

BOOK REVIEW

LICHTWARDT, R. W. (1986): The Trichomyces. Fungal Associates of Arthropods. - Springer Verlag, New York etc., XI + 343 pp.; ISBN 3-540-96237-9; 180.- DM.

The first representative of the Trichomyces was discovered in 1848 and described as a colourless parasitic alga. For a long time, the systematic position was debated until these organisms were finally classified as a separate class of fungi. Even then, they continued to be mistaken, e.g. as rectal or anal gills of Plecoptera (C. F. Wu, 1923, in *Sayedina vallicularia*, and T. Frison, 1935, in *Zealeuctra*).

All Trichomyces are associated with some arthropod hosts, all Mandibulata, no Chelicerata. A single species, *Amoebidium parasiticum*, lives on the external cuticle of various limnic arthropods; all others occur in the digestive tracts of their hosts. These may be terrestrial millipedes or beetles, marine or freshwater crustaceans, or a variety of aquatic insect larvae. The hosts are all detritivores; occurrence in carnivores is the rare and apparently accidental exception. The orders Asellales and Eccrinales occur in Crustacea and various terrestrial arthropods, the few Amoebidiales are found on or in aquatic crustacea and insects, while the many Harpellales are inhabitants of aquatic insects only.

Young thalli normally attach themselves to the front end of the peritrophic membrane and are shifted posteriorly with it. Grown, sporulating fungi are mostly found in the hindguts. During ecdysis they are shed with the cuticular gut lining; to survive they have to sporulate before expulsion from their host and be ingested by some other host. Indeed, growth and sporulation may be complete within 24 hrs, but normally take longer. Sexually produced zygospores or thick-walled sporangiospores (in Eccrinales) appear to be the long-lived stages infesting new hosts. When he moults or dies, the ectocommensal species releases amoebae turning into cysts. The hormones involved do not appear to be responsible for the fungal response to moulting.

In terrestrial forms, both juveniles and adults are infested, while Harpellales are restricted to larvae and absent from adults of aquatic insects, holometabolous or not. Nevertheless, several species in this group occur on several continents. Their spread is as enigmatic as the arrival of the first inoculum to isolated microhabitats, viz. infestation of culicid larvae in a beer can.

Trichomyces are known from most parts of the world but many areas have not yet been studied. Preponderance of Eccrinales in southern latitudes and of Harpellales in upper northern latitudes may simply reflect habitat availability for hosts, or research emphasis. Individual species may be nearly cosmopolitan, or appear to be narrowly restricted. Some isolated areas like New Zealand and Hawaii certainly have endemic taxa, plus some recently introduced together with their hosts.

Life cycles differ between subgroups. Vegetative trichospores and sexual zygospores may be formed simultaneously, or the latter only when the host prepares to moult. Spores of Harpellales do not normally germinate immediately but are released to the outside and lie dormant until ingested by a suitable host. Thalli may be simple or branched, septate or not, minute (30-55 µm) or over 1 cm long. All have holdfasts which differ between taxa. Many details of thallus and spore structure and formation are presented.

Some species may be strictly host specific but most inhabit a number of (usually related) hosts. The genus or family of hosts may often delimit the range of infestation. The relation with the hosts is commensalism, obligate on the part of the fungi. They obtain all nourishment from material in the host gut but whether they can digest food themselves or depend on material digested or secreted by the host is unknown. Nutritional effects on host have not been observed. Normally, the fungi are not pathogenic but in laboratory cultures culicid larvae have been killed by particular Trichomyces. At the same time, there is evidence that in artificial, nutrient-deficient media the fungi may provide vitamins and sterols. Some information is available only for a few cultured species, e.g. spore germination and attachment to the cuticle within 40 mins after ingestion. Maximum spore survival time outside hosts is uncertain, in experiments it was up to 12 months.

Much biological information is presented in each of the 9 chapters preceding the systematic section of the book which comprises keys and descriptions of all known Trichomyces. The chapter on phylogeny discusses both relations within the class and with other fungi (probably with the Kickxellales of the Zygomycetes). It also describes morphologically similar but unrelated organisms. Lists of fungi and their hosts, of hosts and their commensals and of axenic isolates available are followed by extensive references and an alphabetical index.

I expect this interesting, well illustrated book to attract attention from a wide readership and would not be surprized if it lead to a surge of new interest in the Trichomyces.

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Descriptions of the Nymphs of Some Afrotropical Baetidae (Ephemeroptera). I. *Cloeon* Leach and *Rhithroclaeon* Gillies

by

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Descriptions are given of the nymphs of *Cloeon areolatum* Navás, *Cloeon dentatum* Kimmins, *Rhithroclaeon peritrum* Kopelke and *R. indicator* Gillies.

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Taxonomic studies of the Baetidae have always been hindered by the fact that generic characters tend to be poorly developed in the winged stages. In Africa, for example, aside from the relatively well known fauna of temperate South Africa, the majority of described species are known only in the adult stage and have been assigned to cosmopolitan genera. On the other hand, published descriptions of unnamed nymphs show that many of them do not conform to the accepted definition of these same genera. Except for the genus *Cloeon*, the nymphs and adults of almost none of the tropical species have been associated. The assigning of species to the appropriate genus is therefore a difficult matter. The problem is not confined to the African continent. In the Oriental Region the difficulties are even greater. While earlier workers mainly described species from collections of adults, recent studies have been largely confined to the aquatic stages. For example, in a series of valuable papers by Müller-Liebenau (1979, 1980, 1982, 1985), Müller-Liebenau and Morihara (1980) and Braasch and Soldán (1980) seven new genera of Baetidae have been described from the Region, yet the adults of none of them are known. Workers on the African fauna in the past have been more conservative in their approach and, especially in the case of nymphs, have either tended to assign taxa with unusual characters to existing genera or else have avoided the use of formal nomenclature. In both these regions, therefore, there is a pressing need for the association of Baetid adults and nymphs.

In recent years I have taken advantage of the limited opportunities open to me to rear the adults of a small number of African Baetidae from nymphs collected in the field. I have also received valuable material of associated adults and

nymphs from other field workers. It is planned to give an account of these nymphs in a short series of papers, of which this is the first.

Cloeon Leach

Of the thirteen species of *Cloeon* recorded by Gillies (1980, 1985) from tropical Africa the nymphs of nine were described or already known. Of the others, *C. rhodesiae* Barnard seems to be rather localised, if widespread, and the nymph remains unknown. *C. viridellum* Demoulin, from Zaire, was described from a single male. This leaves the nymphs of *C. dentatum* Kimmins and *C. areolatum* Navás to be described here.

Cloeon areolatum Navás (figs. 1-12)

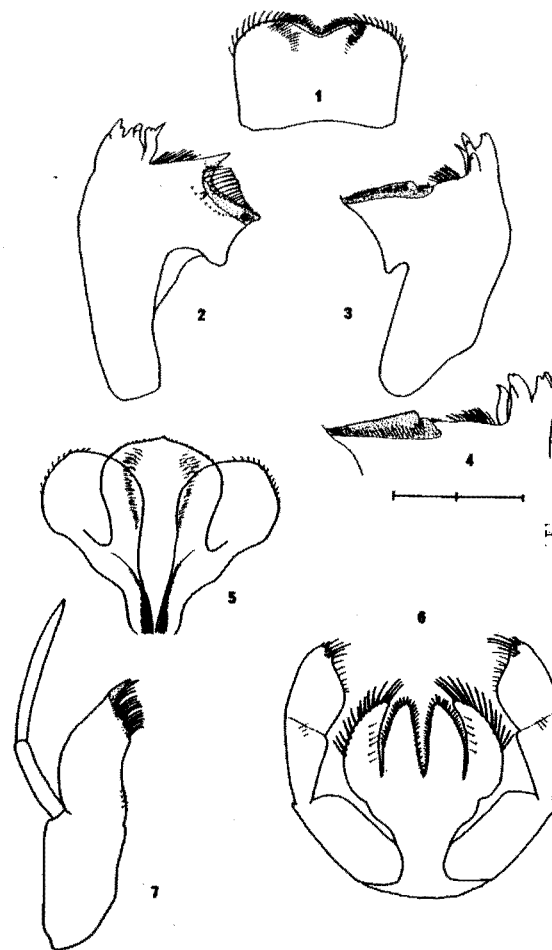
Female imago. Specimens from Nigeria show more highly developed abdominal markings than those figured by Gillies (1980) for material from Cameroun and Zaire. While the basic distribution of dark-red pigmented areas is the same (see Fig. 12), i.e. laterally on terga III and VI and medially on II, there are additional lateral markings on II while VIII is extensively pink. In other respects the two sets of material agree well with each other.

Nymph. Mouthparts typical for the genus, see figs. 1 to 7. Legs, fig. 10, tarsal claws fine and sharply pointed with a double row of rather short teeth (fig. 11). Abdominal segments with lateral spines as follows (4 specimens examined, spine at posterior angle excluded from count); IV to IX with respectively 0, 0-3, 2-4, 3-4, 6-8 and 7-9 spines (fig. 8). Gills have become detached from their insertions on all specimens available, but show well developed double lamellae. Paraproct with numerous teeth on inner margin (fig. 9).

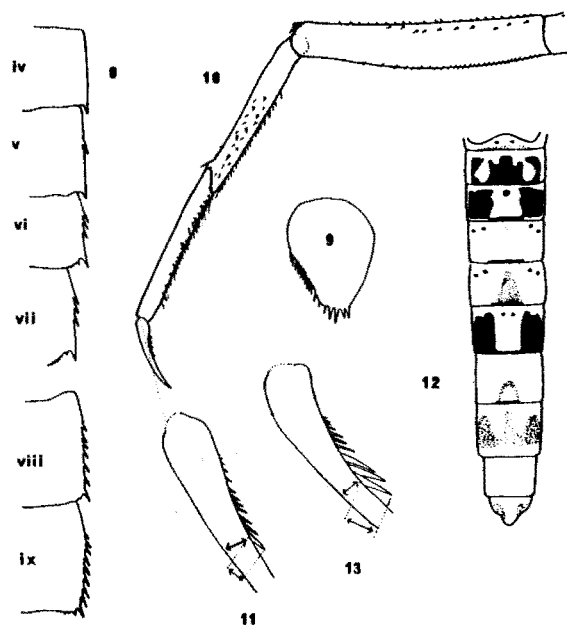
Material: NIGERIA: 1 female subimago and associated nymph skin, Lake Opi, 15 km south-east of Nsukka (6°45'N, 7°29'30"E), xi.79. leg. Landis Hare. Same locality and collector, 9 males, 11 females with nymph skins, partly fragmented and not individually associated. The adults accompanying these skins are all identifiable as *areolatum*, so it has been assumed that all the nymph skins are also of that species.

C. areolatum belongs to the group of species of Afrotropical *Cloeon* in which the nymphs have lateral abdominal spines not restricted to segments VIII and IX. This group includes *bellum* Navás and *cylindrocolum* (Kimmins), as well as *africanum* Esb.Pet. and *lacunosum* Barnard. It most closely resembles that of *C. bellum*. Separation of the two can be effected by comparison of the tarsal claws (figs. 11 and 13). In *areolatum* the teeth on the claw are shorter than the width of the claw, while in *bellum* the reverse is true.

From the material collected by Dr Hare from small lakes in the forest belt of Nigeria it appears that *areolatum* is easily the commonest species of *Cloeon* in



Figs. 1-7. Mouthparts of *Cloeon areolatum* (1) Labrum; (2) and (3) left and right mandibles; (4) right mandible of another specimen at higher magnification (scale line 0.2 mm); (5) hypopharynx; (6) labium; (7) maxilla.

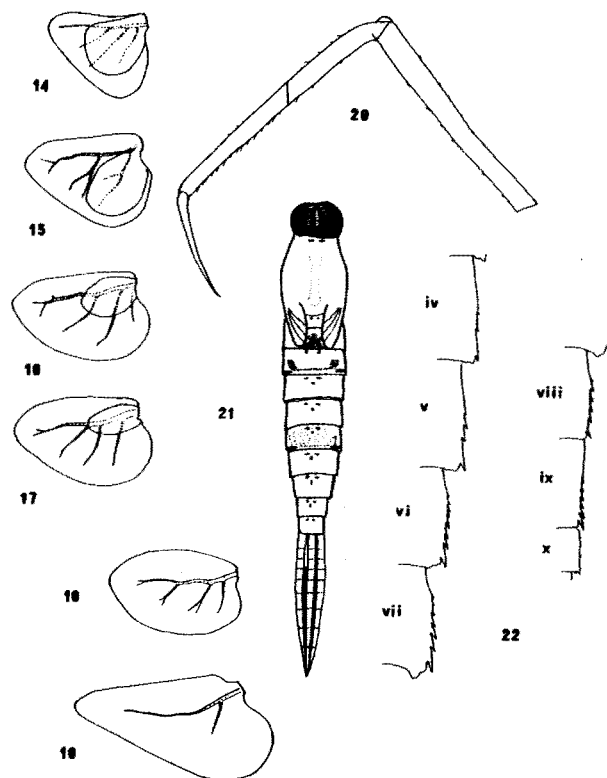


Figs. 8-11. Nymphal structures of *Cloeon areolatum* (8) Abdominal segments; (9) paraproct; (10) fore leg; (11) hind tarsal claw. (12) Abdomen of female imago of *Cloeon areolatum*. (13) Fore tarsal claw of *Cloeon bellum*.

that habitat. Present records of its distribution are all from the humid equatorial zone, from southern Nigeria to Uganda, suggesting that it may be less well adapted to conditions in the savanna regions than are the other widely distributed species of *Cloeon*.

***Cloeon dentatum* Kimmins**
(figs. 14-30)

The adult of *dentatum* differs from other species of *Cloeon* in the length of vein MA2, which reaches up to or almost to the cross-vein between MA1 and MP1, and in the male forceps, which has the second segment swollen and with a prominent tooth on the inner border. Hind tarsal segment 2 is about twice as long as segment 3.



Figs. 14-22. Nymphal structures of *Cloeon dentatum* (14) to (17) Gill lamellae I-IV; (18) and (19) gill lamellae VI and VII; (20) fore leg; (21) body of mature nymph; (22) margins of abdominal segments.

Nymph. Antennae short, about one-third as long as body. Mouthparts: labrum (fig. 25) with a broad median notch between main lobes; maxillary palp (Fig. 26) very long, with two segments, the first extending well beyond the apex of the maxilla; paraglossae of labium (figs. 27, 28) enormously enlarged compared with glossae, labial palp similarly enlarged with two segments, the distal segment approximately triangular and largely obscuring glossae and paraglossae; mandibles (figs. 23, 24) with a sparse tuft of hairs at base of prosthema. All

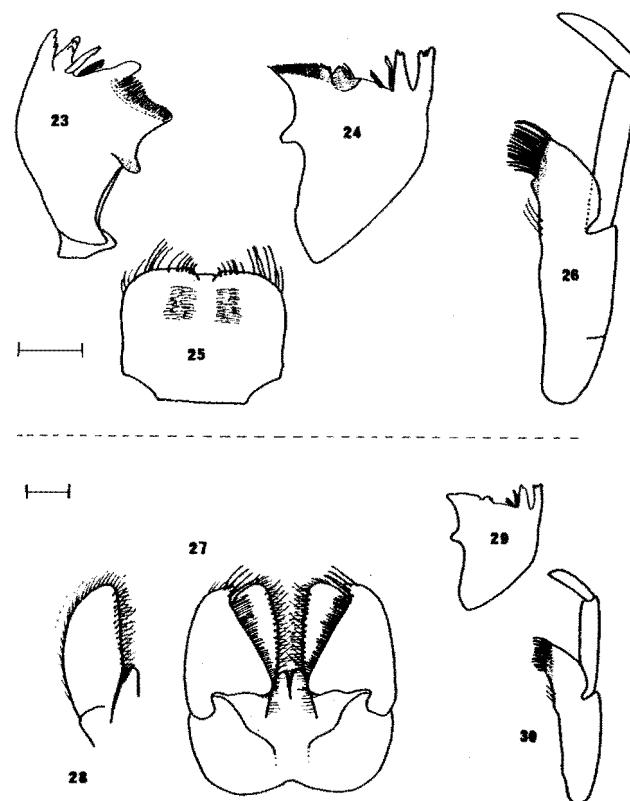
pairs of legs similar, slender (fig. 20), tibiae shorter than tarsi, tibio-tarsal joint apparently fused; tarsal claws very fine and greatly elongated, about equal in length to tibiae, without teeth; a small number of fine, spinous setae present on anterior and posterior surfaces of legs. Abdominal terga with 2-3 strongly marked median spots as in fig. 21, tergum VI extensively dark brown. Gills present on segments I to VII, sub-triangular, double on I and IV with small dorsal lobes, V to VII single, that on VII being the largest gill (figs. 14-19). Lateral margins of abdominal segments IV-IX with respectively 2, 3, 7, 6, 5 and 5 spines (spine at posterior angle excluded from count). Tails three, subequal.

Material: GUINEA, 1 mature nymph, R. Niandam, Sassambaya, 13.ii.86. GAMBIA: 1 mature nymph, R. Gambia, Fatoto, 28.ii.76, 1 nymph.

The association of this nymph with Kimmin's *Cloeon dentatum*, which was described from adults from Uganda, rests on two considerations. Firstly, with the exception of *rhodesiae*, a species only ever recorded once from West Africa, *dentatum* is the only member of the genus which is known from the area and the nymph of which has not been described. Secondly, adults of this species were collected at the same site as the nymphs both on the river Niandam in Guinea and on the river Bouaflé in the Ivory Coast. Further, with the exception of *cylindroculum* Kimmins, *dentatum* is the only *Cloeon* exclusively found in rivers or large lakes. Given the relatively detailed knowledge we have of the West African species of *Cloeon*, it is felt that, while not proven, this association of nymph and adult is highly likely to be correct.

C. dentatum differs from all other known *Cloeon* in the mouthparts, particularly in the enormous size of the paraglossae and palps of the labium, and in the greatly elongated tarsal claw. The adult is atypical in that the forceps are more reminiscent of those in many Afrotropical species of *Centropilum* than in *Cloeon*. Taken together it might be felt that *dentatum* was sufficiently distinct from other members of the genus as to warrant transfer to another genus. However, given the lack of certainty at the present time as to the association of nymph with adult, it seems better to regard it as an aberrant *Cloeon* adapted to life in rivers.

In the River Gambia nymphs were collected in the upper tidal zone of the river from a thin layer of silt overlying clay. In the River Niandam the river bed was of sand with temporary accumulations of detritus in depressions, both sites having essentially unstable substrates. I was not able to study living nymphs, but the structure of the legs suggests that they could act as stilts, allowing the insect to move lightly over the surface of silty or sandy substrates without sinking in. It may be noted that the Nearctic mayfly *Apobaetis* Day has similarly long tarsal claws and, like *C. dentatum*, inhabits rivers with sandy beds, Edmunds et al. (1976).



Figs. 23-30. Mouthparts of *Cloeon dentatum* (23) and (24) left and right mandibles; (25) labrum; (26) maxilla; (27) labium; (28) glossa and paraglossa after removal of labial palp; (29) and (30) mandible and maxilla at same magnification as labium.

Nymphs of *dentatum* have also been found by Dr. J.-M. Elouard in the Ivory Coast near Bouaké, and the figure of the mouthparts of "*Cloeon* sp. III" from the Red Volta in Burkino Faso, given by Guenda (unpublished thesis), clearly represents the same species. *C. dentatum*, is evidently widely distributed in lowland rivers in West Africa.

Rhithrocleon Gillies
(figs. 31-46)

This genus was erected by Gillies (1985) for three species with *Cleon*-like wings but with abnormal genital forceps. The nymph was not known at the time but all captures were made in the vicinity of fastrunning streams. I have recently revisited the type locality of *Rhithrocleon indicator* Gillies in the Eastern Usambara Mountains of Tanzania and was able to rear out a number of nymphs of this species as well as of *R. permirum* (Kopelke). A description of this material follows, but specific identification is presently not possible.

Nymph. Antennae about half length of body. Mouthparts (figs. 31-39): median notch in labrum with a small crested projection; canines of mandibles fused, right prostheca a slender filament; a line of short setae between molar region and canines, molar surface partly divided into separate grinding areas; maxillary palp with three segments, 2 or 3 fine setae at base of lacinia; apical segment of labial palp appearing as a small "cap" on top of the second segment, paraglossae much bigger than glossae and bearing 3 straight rows of long, fine setae.

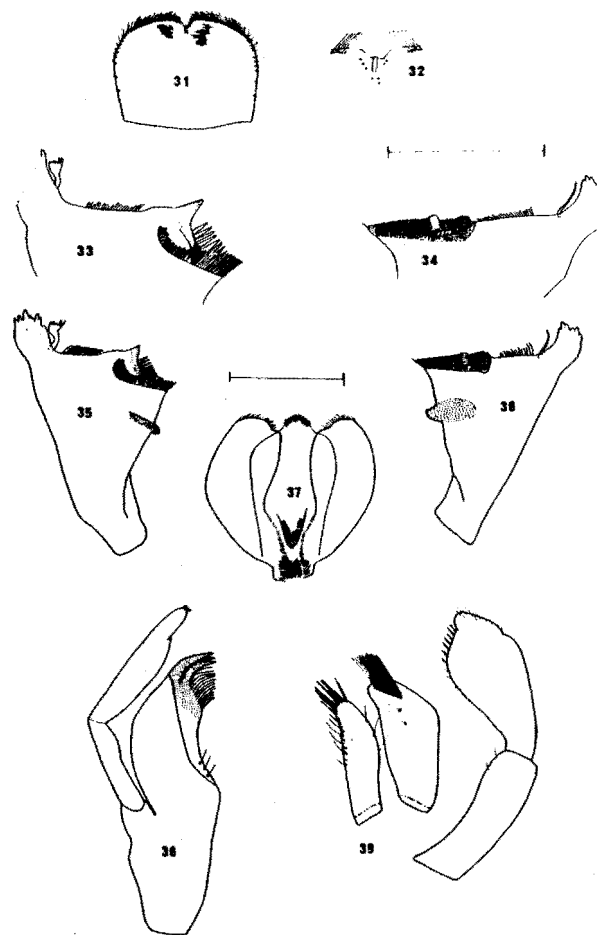
Legs (figs. 43-45): slender with stout setae on anterior margin of femora and posterior margin of tarsi, claws with a single row of teeth.

Hind wing bud absent.

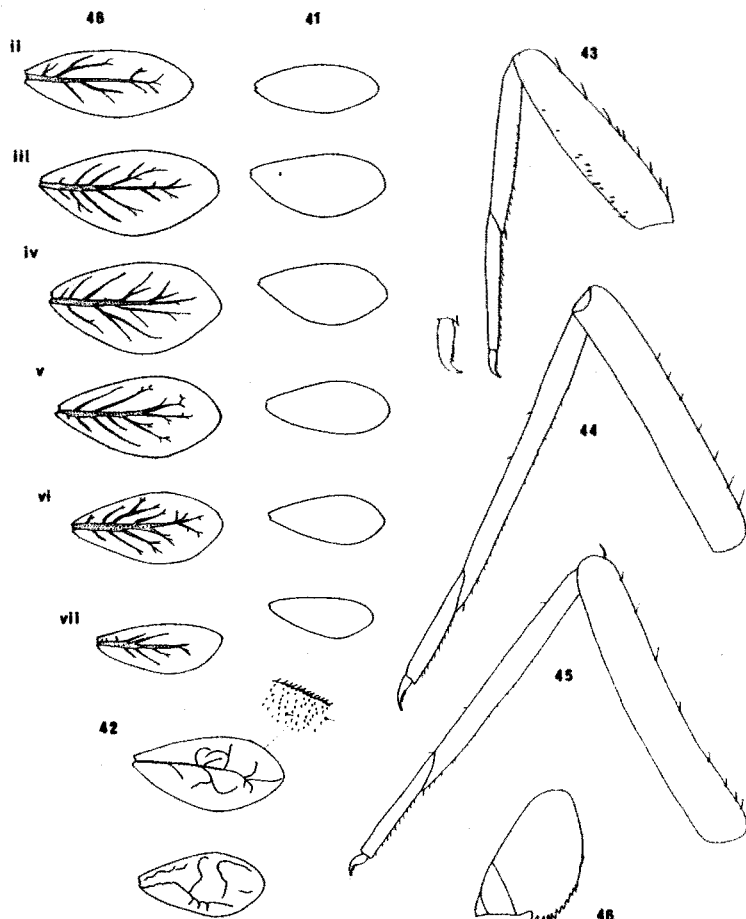
Abdomen with six pairs of gills (Figs. 40-42), on segments II-VII, each being single, rather narrowly obovate, surface of gills pitted with scales, anterior borders toothed and with intervening fine setae, those on posterior border rather longer; in nymphal specimens tracheolar pattern normally developed, but in all skins of reared nymphs tracheoles are degenerate or absent. Lateral margins of abdominal segments without spines except at posterior corners, integument with irregular rows of conspicuous scale pits. Paraproct (fig. 46) with strongly developed teeth on medial and posterior borders. Tails: paracercus $\frac{1}{2}$ - $\frac{2}{3}$ length of cerci, strongly haired in basal $\frac{2}{3}$.

Material: TANZANIA: *R. Sigi* and afferents, Amani district, Tanga Province, February and March, 1985, *R. permirum*, 1 male imago and associated nymph skin, R. Dodwe; *R. indicator*, 1 male imago and associated nymph skin, 1 male subimago and associated nymph skin fragments, R. Ukungwi; *Rhithrocleon* sp., 1 nymph, Amani district, 1 nymph, R. Sigi, 2 nymphs, R. Dodwe.

The nymph of *Rhithrocleon* differs from that of *Cleon* by the six single gills, absence of lateral abdominal spines and in a number of characters in the mouthparts, notably the marked reduction of the apical segment of the labial palp and the fused canines of the mandibles. It shares with *Centroptilum* and *Cleon* the presence of a row of short setae between the molar region of the mandible and the base of the prostheca. It would appear to be closest to the Oriental genus *Indobaetis* Müller-Liebenau and Morihara although differing rather markedly as regards the labium and the maxillary palp. In so far as the



Figs. 31-39. Mouthparts of *Rhithrocleon* spp. (31) *R. indicator*, labrum; (32) anterior notch of same at higher magnification; (33) and (34) *R. indicator*, left and right mandibles (scale line 0.2 mm); (35) and (36) *R. permirum*, left and right mandibles (scale line 0.2 mm); (37) to (39) *R. indicator*, (37) hypopharynx; (38) maxilla; (39) glossa, paraglossa and labial palp.



Figs. 40-46. Nymphal structures of *Rhithrocloeon* spp. (40) Gill lamellae II-VII from mature nymph; (41) *R. indicator*, outline of gills II-VII; (42) *R. permirum*, gills IV and V from nymph skin showing degenerate tracheoles, inset, surface and anterior margin at higher magnification; (43) *R. indicator*, fore leg; (44) and (45) *Rhithrocloeon* sp., mid and hind legs; (46) *Rhithrocloeon* sp., paraproct.

nymphs of Afrotropical Baetidae are known at the present time, *Rhithrocloeon* should be recognised by the combination of six, simple gills, absence of hind wing bud, the cap-like apical segment of the labial palps and the swollen inner margin of the second segment of the maxillary palps.

On the basis of purely nymphal characters Müller-Liebenau & Morihara (1982) considered that *Indobaetis* was most closely related to the *muticus* group of the genus *Baetis* Leach. However, it is at least as close to *Rhithrocloeon* as it is to *Baetis*, although the adults of the latter two genera belong to widely differing groups within the family Baetidae. This anomaly emphasises the need for knowledge of both adult and aquatic stages of Baetidae before phylogenetic relationships can be firmly established.

The nymphs of *Rhithrocloeon* were collected in small, stony streams where there were occasional sandy pools and from the stony bed of the main river. In the past, adults have been collected in the vicinity of the same river and from a similar habitat in eastern Zaire (Kopelke 1980), and it appears to be characteristic of torrential waters in East Africa.

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