklungszyklus, Antibiotika und Immunologie. Hervorzuheben ist, daß trotz der übersichtlichen und knappen Darstellung auch Einzelheiten über abgeschlossene und noch in der Entwicklung befindliche Forschungsrichtungen zu finden sind. Die Gliederung des Stoffes folgt bewährten Prinzipien der Mikrobiologie und wird am Schluß in einem Resumé zusammengefaßt. Nicht nur Mikrobiologen, auch Kliniker und Präventivmediziner werden den Band mit Gewinn gebrauchen können.

E. Mannweiler, Hamburg

Guidelines for the Laboratory Diagnosis of Cholera. Prepared by the WHO Bacterial Diseases Unit. 1974. 23 pp. (World Health Organization, Geneva.) Paper Sw.fr. 5,–

Anleitungen zur Diagnose der Cholera finden sich auf 17 Seiten über folgende Themen:

Einrichtung eines zentralen und peripheren Laboratoriums, Isolierung und Charakterisierung von Cholera-Stämmen, Nachweis von Dauerausscheidern und Serodiagnose.

Auf 6 weiteren Seiten werden die Zusammensetzung und Herstellung von Kulturmedien sowie Durchführung dreier wichtiger Tests zur Erregerbestimmung abgehandelt.

Das Heft ist ein wertvoller Beitrag zur Vereinheitlichung labordiagnostischer Maßnahmen bei der Cholera.

E. Mannweiler, Hamburg

Barker, D.J.P.: **Practical Epidemiology in Medicine in the Tropics.** 1973. 168 pp., 19 figs. (Churchill/Livingstone, Edinburgh.) Paperbound £ 1,–

Der in den Tropen arbeitende Kollege wird häufig mit Fragen der Epidemiologie konfrontiert. Die medizinische Ausbildung in dieser Disziplin ist immer noch unzureichend. Will sich ein Arzt später weiterbilden, so wird seine Bereitwilligkeit meist auf eine harte Probe gestellt, wenn er sich unvertrauten Symbolen der mathematischen Statistik gegenübersieht und zudem erkennt, daß die beschriebenen epidemiologischen Verfahren nicht für die Arbeitsbedingungen in Entwicklungsländern geeignet sind. Dem Autor des vorliegenden – sehr preiswerten – Buches sind diese Schwierigkeiten vertraut, da er lange in Afrika arbeitete und dort Epidemiologie lehrte. Das Buch ist angenehm handlich und kurz, obwohl es alles Wichtige enthält. Die Ansicht von Dr. Barker, daß man gute Epidemiologie auch ohne aufwendige Statistik machen kann, demonstriert er überzeugend – und sicher zur Erleichterung vieler Kollegen, die bisher keinen Zugang zu diesem Gebiet gefunden hatten. *U.K. Brinkmann, Hamburg*

Maegraith, B.: **One World.** (University of London. Heath Clark Lectures 1970) 1973. VIII, 246 pp. (The Athlone Press, London.) Cloth £ 4,–

Der seit vielen Jahren durch Beruf und Berufung mit den Problemen der dritten Welt vertraute Tropenarzt Prof. Maegraith behandelt hier in sieben lose miteinander verbundenen Essays die Wechselbeziehungen zwischen reichen und armen Ländern auf dem Gebiet der Gesundheit. Der Autor meint, daß „vernünftig gegebene und ebenso vernünftig empfangene" Hilfe eine Form „aufgeklärten und konstruktiven Eigeninteresses" sei, der beiden Seiten nütze. Er geht ein auf den gegenwärtigen Stand der Entwicklungshilfe, besonders in Hinblick auf die Ausbildung von Medizinstudenten und die ärztliche Weiterbildung. Prof. Maegraith zeigt Lücken auf und macht Vorschläge zur Verbesserung der gegenwärtigen Situation. Am Beispiel Südost-Asiens beschreibt er regionale Entwicklungen und kommt mit den importierten Tropenkrankheiten auf das Grundthema des Buches zurück: daß Krankheit letztlich ein gemeinsam zu lösendes Problem aller Nationen ist. In dem letzten Aufsatz beschäftigt er sich mit den Aufgaben und der Verantwortung der Tropen-Pädiatrie, wobei ihm die Gefahren der Bevölkerungsexplosion deutlich bewußt sind. Der Schlüssel zur Lösung dieses Problems sei Zusammenarbeit und kluge internationale Planung, die alle Fachbereiche einbezieht, dies ist die Überzeugung eines Man-