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Further observations on some blackflies (Diptera: Simuliidae)  
associated with mayflies (Ephemeroptera: Baetidae and  
Heptageniidae) in Cameroon

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SYNOPSIS

An account is given of the infestation rates, attachment sites, larval size distribution and dispersion of *Simulium baetophilum* on nymphs of Baetidae. The mechanisms of choice shown by *S. afronuri* and *S. lumbwanum* infesting *Afronurus* spp. are discussed.

INTRODUCTION

In a previous paper (Disney, 1971*d*) it was reported that *Simulium afronuri* Lewis & Disney and *S. lumbwanum* De Meillon both occurred on the nymphs of the same species of *Afronurus* Lestage in rivers near Kumba in the forest zone of Cameroon. *S. afronuri* and *S. lumbwanum* were found to exhibit differences in their preferred attachment sites to the nymphs. In addition, it was found that the two species exhibited differences in the frequency with which the different size-classes of their hosts were patronised. These observations were construed as evidence of niche separation; they are, however, slightly paradoxical. The infestation rate of *S. afronuri* on *Afronurus* was highest on "large" nymphs (nymphs >8 mm. in length), whereas *S. lumbwanum* showed significant settlement on "small" nymphs (<4.5 mm. in length), a peak infestation rate on "medium" nymphs (4.5-8 mm. in length) and lowest infestation on "large" nymphs. This evidence of differences in the choice of host size is curious in view of the evidence (Disney, 1971*b-d*) that phoretic *Simulium* appear to locate their hosts as young larvae, relying on chance encounter with their appropriate host. Chance encounter and a mechanism of choice of host size are strange partners, and it was therefore decided to make further collections of *Afronurus* in order to try and elucidate this mechanism of choice.

While collecting further *Afronurus* from the Wowe River, a larva was observed attached to a nymph of a mayfly of the family Baetidae. Further collecting produced a few more larvae attached to baetid nymphs. The larvae were found to belong to an

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undescribed species, which has been named *S.baetiphilum* Lewis & Disney (1972). The species is similar to *S.diceros* Freeman & De Meillon both in appearance and in its habits (Marlier, 1950). When a large population of *S.baetiphilum* was found in the Mangusu stream, the opportunity was taken to obtain basic information on the natural history of the species.

#### METHODS

Collecting methods and routine procedures for examination of *Afromurus* and their *Simulium* larvae have been described elsewhere (Disney, 1971*d*).

*S.baetiphilum* has been found only on nymphs that appear to belong to the genus *Baetis* Leach. These Baetids have been found in two situations in rivers near Kumba. Some were found clinging to loose stones, alongside nymphs of *Afromurus*, and were collected by lifting the stones from the water by hand while simultaneously scooping a net from below so that nymphs that were dislodged were secured by the net. The baetid nymphs were more difficult to handle than *Afromurus*, as they tended to suddenly spring off the stone. Some baetid nymphs were found clinging to smooth rock surfaces (such as exposed beds of volcanic lava) and were collected by "skimming" a standard F.B.A. square-framed net (of 8 meshes/cm.) over the surface of the rock in an upstream direction. As with *Afromurus*, the nymphs of the Baetids were placed in individual tubes of alcohol in the field. Only nymphs bearing pupae, required for rearing to adults, were transported to the laboratory alive. The laboratory examination of the Baetids and *S.baetiphilum* followed the same procedures used for *Afromurus* and its blackflies (Disney, 1971*d*).

#### THE MAYFLIES

The identification of West African mayfly nymphs is still not possible for the majority of species, and it is still impossible to assign the *Afromurus* nymphs collected near Kumba to named species. The Baetidae present even greater difficulties. The species bearing *S.baetiphilum* belong either to the genus *Baetis* or to a closely related genus. At the time of collection and examination for *Simulium* four types were recognised and designated as follows. Types A, B and C have the middle tail filaments approximately half the length of the outer two. Type D has the middle filament less than one-third of the length of the outer filaments. Types A, C and D have simple leaf-like abdominal gills, and B has "frilling" of the proximal posterior margins of the gills. Type C has decidedly fewer veins in the gills than the others and also has small orange spots on the terga and an orange streak on each of the femora (in the fresh alcohol-preserved nymphs). Dr M.T.Gillies has kindly examined samples of the baetid nymphs since the completion of the studies in Kumba. He finds that Type D appears to comprise two distinct species, which were not distinguished at the time of the observations.

All four types of Baetid were collected from loose stones. A, B and in particular D were also collected from smooth rock surfaces. Initially D was collected from stones only, but when the large population was discovered on the rock surfaces the collecting effort was directed to the latter situation. However, it was evident that those on stones and those on rock surfaces represented different fractions of the population in terms of the age of the nymphs. In figure 1 are shown length frequency histograms for Baetid

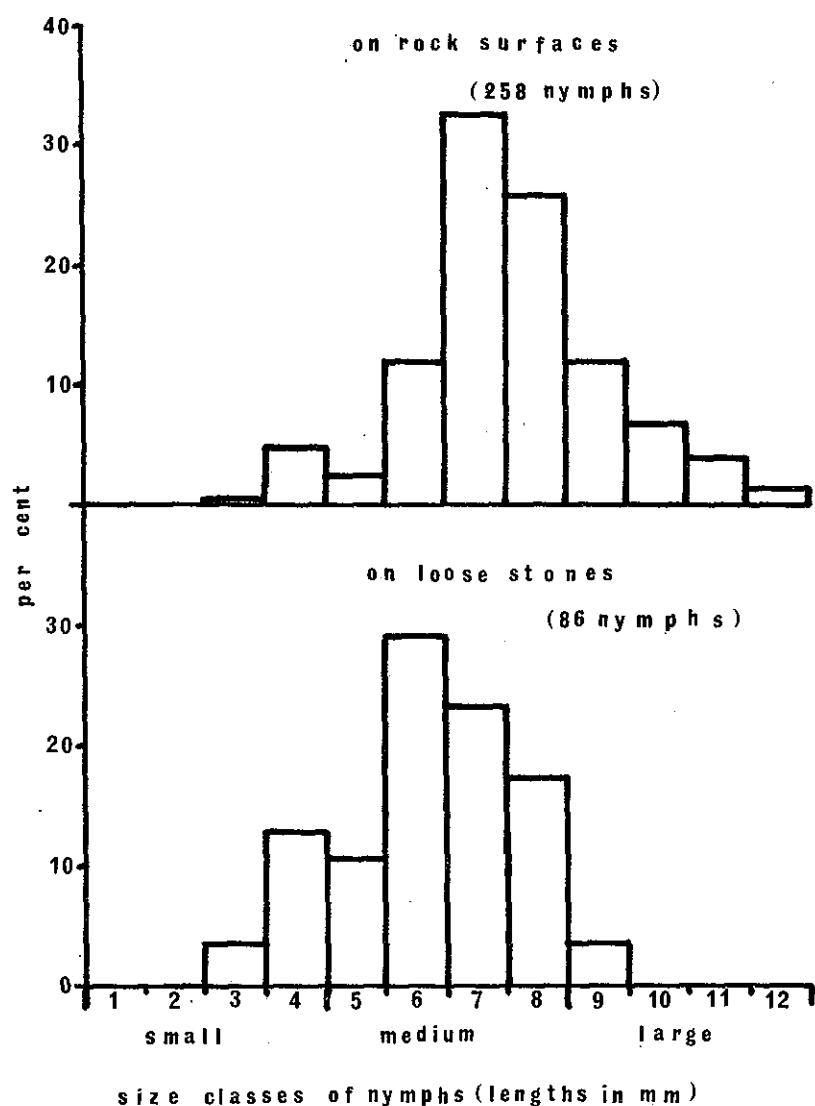


Fig. 1. Length frequency histograms of 86 Baetid D nymphs collected from loose stones (below) and 258 collected from submerged rock surfaces (above) in the Mangusu stream (second week of June 1970).

D nymphs collected from stones and from exposed rock surfaces in the Mangusu stream during the second week of June 1970. The smaller nymphs were more abundant on the lower faces of stones, whereas larger nymphs were more frequent on the exposed rock surfaces.

A similar situation, but less marked, was manifested by the *Afronurus* nymphs. In this case the shift in distribution is from the lower (more protected) faces of the stones to the upper (more exposed) faces of the same stones. Figure 2 plots the size distribution of nymphs collected from the upper and lower faces of stones carefully

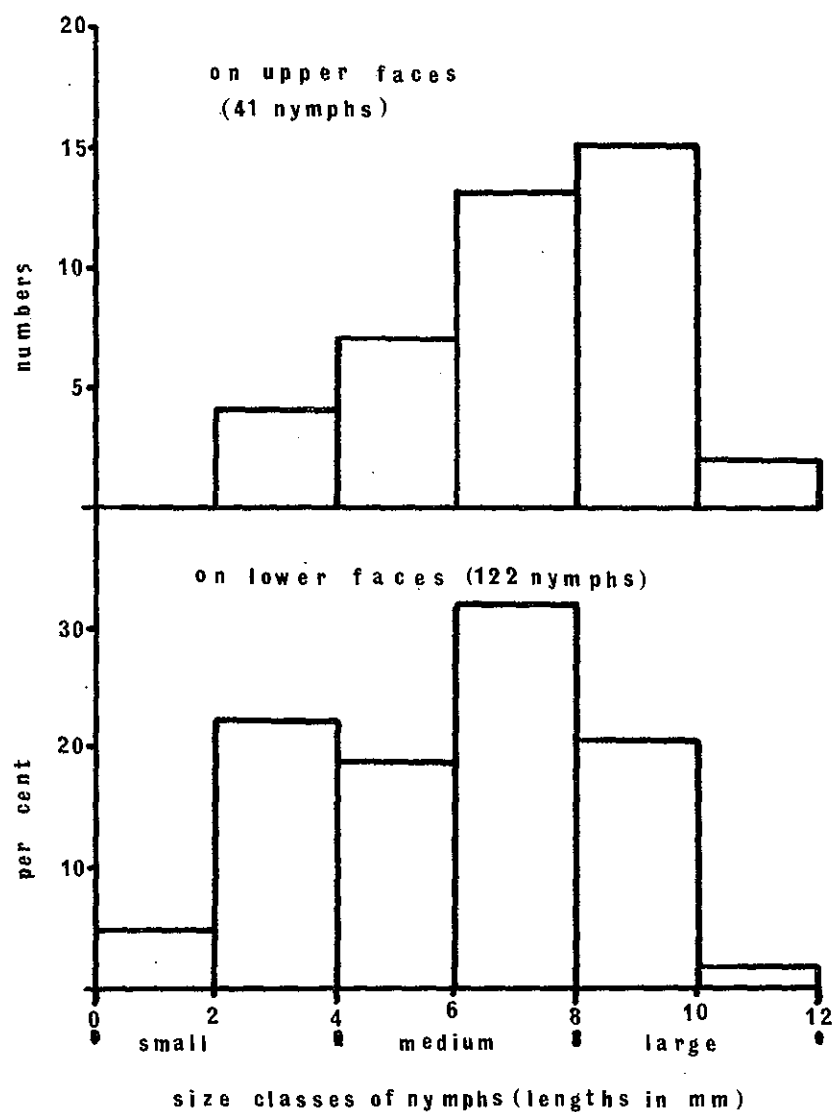


Fig. 2. Length frequency histograms for 122 *Afronurus* nymphs collected from the lower faces of stones (below) and 41 nymphs collected from the upper faces of the same stones (above). Wowe River 29th May, 1970.

lifted from the Wowe River on 29th May 1970. The smaller *Afronurus* tended to avoid the upper faces of the stones, at least by day. The proportion of the population on the upper faces of the stones appears to be lower in conditions of spate, but this subjective observation is difficult to substantiate because of the difficulty of making careful quantitative collections during conditions of spate.

#### OBSERVATIONS ON *Afronurus*-PHORETIC *Simulium*

A re-examination of the data from which the previously observed infestation rates on

Table 1. Infestation rates of *Simulium afronuri* on *Afronurus* nymphs. Wowe River, 1969-1970

Nymph size class	No. of nymphs (N)	Young larvae		Medium larvae		Mature larvae		Pupae	
		No. (Y)	10Y/N Ratios	No. (M)	10M/N Ratios	No. (L)	10L/N Ratios	No. (P)	10P/N Ratios
Small	158	0	0	0	0	0	0	0	0
Medium	598	26	0.43	33	0.55	14	0.23	4	0.07
Large	271	18	0.66	49	1.81	38	1.40	14	0.52
			1.5		3.3		6.1		7.4

Table 2. Infestation rates of *Simulium lumbecanum* on *Afronurus* nymphs. Wowe River, 1969-1970

Nymph size class	No. of nymphs (N)	Young larvae		Medium larvae		Mature larvae		Pupae	
		No. (Y)	10Y/N Ratios	No. (M)	10M/N Ratios	No. (L)	10L/N Ratios	No. (P)	10P/N Ratios
Small	158	15	0.95	0	0	0	0	0	0
Medium	598	33	0.55	43	0.72	21	0.35	13	0.22
Large	271	16	0.59	10	0.37	3	0.11	0	0
			1.1		0.5		0.3		0

the different sized nymphs were calculated (Disney, 1971*d*) indicated that the younger larvae were distributed differently from older larvae in relation to the three size-classes of *Afronurus*. It was considered advisable to make additional observations, not only to confirm this indication but also to augment the figures in order that they might possess greater statistical validity. The new collections were from the same locality in the Wowe River as the previous collections. As before, the *Afronurus* nymphs were divided into three size-classes (small, medium and large). The blackflies were divided into four classes as follows: "young larvae", 0.5–1.5 mm. in length (0.5 mm. first instar larvae of *S.lumbwanum* were found for the first time in the present study, similar larvae of *S.afronuri* having been recorded previously, Disney, 1971*d*); "medium larvae", 2.0–3.5 mm. (*S.afronuri*) and 2.0–4.5 mm. (*S.lumbwanum*); "mature larvae", 4.0–5.0 mm. (*S.afronuri*) and 5.0–6.0 mm. (*S.lumbwanum*); and pupae.

The results are presented in Tables 1 and 2. *S.lumbwanum* settled on all sizes of nymphs, whereas *S.afronuri* would seem to have found small nymphs unacceptable. The increase in the ratio of the numbers of *S.afronuri* on large nymphs to those on medium nymphs with increasing age was presumably due to the fact that the nymphs were growing as well as the *Simulium*. Likewise the lack of older *S.lumbwanum* on small nymphs would also be accounted for by the growth of the nymphs along with the settled *Simulium*.

The ratio of the numbers of *S.lumbwanum* on large nymphs to those on medium nymphs changes, with increasing age of the *Simulium*, in the unexpected direction: older *S.lumbwanum* appear to be more frequently lost from large nymphs. It seems not improbable that the more exposed attachment sites of *S.lumbwanum* (compared with those of *S.afronuri* (Disney, 1971*d*)), combined with the tendency for larger nymphs to be more frequently exposed to the full force of the current (fig. 2), might account for a relatively higher frequency of dislodgement of *S.lumbwanum* from large nymphs of *Afronurus*. It is not without interest that the smallest larvae of *S.lumbwanum* show their highest infestation rate on small nymphs (Table 2), i.e. on nymphs more or less restricted to the lower faces of the stones (fig. 2), where the exposure is minimal.

It seems that in *S.afronuri* the realised niche results from the choice of the young larva, in so far as small nymphs of *Afronurus* are not accepted as suitable for settlement. By contrast, in *S.lumbwanum* the mechanism of choice seems to be the environment, in that the settlement sites of the larvae combine with change in the habits of the larger nymphs to increase the frequency of dislodgement from large nymphs. It is concluded that host location by chance encounter and a mechanism of choice of host size do not constitute a paradox. When analysed in more detail, the choice exhibited by larvae of *S.lumbwanum* is seen to result from dislodgement (selective reduction in relation to *S.afronuri*) subsequent to the initial settlement.

#### ASSOCIATION OF *Simulium baetophilum* WITH NYMPHS OF BAETIDAE

##### *Infestation rates*

Table 3 shows the infestation rates of *S.baetophilum* on the beatid nymphs collected near Kumba; infestation rate is defined as the mean number of larvae plus pupae per nymph. The nymphs have been divided into three size classes, as follows: small nymphs, 4.0 mm. or less in length; medium nymphs, 4.5–8.0 mm. in length; large nymphs,

Table 3. Infestation rates of immature *S.baetophilum* on small, medium and large nymphs of Baetidae

		No. of <i>Simulium baetophilum</i> on												
		Small nymphs				Medium nymphs				Large nymphs				
Date (1970)	Locality	Baetid type	No. nymphs (N)	No. <i>Simulium</i> (S)	S/N	No. nymphs (N)	No. <i>Simulium</i> (S)	S/N	No. nymphs (N)	No. <i>Simulium</i> (S)	S/N	No. nymphs (N)	No. <i>Simulium</i> (S)	S/N
May/June	Wowe	A	2	—	—	110	3	0.03	45	2	0.04	1	1	(1.0)
		B	—	—	—	1	—	—	1	—	—	—	—	—
		C	—	—	—	4	1	(0.25)	—	—	—	—	—	—
June	Mangusu	A + B + C	2	—	—	115	4	0.03	46	3	0.07	—	—	—
		A	2	1	(0.5)	2	1	—	—	—	—	—	—	
		B	—	—	—	1	—	—	—	—	—	—	—	—
		D	27	7	0.26	254	123	0.48	63	39	0.62	—	—	—
10 July	Mangusu	A + B + D	29	8	0.28	257	124	0.48	63	39	0.62	—	—	—
		A	—	—	—	21	3	0.14	32	4	0.13	—	—	—
		D	3	1	0.33	113	43	0.38	132	34	0.62	—	—	—
June/July	Okia	A + D	3	1	0.33	134	46	0.34	164	38	0.23	—	—	—
		D	—	—	—	1	—	—	1	1	(1.0)	—	—	—

8.5 mm. or more. The three localities where *S.baetiphilum* have been found are shown on the map in a previous paper (Disney, 1971a).

The observations in Table 3 indicate that Baetid D seemed to be more acceptable as a host than Baetid A. Thus on 10th July 1970 the infestations on both medium and large nymphs in the Mangusu were at least twice as high on Baetid D as on Baetid A. It is possibly significant that the collections made in the same place in the second week of June 1970 encountered a different situation, in that Baetid A was relatively rare at that time. A comparison of the natural histories of the different baetid species might be illuminating. Casual observation suggests that Baetid D tend to characterise minor streams, which often dry up in the dry season (e.g. Mangusu, Okia, Mess stream at Kumba). Baetid A appears to be more widely distributed in the main tributaries of the Mungo River (e.g. Kobe, Dilolo, Blackwater and Wowe) and less characteristic of the minor tributaries such as the Mangusu.

The observations in Table 3 indicate that in general the infestation rate is greater on larger nymphs. However, the observations for the Mangusu on 10th July indicate a higher infestation rate on medium nymphs than on large nymphs. The infestation rates on Baetid D in the Mangusu for the second week of June and for 10th July are analysed in more detail in Tables 4 and 5. In these tables the *S.baetiphilum* are divided into four age-classes as follows: young larvae, 0.5-1.5 mm. in length; medium larvae, 2.0-4.0 mm.; mature larvae, 4.5-5.5 mm.; and pupae. It is at once apparent that the age-structure of the two samples of *S.baetiphilum* are quite different, the July sample showing a dearth of young larvae and a relatively high proportion of pupae and mature larvae. But this by itself does not explain the higher infestation rate on medium nymphs, compared with large nymphs in July.

**Table 4.** Infestation rates of four age-classes of immature *S.baetiphilum* on small, medium and large nymphs of Baetid D. Second week of June 1970 (Mangusu)

Classes of <i>S.baetiphilum</i>	No. of <i>S.baetiphilum</i> on						Total No.	Ratio L/M
	27 small nymphs		254 medium nymphs		63 large nymphs			
	No.	Rate	No.	Rate (M)	No.	Rate (L)		
Pupae	0	0	8	0.03	3	0.05	11	1.7
Mature larvae	0	0	25	0.10	5	0.08	50	0.8
Medium larvae	5	0.19	40	0.16	12	0.19	57	1.2
Young larvae	2	0.07	50	0.20	19	0.30	71	1.5

**Table 5.** Infestation rates of four age-classes of immature *S.baetiphilum* on small, medium and large nymphs of Baetid D. 10th July, 1970 (Mangusu)

Classes of <i>S.baetiphilum</i>	No. of <i>S.baetiphilum</i> on						Total No.	Ratio L/M
	3 small nymphs		113 medium nymphs		132 large nymphs			
	No.	Rate	No.	Rate (M)	No.	Rate (L)		
Pupae	—	—	—	—	19	0.14	19	++
Mature larvae	—	—	21	0.19	4	0.03	25	0.2
Medium larvae	1	0.33	18	0.16	10	0.08	29	0.5
Young larvae	—	—	4	0.04	1	0.01	5	0.3



The June figures (Table 4) suggest a similar situation to that for *S.lumbwanum* on *Afromurus* (Table 2), that is to say a tendency for older larvae to be more frequently dislodged from larger nymphs. The July figures (Table 5) suggest that this situation has become greatly exaggerated, and that prior to pupation the chances of larvae of *S.baetophilum* being dislodged from larger nymphs was much higher than in June. It is probably significant that a far larger volume of water was flowing down the Mangusu in July. It is possible that, when the nymphs move from the shelter of stones to rock surfaces (fig. 1), they move initially into regions of less violent flow and then with increasing size move into faster water. While collecting the nymphs it appeared that large nymphs and medium-sized nymphs were differently distributed on the rock surfaces, the former tending to occur in the faster runs. However, such an impression needs to be confirmed by careful collecting in conjunction with measurements of velocity in the half centimetre or so flowing immediately above the rock surfaces to which the nymphs attach themselves. In the present study no suitable instrument for such velocity measurement was available.

Infestation rates not only varied with the size class of the nymphs but also with the age-structure of the *S.baetophilum* population. This must be taken into account in comparisons of infestation rates in space and time.

#### Attachment sites

Table 6 shows the attachment sites of *S.baetophilum* on baetid nymphs.

Table 6. Attachment sites of *Simulium baetophilum* to nymphs of Baetids

Position on mayfly nymph	Size of <i>Simulium</i> larvae (P = pupae)												Totals	Percentage	
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	P			
Lower parts of head	—	3	1	—	—	—	—	—	—	—	—	—	—	4	1.5
Thoracic nota	—	—	—	2	10	7	11	6	17	19	14	30	116	43.9	
Thoracic sterna and pleura	3	5	6	1	—	—	—	—	—	—	—	—	15	5.7	
Coxae	—	4	2	—	—	—	—	—	—	—	—	—	6	2.3	
Femora	1	—	—	—	—	—	—	—	—	—	—	—	1	0.4	
Abdominal segment															
1 Tergum	—	—	—	1	—	—	—	—	—	—	—	—	1	0.4	
Sternum	2	2	1	—	—	—	—	—	—	—	—	—	5	1.9	
2 Tergum	—	—	5	10	—	1	—	—	—	—	—	—	16	6.0	
3 Tergum	—	1	1	1	1	—	—	—	—	—	—	—	4	1.5	
4 Terga	—	1	2	1	1	—	—	—	—	—	—	—	5	1.9	
to															
7 Sterna	—	—	1	—	—	—	—	—	—	—	—	—	1	0.4	
Dislodged	5	16	19	9	5	7	14	5	2	6	2	—	90	34.1	
Totals	11	32	38	25	17	15	25	11	19	25	16	30	264	100	

The smallest larvae were 0.5 mm. first instar larvae (bearing an egg tooth on top of the head). It is evident that the smaller individuals tend to settle beneath the head, thorax and abdomen. The larvae then appear to move via the abdominal tergites, or

in some cases direct, to the top of the thorax. The pupae were all found on the mesonotum (and wing covers), although on smaller nymphs they may extend over the first abdominal segments (but without adhering to these). The pupae all faced towards the tail of the nymph.

The more exposed position of the larger larvae might partly explain their tendency to dislodgement from the larger nymphs (as indicated above).

#### Dispersion on nymphs

It has been shown (Disney, 1971c) that the dispersion of larvae of *S.berneri* Freeman on nymphs of *Elassoneuria* Eaton (i.e. the frequencies of nymphs bearing 0, 1, 2, 3, etc. larvae) is random. A similar situation has been reported for *S.lumbwanum* and *S.afronuri* on *Afronurus* nymphs (Disney, 1971d). From these observations it was inferred that the larvae of phoretic *Simulium* reached their hosts as single larvae, depending on chance encounter for success. Evidence to support this view was obtained when *Simulium*-free crabs were exposed in cages in rivers in which the crab-phoretic species *S.ovazzae* Grenier & Mouchet was known to breed abundantly, and single larvae of *S.ovazzae* were obtained on these crabs (Disney, 1971b).

The dispersion data for *S.baetiphilum* on Baetid D nymphs from the Mangusu in June are given in Table 7 together with the Poisson distributions, for those on medium and large nymphs, calculated from the infestation rates. Close coincidence of the observed figures with the appropriate Poisson figures indicates a random dispersion.

**Table 7.** Dispersion of *Simulium baetiphilum* on different sized nymphs of Baetid D together with theoretical random dispersions (= Poisson figures). All figures are expressed as percentages of total nymphs within a particular size class

No. <i>Simulium</i> per nymph	Small nymphs (27)		Medium nymphs (254)		Large nymphs (63)	
	Obs.		Obs.	Poisson	Obs.	Poisson
0	81.5		61.8	60.7	55.6	54.9
1	11.1		31.5	30.3	31.7	32.9
2	7.4		5.1	7.6	9.5	9.9
3	0		0.4	1.3	1.6	2.0
4	—		0.8	0.2	1.6	0.3
5	—		0	0.02	0	0.04
6	—		0.4	—	0	—

#### DISCUSSION

The observations reported here for *Simulium baetiphilum* parallel similar observations for *S.lumbwanum* (Disney, 1971d and above); it would appear that *S.baetiphilum* differs in its natural history primarily in its choice of host. One interesting feature of *S.baetiphilum* is that the population in the Mangusu in June had built up from nothing in April; the Mangusu dried up in February and remained more or less continuously dry until well into April. It is not improbable that the Baetid D passes the dry season as eggs, in the way that cool-water species of *Baetis* in Europe span the unfavourable

(warm) season as eggs (Pleskot, 1961). It would be interesting to discover whether *S.baetophilum* passes the dry season in the egg stage. *Simulium* inhabiting temporary streams in other parts of the world are thought to survive adverse periods as eggs (e.g. Anderson & Dicke, 1960).

*S.baetophilum* is found attached to nymphs of Baetids and settles on similar positions to those reported by Marlier (1950) for *S.diceros* on *Baetis* nymphs. The two species are closely similar and are clearly related (Lewis & Disney, 1972). It seems probable, therefore, that *S.baetophilum* in Cameroon is occupying an equivalent ecological niche to that of *S.diceros* in East Africa. Marlier (1950) reported that larvae of *S.diceros* have fragments of leaves (of Dicotyledons and grasses) in their stomachs. He presumed these were derived from the feeding activities of the nymph host and suggested that *S.diceros* depended on this source of food, as the streams in which it occurred were practically devoid of plankton. The Mangusu, however, supported dense populations of free-living *Simulium* at the time of year when the populations of *S.baetophilum* were sampled. Also, both the Wowe and Okia supported sizeable populations of various free-living *Simulium* when *S.baetophilum* was collected (Disney, in press). Although *S.baetophilum* is likely to derive food from that being macerated by its mayfly partner, as does *S.diceros*, it seems improbable that a lack of the food normally eaten by free-living *Simulium* larvae made such a diet necessary. Since Marlier's studies it has been shown that *Simulium* larvae can complete their development on suspensions of bacteria alone (Fredeen, 1964).

Our knowledge of mayfly-phoretic blackfly natural history will advance when a knowledge of the natural history of their mayfly partners is available. The importance of a shift in microhabitat with age of the nymphs is apparent from the few observations above. Our almost complete ignorance of the natural history of most West African mayflies springs from an extreme neglect of their taxonomy. Until nymphs can be confidently assigned to named species the student of mayfly-phoretic blackflies will continue to be frustrated in his investigation of these unusually interesting *Simulium*.

#### SUMMARY

1. The nymphs of *Afronurus* and Baetidae, which carry phoretic blackflies in the forest zone of Cameroon, tend to show a change in their preferred microhabitats with increasing age of the nymphs.
2. Differences in the frequency of infestation of *Afronurus* result partly from mechanisms of choice by *Simulium* larvae. *Simulium afronuri* Lewis & Disney avoids settlement on small nymphs, whereas *S.lumbwanum* De Meillon tends to be more frequently dislodged from the larger nymphs.
3. *S.baetophilum* Lewis & Disney shows patterns of settlement and infestation rates on Baetidae similar to those of *S.lumbwanum* on *Afronurus*. It showed marked preference for one type of Baetid when two were present in the same stream.
4. The preferred attachment sites of *S.baetophilum* change with the age of the *Simulium* larvae. The dispersion appears to be random.

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