

THE MAYFLY-MUSSEL ASSOCIATION, A NEW EXAMPLE FROM THE RIVER NIGER BASIN

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ABSTRACT

A new genus and species of Baetidae associated with freshwater mussels, *Mutelocloeon bihoumi*, is described from nymphs collected in rivers in Mali and Guinea, West Africa. A description is also given of the adult, based on material from light-trap catches made at the same sites as the nymphal captures and on the morphology of mature nymphs. It is shown that *Centroptilum corbeti* Kimmins, described from adults collected in Uganda, should be transferred to *Mutelocloeon*. Mayfly nymphs were found sporadically in several species of Mutelid mussels occurring in sandy rivers, and it was concluded that the ecology of the mussel was the main factor regulating the association. Nymphs are attached to the folds of the branchiae within the mantle cavity. Individual mussels contained up to five nymphs.

INTRODUCTION

At the Second International Conference on Ephemeroptera in 1975 Müller-Liebenau and Heard gave an account of a curious Baetid mayfly nymph that had been unexpectedly found by Heard while dissecting freshwater clams (mussels) that he had collected in Thailand. The association was considered to be obligatory for the mayfly and its presence of little consequence to the host. This report came to mind last year when we were carrying out a spot survey of several rivers in the Republic of Guinea, and prompted us to collect and open up a number of mussels. Of the first dozen we collected, three contained Baetid nymphs. Subsequently, more systematic collections of Mutelid mussels from mainly sandy substrates in the River Niger at Bamako in Mali showed the presence of similar nymphs in several species of hosts. We also re-examined some puzzling adults from earlier light-trap catches from Guinea and elsewhere in West Africa and found that they had almost identical abdominal

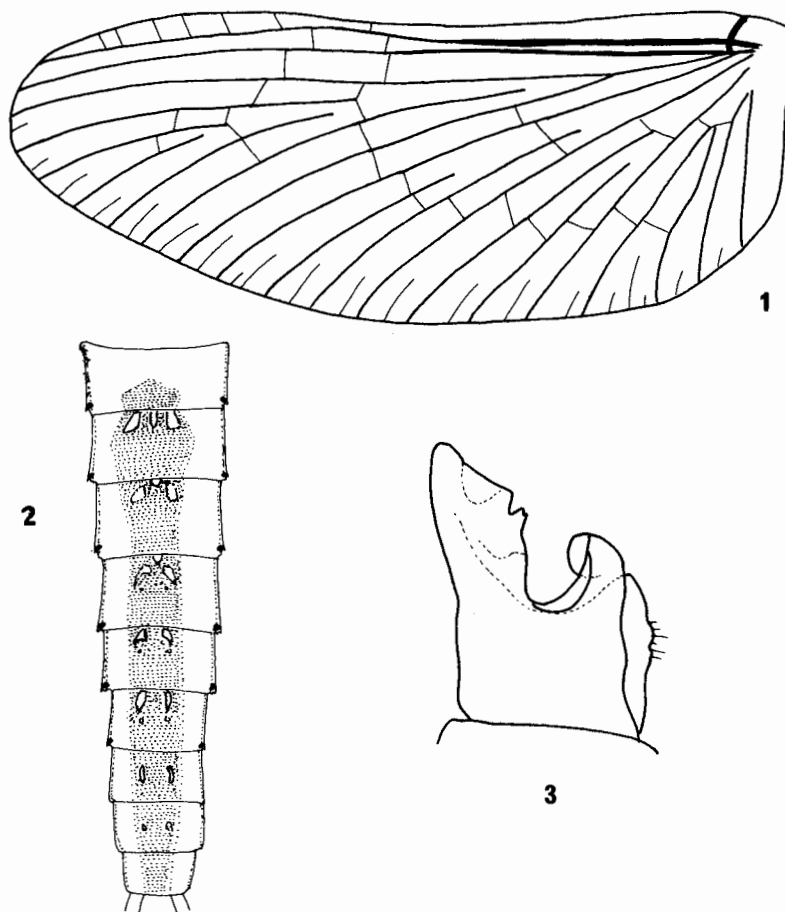
markings with mature nymphs from mussels. The nymphs differ from the Oriental form, *Symbiocloeon* Müller-Liebenau, in a number of important characters and, together with the adult, are described below as a new genus.

DESCRIPTION

Mutelocloeon gen. nov.

Adult. Turbinate eyes large, round. Forewing with single marginal intercalaries, hindwing reduced to a minute rudiment. Mid and hind tarsal segment 2 about one and a half times segment 3. Forceps in male reduced to a single, abbreviated segment with two or three highly irregular lobes.

Nymph (Fig. 4). Antennae very short, 1.1–1.3 times width of head; mandibles with a single canine, a fringe of hairs present between base of protheca and molar surface; maxillary palp short, not reaching to apex of maxilla; labial palp



Figs 1-3. *Mutelocloeon bihoumi*, male imago. 1. Forewing. 2. Abdominal tergal markings. 3. Forcep limb.

stout and with only two segments. Legs bare, entirely without setae except for a very few, minute spine-like setae on posterior margin of hind tibia; claws blunt, without teeth. Abdominal gills present on segments I to VII, rounded, margins without teeth. Tails three, from one-sixth to one-third length of body.

Type species *M. bihoumi* Gillies and Elouard.

The nymph of *Mutelocloeon* is closest to the Oriental genus *Symbiocloeon* Müller-Liebenau. It shares the derived characters of reduction in the setae on the legs and gills and the presence of blunt, curved claws without teeth. It differs from it in the shortness of the antennae, the proportions of the maxilla, the two-segmented labial palp, the virtual absence of setae on the legs and the reduction in length of the tails. Both genera share a number of

ancestral characters with the *Centroptilum* lineage, including the single gills and a line of hairs at the base of the canines of the mandibles. In the adult, the reduction of the forceps to a single, multi-lobed segment differentiates it from all other described Baetidae except the aberrant *Centroptilum corbeti* Kimmins from Uganda.

Mutelocloeon bihoumi sp. nov.

Male imago. Eyes contiguous, bluish-cream. Pronotum and mesonotum cream except for a pair of oblique umber streaks internal to the wing base along the scutellar suture; metanotum with transverse dark streaks along sutures. Femora cream, tibiae and tarsi burnt umber. Forewing (Fig. 1) membrane hyaline, costa and subcosta reddish-brown in basal half. Posterior corners of abdominal terga II-VI slightly flared, produced into fine

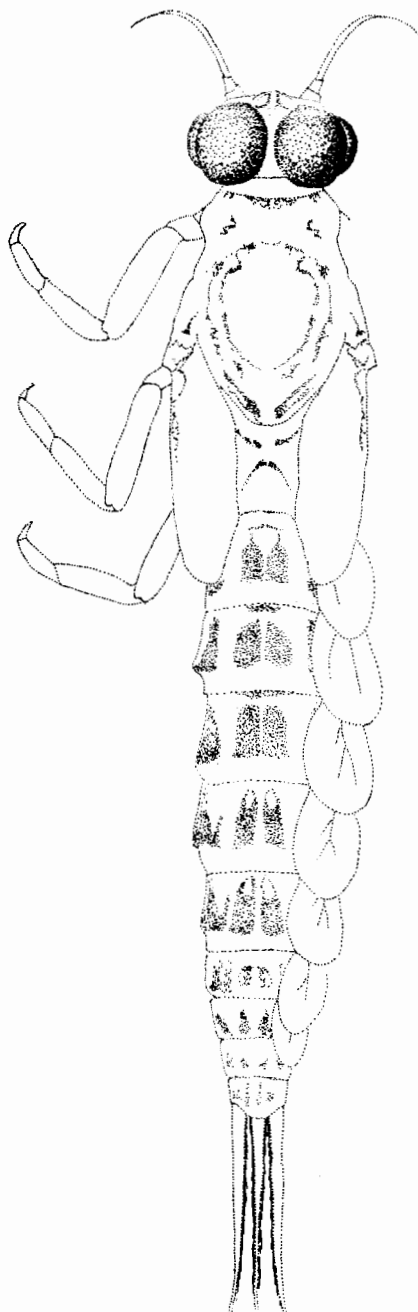


Fig. 4. *M. bihoumi*, mature nymph.

points by deep notches internal to the corners (corresponding to insertions of nymphal gills). Abdominal integument cream with a broad chestnut, median band extending from apical third of tergum 2 to posterior margin of X, with paired markings as in Fig. 2. The extreme lateral margins of terga II-IX are narrowly banded in chestnut

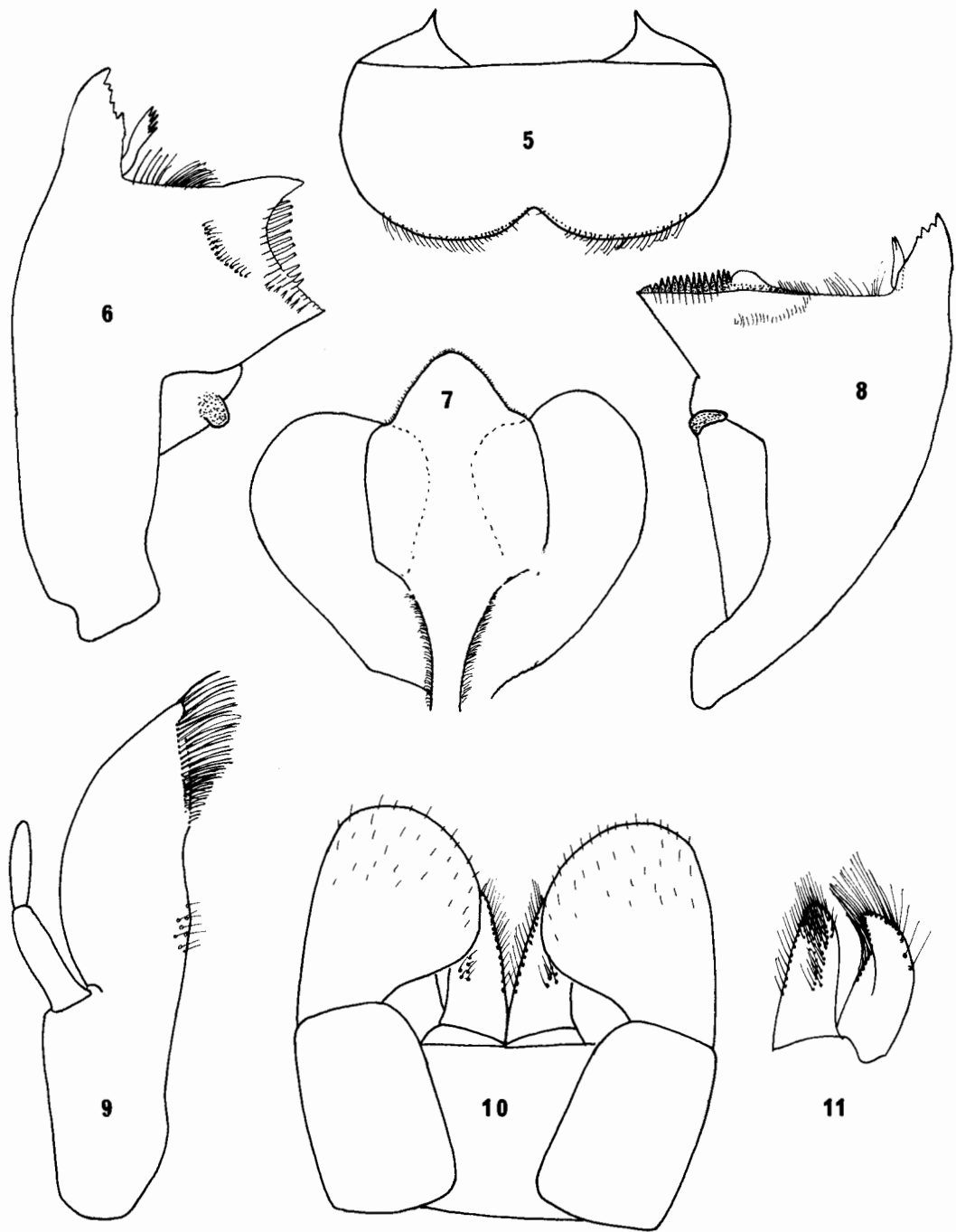
with, on II-VI, conspicuous burnt umber spots at the postero-lateral corners. Venter and forceps (Fig. 3) cream; tails dark brown.

Female subimago. Head and pronotum cream; mesonotum cream with dorsolateral sutures outlined in burnt umber; metanotum narrowly dark along posterior margin. On mesopleuron a dark, strongly marked umber streak below wing root; similar smaller mark posterior to and between hind wing rudiment and insertion of hind leg. Fore femur pink, tibia and tarsus cream, mid and hind femora faintly tinged pink, tibiae and tarsi cream. Forewing pale grey, basal half of costa and subcosta deeply pigmented pink up to and including bulla; basal portion of hindwing rudiment pink. Abdominal tergal markings much as in male.

Nymph. Immature nymphs cream, entirely without markings except for a small patch of brown in front of the insertion of each gill. Later instars with abdominal markings characteristic of adult; in wing bud outlines of veins conspicuously pink. Mouthparts (Figs 5-11): canines of both mandibles fused; apical setae of maxilla scarcely stouter than rest of fringe, palp very short, two-segmented; labial palps with two segments, the distal segment rounded and swollen. Legs stout (Figs 12-14). Gills (Fig.-15) from 1-1/4 to 1-1/2 times the length of abdominal segments, without marginal spines except for a double row of minute villae at the apex, only visible under high magnification. Paraproct with coarse teeth on inner margin in apical half (Fig. 17). Tails subequal, unbanded, finely haired.

Body. male 10 mm, female 12 mm; wing: male 9 mm, female 11 mm.

Material. Holotype male imago, GUINEA, Sassandra, R. Niandan, 27.iii.85. Two female subimagines, GUINEA, Boussoule, R. Milo, 31.v.85. 5 nymphs, GUINEA, R. Niandan, Sassandra, 12.ii.86; 16 nymphs, MALI, R. Niger, Bamako, 17.ii.86, 19.ii.86; 5 nymphs, MALI, R. Bafing, Timbo, i.87.



Figs 5-16. *M. bihoumi*, nymphal mouthparts. 5. Labrum. 6. Left mandible. 7. Hypopharynx. 8. Right mandible. 9. Maxilla. 10. Labium. 11. Glossa and paraglossa.

Named for Mr. Moussa Bihoum for his valuable assistance in this study.

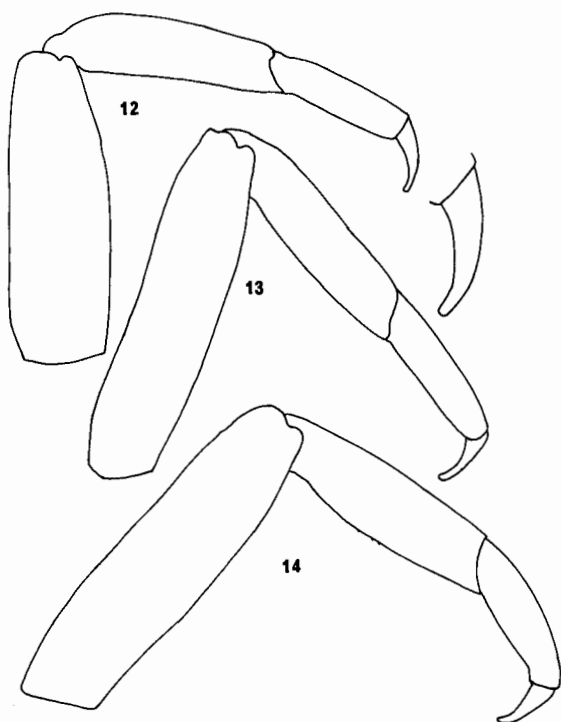
This species differs from *M. corbeti* in the male forceps and in the abdominal markings of the

imago. In *M. bihoumi* the pigmented area forms a continuous median band from the posterior one-third of tergum II to the tip of the abdomen, where in *corbeti* the pigmented areas on most segments do not extend to the posterior margins, thus tending to form discrete blocks of pigment.

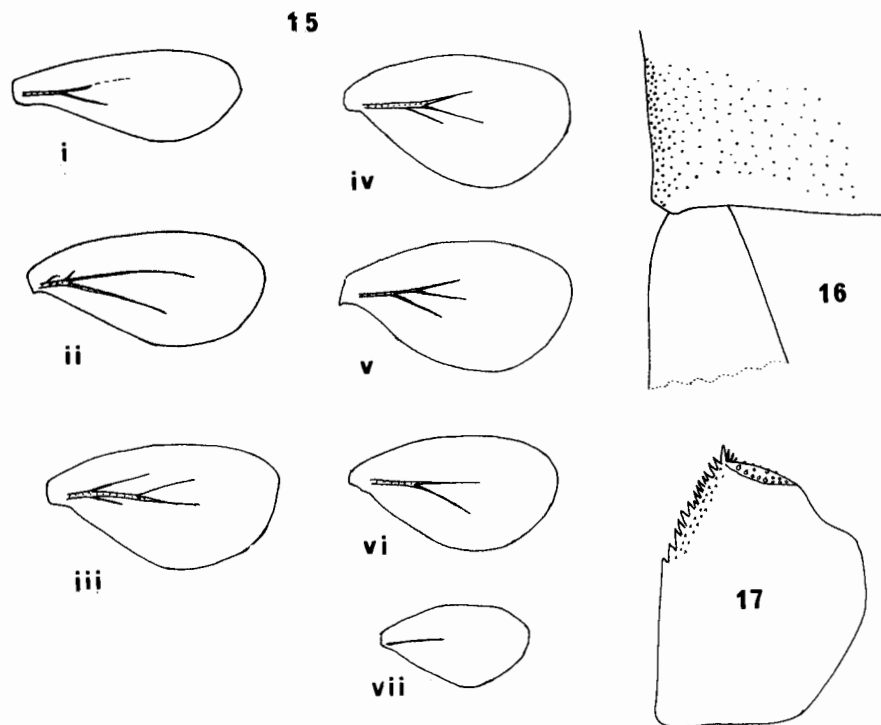
Mutelocloeon corbeti (Kimmins) comb. nov.

Centroptilum corbeti Kimmins, D.E. (1956). *Bull. Brit. Mus. (Nat. Hist.). Entomol.* 4, 75.

This species was described from material collected by Dr. P.S. Corbet from an extended series of light-trap catches made at Jinja on the shores of Lake Victoria at the outlet of the river Nile. Despite the highly atypical forceps of the male imago, Kimmins preferred to retain the species in *Centroptilum*. However, the discovery of the closely similar species, *M. bihoumi*, makes it clear that *corbeti* belongs to the same genus. This immediately raises the question as to whether the nymph of *corbeti* is also associated with mussels. At the same research station, Fryer (1961) made a detailed study of *Mutela bourguignati*, a mussel occurring in the river Nile at its outflow from the lake, but did not come across any mayfly nymphs in the mantle cavity of this species, which was only studied in a fairly fast-flowing stretch of the river (Fryer, pers. comm.). However, Corbet (pers. comm.) also made light-trap catches at other



Figs 12-14. *M. bihoumi*, legs of nymph. 12. Fore. 13. Mid. 14. Hind



Figs 15-17. *M. bihoumi* nymph. 15. Gill lamellae i-vii. 16. Base of gill vi more highly magnified. 17. Paraproct.

points round the lake, and took *M. corbeti* at two locations (Lukunyu pier near Entebbe and Bukakata) where the captures could only be derived from the lake itself. The same could be true of the specimens from Jinja, so that the absence of nymphs in mussels from the river is not by itself evidence against *corbeti* having adopted the same commensal lifestyle as *bihoumi*.

BIOLOGY OF *M. BIHOUMI*

Mayfly nymphs were found in 5 or possibly 6 species of large mussels belonging to the genera *Mutela*, *Aspartharia* and *Spathopsis* (Mutelidae) (Table 1). The overall proportion of hosts harbouring nymphs was low. The majority of collections was negative, and positive findings were limited to certain species at particular sites and seasons. The first nymphs were found in the river Niandan in a small collection of *Spathopsis bellamyi*. Yet we found no nymphs in more than 100 specimens of the same mussel from two different sections of the Niger, even though at one site

mayflies were present in other species of mussel. The ease with which one could find mussels was also highly variable. For example, 50 per cent of a small collection of *Aspartharia* sp. from the river Niger in February contained mayfly nymphs, whereas in the same shallow stretch of river two months later no mussels of this genus could be found. Most mussels were collected from sandbanks in places where the water was not much more than 1m deep, the body of the mollusc being buried in the sand with just the dorsal lip above the surface. At some sites the sand was covered with a shallow layer of silt. In addition to mussels, 46 small bivalves, *Coelatura* spp., and 30 river oysters, *Etheria* sp., were examined and found negative.

Of the 23 mussels found to be positive for mayflies 11 contained single nymphs, 9 two each and the remainder either four or five. The mean size of nymphs was 8.25 mm (Table 2). No specimens smaller than 2 mm were collected, possibly partly due to our failure to detect very small nymphs. While the exhalant siphon in freshwater mussels is a simple unobstructed tube the mouth

Table 1. Results of examination of mussels for presence of mayfly nymphs

River	Positive sites	Number examined	No. with nymphs	Nymphs per +ve host*	Negative sites	Number examined
Host: <i>Spathopsis bellamyi</i>						
Niandan	Sassambaya	21	6	1-6 (2.2)	Bassikoro	16
Niger	-	-	-	-	Bamako, Siguiri	102
Tinkisso	-	-	-	-	Dabola	2
Host: <i>Spathopsis rubens</i>						
Niger	-	-	-	-	Siguiri, Kissidougou	82
Host: <i>Mutela dubia</i>						
Niger	Bamako	41	5	1-2 (1.4)	Siguiri	5
Host: <i>Aspartharia</i> spp. #						
Niger	Bamako	16	7	1-2 (1.3)	Siguiri	2
Niandan	-	-	-	-	Sassambaya	1
Bafing	Timbo	7	5	1-4 (2.6)	-	-
Tinkisso	-	-	-	-	Dabola	13

* Mean in parentheses. # *A. chaiziana*, *A. dahomeyensis*, *A. rochebrunei*

Table 2. Size-classes of *Mutelocloeon* nymphs from mussels, dry season collections, 1986–87

Sites	Body-length in mm (to nearest 0.5 mm)											
	2– 2.5	3– 3.5	4– 4.5	5– 5.5	6– 6.5	7– 7.5	8– 8.5	9– 9.5	10– 10.5	11– 11.5	12– 12.5	13– 13.5
R. Niandan, Sassambaya	–	–	2	–	1	2	2	1	2	1	–	1
R. Niger, Bamako	–	–	–	2	–	–	3	–	4	5	2	–
R. Bafing, Timbo	1	2	–	4	1	–	2	–	1	–	2	–

of the inhalant siphon is protected by fimbria, which presumably act as a barrier to filter off large particles and keep out unwanted intruders. It could also serve to prevent the entry of all except the very smallest nymphs.

Emergence season

Light-traps were run on two rivers on Guinea every month during the period of the year (December to June, 1984–1986) when water levels are receding (Fig. 18) and the course of the rivers increasingly dissected by exposed sandbanks. Adults of *M. bihoumi* have only been caught during the later months of this season of the year (Table 3). Although it was not possible to operate light-traps during the rainy season, these findings suggest that the emergence season is very short and that the species has few generations in the year and could even be univoltine.

These observations raise the question of the invasion of the mussels and the stage in the life cycle

Table 3. Dates of captures of *M. bihoumi* adults in light-traps from rivers in Guinea

Date	River	Captures
27.03.85	Niandan	1 male imago
28.03.85	Milo	2 female subimagines
31.03.85	Milo	2 female subimagines
20.04.86	Milo	1 male, 3 female subimagines
21.04.86	Milo	1 female subimago

in which *M. bihoumi* passes the wet season. If the eggs are laid by females from March to May, what happens in the flood season? From June onwards the mussels will be much less accessible, since there is a much greater area and depth of water. Are the eggs at this season quiescent and, if so, are they on the river bed or in the host? If the mussels have already been invaded by the mayfly, has larval development commenced? If so the developmental cycle is very long (10–12 months), or there is a long cycle in the rains and a short one during the dry season.

Behaviour

Mussels were collected from the Niger at Bamako in the afternoon and kept overnight and for part of the following morning at ambient temperatures (26–35°) in a bucket without water. When the mussels were opened, some nymphs were still alive up to 24 hours after the host had been removed from the river. Nymphs were lying, pale and inert, among the fimbriated lamellae of the gills, and even when prodded with forceps the only sign

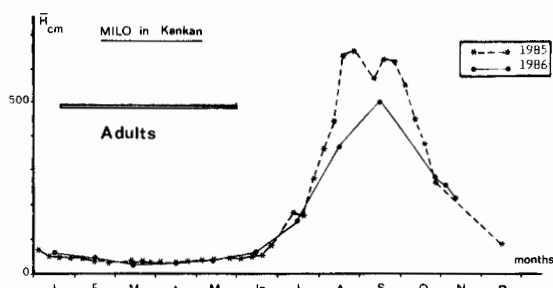


Fig. 18. Discharge curves of River Milo, Guinea.

of life would be a nervous twitch. When forcibly removed from contact with the lining of the branchial chamber they showed normal activity. The same lack of responsiveness was shown by nymphs from mussels opened at the river side.

RELATIONSHIP WITH THE HOST

Adaptations

The nymphs of *Mutelocloeon* show a number of characters that appear to be related to life in this specialised environment. The younger instars of *Mutelocloeon* are entirely pale, and it is only in the largest nymphs that the distinctive abdominal markings appear. Similar pallor is commonly encountered in burrowing mayflies, especially those that emerge at night, and the common factor is obviously life in almost totally dark surroundings. Mussel-associated mayflies enjoy an analogous life-style to burrowers, with the burrowing done for them by the host. They live in a sort of caisson providing protection in a hostile environment and equipped with life-support systems.

A unique feature of *Mutelocloeon* is the almost complete absence of hairs or spines on the legs, a feature shared to a much lesser degree by *Symbiocloeon*. The branchial chamber in mussels is coated with a layer of mucus, which tends to attach itself to the legs of the nymphs, and hairiness in these conditions would obviously be a disadvantage. In the limited space available it is equally important for the intruding nymph to disturb the host as little as possible. Selection would therefore tend to operate against the presence of spines and sharp projections. In *Mutelocloeon* the only sharp points are on the inward facing aspect of the paraprot. The outer and posterior margins of the abdominal segments are, by contrast, entirely smooth. The tarsal claws have blunt tips sufficient to anchor the nymph to a mucus-covered surface, while the absence of sharp points or auxiliary teeth minimises the possibility of damage to the delicate lamellae of the gills.

Further adaptation to life in the close conditions of the branchial chamber are evident in the

shortness of the antennae – not much longer than the width of the head – and the tails which are only sparsely fringed with fine hairs.

The unresponsiveness of the nymphs when the host was opened up may be explained by the intimate contact made with the internal organs of the host. Any unnecessary movement might invite unfavourable responses by the mussel and a well-adapted inquiline seeks to reduce the effects of its presence. There is no obvious reason why the nymph should need to shift its position. It is provided with a continuous supply of oxygenated water and food particles, and the only activity required would be restricted movements of the mouthparts. These show no obvious adaptations, which is perhaps not surprising since the generalised baetid design of gathering and grinding organs is well suited to the processing of detritus. The gills are relatively large, and auxiliary respiratory movements might well be unnecessary under normal conditions. We saw none in exposed nymphs. The same lethargy has been remarked on by Forsyth and McCallum (1978) in their study of *Xenochironomus canterburyensis*, an inquiline commensal of a mussel in New Zealand.

BIOLOGICAL ADVANTAGES

The association may be regarded as one of commensalism, beneficial to the insect, neutral for the mollusc (Müller-Liebenau and Heard 1979) although in view of the internal lodgement of the nymph the mayfly might well be regarded as an inquiline. The affect on the host is probably limited to a degree of discomfort and food loss when the nymphs are maturing and reaching their maximum size. Mussels may live for many years, whereas the mayflies stay for what is probably a matter of weeks before easing their way at night through the exhalant siphon. The limited number of nymphs per host indicates that some regulation of numbers occurs, possibly through ejection of new arrivals by those already established.

For the mayfly the advantages of the association are enormous. Sandy substrates are notoriously inhospitable to small insects, and the evol-

utionary strategies open to mayflies to exploit this environment are limited. *Symbiocloeon* and *Muteloocloeon* escape the hazards of life on sandbanks by adapting to life within the body cavity of mussels.

Once established in the host the survival rate of nymphs should be very high. Food and oxygenated water should be adequate and the perch a stable one. The risk of predation would be limited to enemies of the host such as the Open-bill, a Ciconiid stork. But the chances of recently emerged larvae coming across an accessible mussel in the great expanse of river-bed must be extremely low, and the mortality at this stage in the life cycle must be correspondingly high.

Mayflies are not alone in exploiting the opportunities offered by the branchial chamber of mussels. Chironomid larvae have been recorded in *Anodonta* in Britain, (Needham, 1966, 1970), while many species of Hydracarine mites are known to be associated with bivalve molluscs (Gledhill, 1985). Perhaps the most bizarre of the lot is the European fish, *Rhodiusserriceus*, which lays and fertilises its eggs in the mantle cavity of a freshwater mussel (Norman, 1975).

CONCLUSIONS

The discovery of mussel-associated baetids in West Africa shows that the phenomenon is much more widespread than appeared when it was first reported. It suggests that it would be worthwhile examining mussels in other parts of the world also, wherever they form an important part of the fauna of sandbanks and accumulations of silt.

This study leaves a number of unanswered questions. Are the eggs of the mayfly sucked in incidentally by the host or do the young larvae actively seek it out? Does development occur normally in the mussel, or can the nymph undergo a period of quiescence if, for example, the host remains buried in the sand for prolonged periods?

A puzzling finding in the river Milo in Guinea was the presence of adults in light-trap catches even though, because of mining operations upstream and the resultant heavy load of suspended mineral particles, mussels were believed to be absent from the river.

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REFERENCES

- Needham, G.E. (1966). A chironomid larva associated with the lamellibranchiate mollusc *Anodonta cygnea* L.. *Entomol. Mon. Mag.* 101: 142-143.
- Needham, G.E. (1970). A further example of an association between a chironomid (Dipt.) and a bivalve mollusc. *Entomol. Mon. Mag.* 106: 3-5.
- Forsyth, D.J. and McCallum, I.D. (1978). *Chironomus canterburyensis* (Diptera: chironomidae), a commensal of *Hyriella menziesi* (Lamellibranchia) in Lake Taupo; features of pre-adult life. *N. Z. J. Zool.* 5: 795-800.
- Fryer, G. (1961). The developmental history of *Mutela bourguignati* (Ancey) Bourguignat. (Mollusca: Bivalvia). *Phil. Trans. Roy. Soc. Lond., B.* 711: 259-268.
- Gledhill, T. (1985). Water Mites - Predators and Parasites. *Ann. Rep. Freshwat. Biol. Assn.* No. 53: 45-59.
- Müller-Liebenau, I. and Heard, W.H. (1979). *Symbiocloeon*: a new genus of Baetidae from Thailand (Insecta, Ephemeroptera). *Proc. 2nd Internat. Conf. Ephemeroptera.* Krakow, 1975: 57-65.
- Norman, J.R. (1975). *A History of Fishes.* 3rd edn, P.H. Greenwood (ed.).