Stringer et al. 1996

Distribution of Flying Insects in Relation to Predacious Web-Spinning Larvae of *Neoditomyia farri* (Diptera: Mycetophilidae) in a Jamaican Cave

IAN A. N. STRINGER[1] AND V. BENNO MEYER-ROCHOW[2]

Department of Ecology, Massey University, Private Bag 11222, Palmerston North, New Zealand

Ann. Entomol. Soc. Am. 89(6): 849–857 (1996)

ABSTRACT Larvae of predacious *Neoditomyia farri* Coher (Mycetophilidae: Keroplatinae) in Dromilly Cave in Trelawny, Jamaica, were restricted to the chamber where flying insects were most abundant. Here they occupied overhangs within 2 m of the floor. The distribution of flying insects was determined using adhesive traps. Total mean numbers throughout the cave varied between 953.0 and 10.5 insects per square meter of trap surface per hour. Scatopsidae predominated (up to 96%) where there were deep deposits of fresh bat guano and numerous roosting bats. *Pholeomyia* (Milichiidae) (0–2.4%) were similarly distributed but Phoridae (4–63%) were more evenly distributed throughout the cave. Minor components comprised Sciaridae (1%) followed by Scelionidae, Staphylinidae, Streblidae, Tineidae, Formicidae, and Mycetophilidae (all <0.2%). Numbers of flying insects decreased logarithmically with increasing height. In areas of high insect abundance, fewer insects flew near the walls than in the center of the chamber. Estimates of numbers of insects caught in *N. farri* webs indicated that food availability more than any other factor determines the distribution of these larvae.

KEY WORDS *Neoditomyia farri*, Diptera, cave ecology, Mycetophilidae, fungus gnats

MANY PREDACIOUS MYCETOPHILID fly larvae in the subfamily Keroplatinae build 3–dimensional webs beneath overhanging surfaces. The webs consist of horizontal threads that support a central gallery, and numerous vertical *fishing lines*. Fishing lines are adhesive and trap flying insects that are hauled up by the larvae and eaten. The best known keroplatine is the New Zealand glowworm *Arachnocampa luminosa* (Skuse) and the larvae of these produce light to attract their prey (see reviews by Hudson 1950; Richards 1960, 1964; Vandel 1965; Kermode 1974). Another keroplatine, *Orfelia fultoni* (Fisher), also uses bioluminescence to attract its insect prey although its web lacks vertical fishing lines (Sivinski 1982). A number of other nonbioluminescent Keroplatinae also catch insect prey in webs with adhesive fishing lines (Lane and Sturm 1958, Sturm 1973, and reviews by Peck and Russell 1976, and Pugsley 1983), but no research has been published on how they snare sufficient food without the use of light.

The only published information about food relationships of keroplatines with 3–dimensional webs is by Pugsley (1980, 1984) on *A. luminosa*. He suggested that food availability is almost certainly a major influence on the distribution of *A. luminosa* within the Glowworm Cave, Waitomo, New Zealand, but he was unable to estimate the food requirements of the larvae or the total amount of food available to them. Pugsley (1980, 1984), furthermore, discusses environmental factors that limit the distribution of *A. luminosa*.

Here we report on the distribution of the larvae of a nonluminescent, tropical, web–building mycetophilid fly, *Neoditomyia farri* Coher, and the flying insects that constitute its food in Dromilly Cave, Trelawny, Jamaica. *N. farri* occurs widely although infrequently in Jamaican caves but an unusually large concentration of them occurs in Dromilly Cave (Peck 1975, 1992). This species is endemic to Jamaica (Coher 1966) although there is a closely related species, *Neoditomyia troglophila* Matile, on Cuba (Matile 1977). The larvae of *N. farri* live beneath low overhangs in caves where they make 3-dimensional webs similar to those of other keroplatines (Stringer and Meyer-Rochow 1993). Large deposits of bat guano are present in Dromilly Cave together with numerous small flies and other guano-associated insects. Individuals of *N. farri* are restricted to a relatively small region within the cave (Peck 1975), and yet initially their distribution did not appear to us to be caused by either a lack of suitable sites or by a lack of flying insects elsewhere in this cave. Large numbers of

[1]Department of Ecology, Massey University, Private Bag 11222, Palmerston North, New Zealand.
[2]Department of Zoology, Oulu University, S-F-90570-Oulu-Linnanmaa, Finland.

0013-8746/96/0849–0857$02.00/0

flying insects congregated around flashlights throughout much of the cave although it was possible that these were attracted to the light from some distance (Stringer and Meyer-Rochow 1994). We estimated the distribution of flying insects within the cave using adhesive traps set for 20–23 h on 3 occasions between 31 October 1992 and 5 December 1992. This enabled us to assess whether the availability of food in the form of these insects limits the distribution of *N. farri* larvae.

Materials and Methods

All research was conducted in Dromilly Cave, Trelawny, Jamaica (Jamaica Survey Department map 2, 1:50,000; E738 N920). Descriptions of this cave, together with maps, are given in Fincham et al. (1977) and Speleoclub SC33 (1993). Access to the cave is relatively easy and no specialized caving equipment is required. Few people visit the cave although local farmers occasionally remove bat guano for fertilizer.

Flying insects were caught with adhesive traps covered with Tangle-trap (Tanglefoot, Grand Rapids, MI). Sheet traps consisted of clear acetate sheets (220 mm high, 70–290 mm wide). Each thread trap consisted of a single row of 15 vertical cotton threads (19 cm long, 0.35–0.40 mm diameter) spaced 1 cm apart and attached at both ends to a wire frame to prevent tangling. Sheet traps and thread traps were suspended at predetermined heights above the cave floor from either wire pushed into the bat guano or from wire attached to long sticks pushed into the guano. All traps were left in the cave for 20–23 h. They were set and recovered with the aid of a flashlight covered with 2 layers of red cellophane. This substantially reduced the numbers of flies attracted to the light (Stringer and Meyer-Rochow 1994). Care was taken to ensure that no other artificial lighting was used and that the cave was left undisturbed while trapping was in progress. Adhesive traps were placed individually between white paper and sealed in envelopes as soon as they were recovered. The insects caught were then identified and counted under a binocular microscope later in the laboratory.

Neoditomyia farri fishing lines were measured to the nearest 5 mm with a ruler held ≈1 cm away and parallel to them. Care was taken to avoid creating any wind, because it tangled the fishing lines. Temperature and humidity readings were taken with a digital meter (Model HI 8564, Hanna, Woonsocket, RI).

Variances of estimated numbers of flies caught in webs were made by the delta method (Seber 1982). Model I regression analysis (Sokal and Rohlf 1981) was used to determine the relationship between catch rate (after logarithmic transformation) of adhesive traps and height.

One adult *N. farri* was deposited as an allotype in the Institute of Jamaica, Kingston by Coher (1996). Samples of all families of insects caught in adhesive traps were also deposited in the Institute of Jamaica, Kingston, and in The Museum of New Zealand, Wellington.

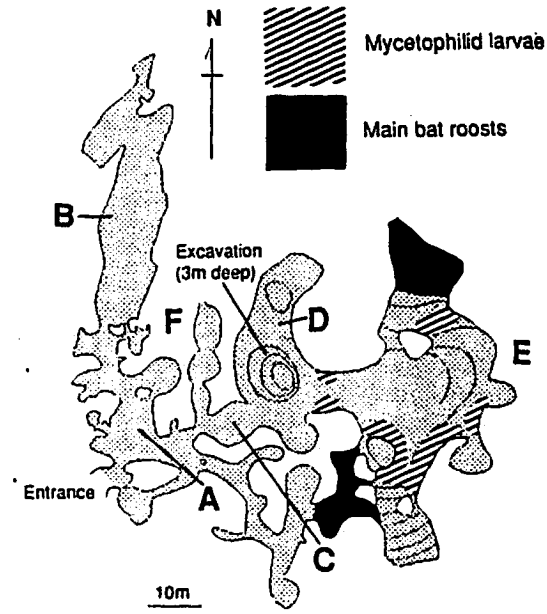

Fig. 1. Location of web building mycetophilid larvae and major bat roosts in Dromilly cave during November and December 1992. Map adapted with permission from Speleoclub SC33 (1993). Samples of flying insects were taken in chambers indicated with capital letters A–F.

Results

Distribution of Web Building Mycetophilid Larvae within Dromilly Cave. *N. farri* larvae (300–500) were present on the southern and southeastern walls of chamber E in Dromilly Cave (Fig. 1). A further 30–40 were located beneath an arch halfway up the northern guano covered rockfall in this chamber and 10–20 more were at the entrance into the passageway to chamber D (Fig. 1). The larvae occupied webs beneath overhanging ledges or rocks within ≈1.8 m of the guano floor and no larvae were seen on the ceiling of chamber E or beneath the many other suitable overhangs either here or elsewhere in the cave. Where larvae were present they occupied most of the overhanging surfaces that appeared to be suitable. Here their webs were packed usually closely together to form dense curtains of fishing lines. Larvae were absent from the western wall of chamber E because it curved smoothly upward and lacked suitable overhangs until it reached the ceiling, ≈20 m up. Twice during the 8 mo when we visited the cave almost all of the larvae beneath 2 different overhangs had been killed by a white fungus. These overhangs subsequently remained bare for 1 mo or more before small larvae appeared on them.

Table 1. Adhesive trap catches in different parts of Dromilly Cave over 23 h from 21 November 1992

Family	Chamber of cave					
	A	B	C	D	E	F
Scatopsidae	128	17	266	338	4,082	38
Phoridae	42	53	236	72	192	1
Milichiidae	2	0	12	8	35	1
Sciaridae	19	12	20	4	2	1
Streblidae	0	0	0	1	4	0
Tineidae	0	0	2	1	2	0
Staphylinidae	0	2	0	1	8	0
Scelionidae	2	0	1	0	10	0
Mycetophilidae	1	0	0	0	0	0
No. traps	5	5	5	5	5	3

Temperature and Humidity within Dromilly Cave. The greatest temperature range we recorded throughout Dromilly Cave was 23.8–24.7°C during 15 visits between July and December 1992 and 1993. The relative humidity was also always >95% (the upper accuracy limit of our meter) in all areas of Dromilly Cave during these visits.

Distribution and Composition of Flying Insects within Dromilly Cave. Flying insects from 10 different families were trapped in Dromilly Cave (Table 1). The most abundant were Scatopsidae, Phoridae, *Pholeomyia* (Milichiidae), and Sciaridae, and minor catches composed of undescribed species of *Atheta* (Staphylinidae) and *Proterospastis* (Tineidae), together with scelionid wasps, and sciarid and streblid flies (Table 1). A single undetermined mycetophilid was caught in the entrance chamber but this was not *N. farri*. Winged ants were also occasionally caught in adhesive traps.

The highest numbers of flying insects were trapped in chamber E (Fig. 2), where between 4,626 and 33,829 were caught per square meter on sheet traps over 23 h. Here Scatopsidae accounted for 82–96% of individual trap catches. Traps in chamber D, passageway C, and entrance chamber A caught, respectively, 230–2,772, 953–3,867, and 353–1,201 insects per square meter during the same period. These catches were smaller largely because there were fewer Scatopsidae (Fig. 2). Few insects were trapped in either chamber F, where there was almost no bat guano, or in chamber B, where bats were seldom seen but where there was a large deposit of old guano at the northern end (Fig. 2). Elsewhere, bat guano completely covered the floor of the cave and apparently increased in depth with increasing distance from the entrance. Local farmers have removed guano for fertilizer from small excavations in chambers B, C, and E and from a large hole ≈8 m in diameter and >3 m deep in the center of chamber D (Fig. 1). No adhesive traps were set in the narrow western passage connecting chambers A and E because of difficult access and because insects rarely became attracted to flashlights there.

The distribution of insects of different families varied within the cave. Scatopsidae and Milichiidae had similar distributions although Scatopsidae were usually more abundant. The highest numbers of both insects occurred in chamber E, and elsewhere their numbers generally diminished toward the entrance except for a slight increase in passageway C and for the low numbers in chambers B and F already noted (Fig. 2; Table 1). In contrast, Sciaridae appeared to be most abundant near the entrance and fewer were caught deeper within the cave. Exceptionally, Sciaridae comprised 14% of the catch in chamber B. Phoridae were the most evenly distributed flies (Fig. 2; Table 1), mean catch rates varied between 6.4 and 32.2 per m^2/h. The exception occurred in chamber F, where 0.26 flies on average were caught per m^2/h. Other flying insects were caught in such low numbers that their distributions were obscure. Streblidae, Staphylinidae, and Scelionidae, however, appeared to be most abundant in chamber E (Table 1).

Distribution of Flying Insects within Chamber E. The numbers of flying insects diminished approximately logarithmically with increasing height in chamber E (Fig. 3). This occurred both above the center of the chamber and with increasing height up the northern guano slope. However, the rates of capture of all insects diminished more slowly with increasing height up the guano slope than they did in the center of the chamber (Fig. 4; Table 2). Scatopsidae were the most abundant insects in both situations and at all heights. Phoridae showed the fastest reduction in numbers with increasing height in the center of the chamber but their numbers diminished slower than did those of Scatopsidae up the guano slope (Table 2). The catches of other flying insects were too low to show their relationships between numbers caught and height (Table 3).

There was no significant difference between the numbers of insects caught in adhesive traps positioned immediately in front of an overhang with *N. farri* larvae and another overhang that had previously supported these larvae (Fig. 5). These were the only comparable overhangs. Both were 10–12 m in from the entrance to chamber E and ≈0.3 m up the chamber wall. Here the traps were ≈0.8 m above the center of the chamber and yet the numbers of insects caught in them averaged 2.2% (overhang with *N. farri*) and 3.4% (*N. farri* absent) of the number trapped in the center of the chamber. This suggests that *N. farri* do not attract flying insects. Adhesive traps set ≈1 m away from the wall of chamber E and 12 m in from its entrance caught 6.7% of the number trapped in the center of the chamber. In contrast, traps in front of an overhang with *N. farri* larvae located ≈3 m in from the entrance to chamber E caught 16% as many insects as in the center of chamber E, whereas traps in the middle of this entrance caught 33% as many insects as in the center (Fig. 5). All of these reduced catches were largely caused by a reduction in the numbers of Scatopsidae (Fig. 5).

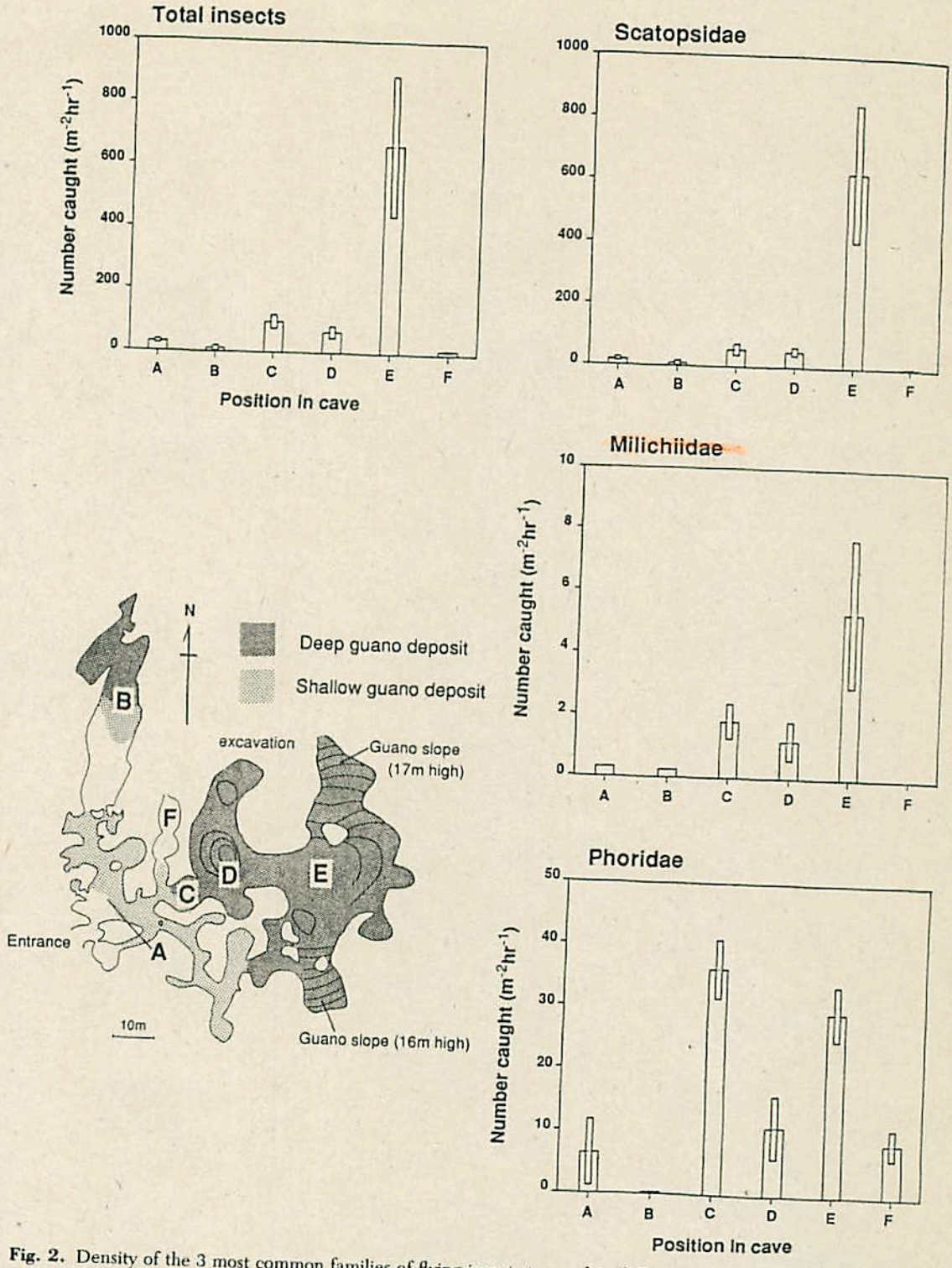

Fig. 2. Density of the 3 most common families of flying insects trapped in different parts of Dromilly cave. Traps were set for 23 h from 1500 hours on 21 November 1992. Histograms of hourly catch rate with ± 1 SE bars. Five adhesive traps were set in each of chambers A–E and 3 were set in chamber F.

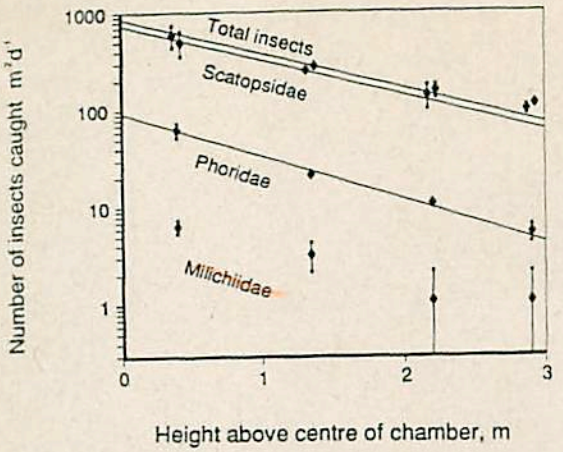

Fig. 3. Relationship between numbers of trapped insects and height above the center of chamber E. Traps were set for 20 h from 1400 hours on 5 December 1992. Means shown with ± 1 SE bars. Regression lines fitted using individual trap catches (n = 11).

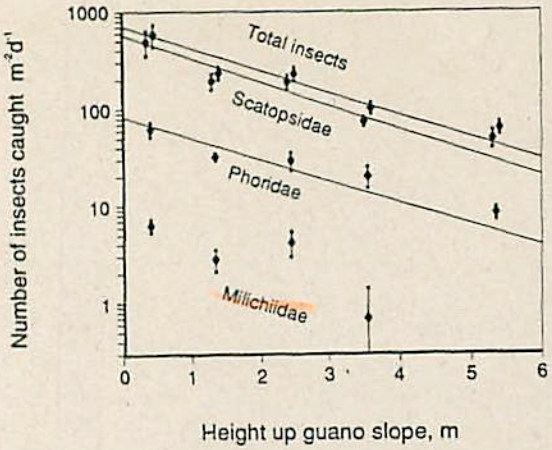

Fig. 4. Relationship between numbers of insects trapped and height up a guano slope in chamber E. All traps were set 0.2 m above the guano surface for 20 h from 1400 hours on 5 December 1992. Means shown with ± 1 SE bars. Regression lines fitted using individual trap catches (n = 17).

Relationship Between Numbers of Flying Insects Caught on Sheet Adhesive Traps and Numbers Caught on Threads Coated with Adhesive. Thread adhesive traps were set alongside sheet adhesive traps in the center of chamber E on 1 occasion to establish the relative numbers of insects caught by them. On average, thread traps caught 33.2 flying insects per meter of thread for each 1,000 insects caught per square meter of sheet trap (Fig. 6). Overall, the percentage of composition of insect families caught on thread traps was similar to those caught on sheet traps except for Sciaridae, which were not caught in thread traps (Fig. 6). Thread traps caught slightly higher proportions of Phoridae, Scelionidae, and Staphylinidae than sheet traps but the differences were not significant (Fig. 6).

We measured the lengths of fishing lines in webs of 9 *N. farri* last instars in Dromilly Cave to estimate the total trap lengths in such webs (Table 4). The webs chosen were slightly separated from dense aggregations of other webs. The structure of these webs is described in detail by Stringer and Meyer-Rochow (1993). Briefly, each consisted of a horizontal network of threads that supported a gallery 8.5–30 cm long (Table 4). The gallery consisted of numerous silken strands enclosed within mucus to form a thin flat ribbon. Each larva has a segmental series of ventral transverse bands of minute spines with which it clings upside down beneath the gallery. Attachment is accomplished by infolding the bands of spines to form transverse grooves. These each draw in and grip onto a portion of the gallery. Fine vertical fishing lines covered with adhesive mucus are lowered from the web to trap insects that fly into them. These fishing lines reached an average length of 8.38 cm (Table 4) and were spaced ≈1–2 cm apart.

Discussion

From a physical, abiotic viewpoint, numerous apparently quite suitable overhangs for *N. farri* to colonize were present in all chambers of Dromilly Cave, yet *N. farri* larvae were found only inside chamber E and near its entrance. Even when present they displayed a patchy distribution.

Light did not appear to affect the larval distribution, because larvae were also collected from the twilight region of caves in the Red Hills area (Speleoclub SC33 1993) and in Windsor Cave (location in Fincham et al. 1977). There was even an unconfirmed sighting of them under a rock in the forest (Stringer and Meyer-Rochow 1993). Certainly other webspinning mycetophilids with similar nests live both in and outside caves (Lane and Sturm 1958, Sturm 1973, Peck and Russell 1976, Pugsley 1983). For *A. luminosa* larvae to thrive, Pugsley (1980, 1984) considered high humidity and overhangs above flood height as essential requirements. He suggested that 1st instars were probably threatened most by desiccation and a fungal pathogen (*Tolypocladium* sp.) and that these 2 together influenced the distribution because the larvae seldom moved more than a few meters from their original nest sites. Cannibalism

Table 2. Increase in height required to halve the number of flying insects trapped in chamber E of Dromilly Cave during 20 h from 5 December 1992

Family	Ht in center of chamber, m	Vertical ht up guano slope, m
Scatopsidae	1.13	1.48
Phoridae	0.76	1.84
Milichiidae	0.89	1.25
Total insects	1.10	1.57

Table 3. Minor components of trap catches at different heights after 20 h in chamber E of Dromilly Cave on 5 December 1992

Family	Total no. caught							
	In center of chamber				On guano slope			
Sciaridae	7	1	1	2	0	2	1	0
Streblidae	2	0	1	0	0	0	1	3
Scelionidae	7	1	0	1	4	2	5	3
Tineidae	5	1	0	0	1	2	2	1
Staphylinidae	5	0	2	4	2	3	1	1
No. traps	5	2	2	2	3	3	3	3
	(0.20)	(1.35)	(2.20)	(2.90)	(1.35)	(2.45)	(3.55)	(5.35)

Numbers in parentheses are height of traps in meters.

and predation by opiliones were considered to be less important. Pugsley (1980, 1984) also reported that the availability of flying insects had an effect on the distribution of *A. luminosa* in the Waitomo Cave, New Zealand, although *A. luminosa* can attract its prey with light from its modified Malpighian tubules. We found no evidence that larvae of *N. farri* possessed any means of attracting their prey and assume that the latter get caught purely by chance. In total darkness, not even web movements, deemed important for the interception of insects by spiders with orb-webs (Craig et al. 1985), would make much of a difference. If prey insects are not distributed evenly in the caves and are caught accidentally, it must therefore clearly be of great importance for *N. farri* where exactly in the cave its larvae construct their webs.

Our survey showed that the numbers of flying insects in chamber E were highest and that the numbers caught elsewhere varied between 0.9 and 15% of the catch in chamber E. Furthermore, the numbers of flying insects diminished rapidly both with increasing height above the cave floor and with increasing proximity to the walls of chamber E. If this situation occurs elsewhere in Dromilly Cave, then the numbers of insects that fly near the walls where webs can be constructed would be even lower. *N. farri* larvae were only found close to the guano surface in chamber E, and this is clearly where the highest density of flying insects occurred. Interestingly, this location coincides with the area within the cave that is usually least disturbed by flying bats, suggesting that air movements could also be a determining factor.

If food availability influenced the distribution of *N. farri* larvae most, an estimation of the numbers of flying insects that *N. farri* could catch if they did occur in other areas of the cave is required. Such estimates, derived from the relative trapping efficiencies of our thread and sheet adhesive traps, are given in Table 5. Assuming that our thread traps were as effective at catching insects as larval fishing lines, our results (Table 5) demonstrate that large larvae could collect up to 5 insects per day on average in chamber E, but their catch rates would drop to fewer than 1 insect per day on average elsewhere in the cave. *N. farri* larvae can probably survive on a few small insects per week because they reached maturity in the laboratory when provided with 1–2 Drosophila each per week. More than 80% of their potential food in Dromilly Cave were Scatopsidae, which are smaller (<2 mm in length) than Drosophila, so that the larvae would require proportionately more of the former.

Because apparently suitable sites for colonization did exist elsewhere in the cave where disturbance by bats was negligible, we suggest that the absence of *N. farri* elsewhere in the cave relates mainly to the chance of obtaining food, especially during the 1st stadium. *N. farri* larvae measured 3–4 mm in length when hatched in the laboratory and they formed webs with up to 7 fishing lines averaging ≈2 cm in length. These larvae survived for up to 10 d when not fed, although they were cannibalistic when kept together. The small total lengths of fishing lines produced by these larvae would reduce the likelihood of their catching flies to ≈30th of that of the larger larvae (Table 5). Furthermore, if the numbers of flying insects diminish near the walls throughout the cave as they do in chamber E, then 1st instars can be expected to catch ≈1 fly every day on average if they lived in chamber E, whereas in chamber C they would average <1 fly every 8 d and in chamber B they would average 1 fly every 55 d. We suggest that such low capture rates do not provide sufficient food for these larvae to survive.

Air movements created by flying bats probably also decrease the numbers of prey caught by *N. farri*, because their fishing lines stick together, tangle, and become less efficient at ensnaring prey in the slightest breeze. Additionally, the distribution of *N. farri* larvae could be affected by parasitism, predation, or both, perhaps preferentially hitting weak and starved larvae. A white fungus, similar in appearance to the fungus known to attack the New Zealand mycetophilid *A. luminosa* and to influence its distribution or density (Richards 1960; Pugsley 1980, 1984) is certainly present in Dromilly Cave.

We have no information on how *N. farri* selects oviposition sites in caves or how this might affect the distribution of their larvae. Adults were encountered rarely in Dromilly Cave and the only eggs we saw were laid on damp plaster of paris

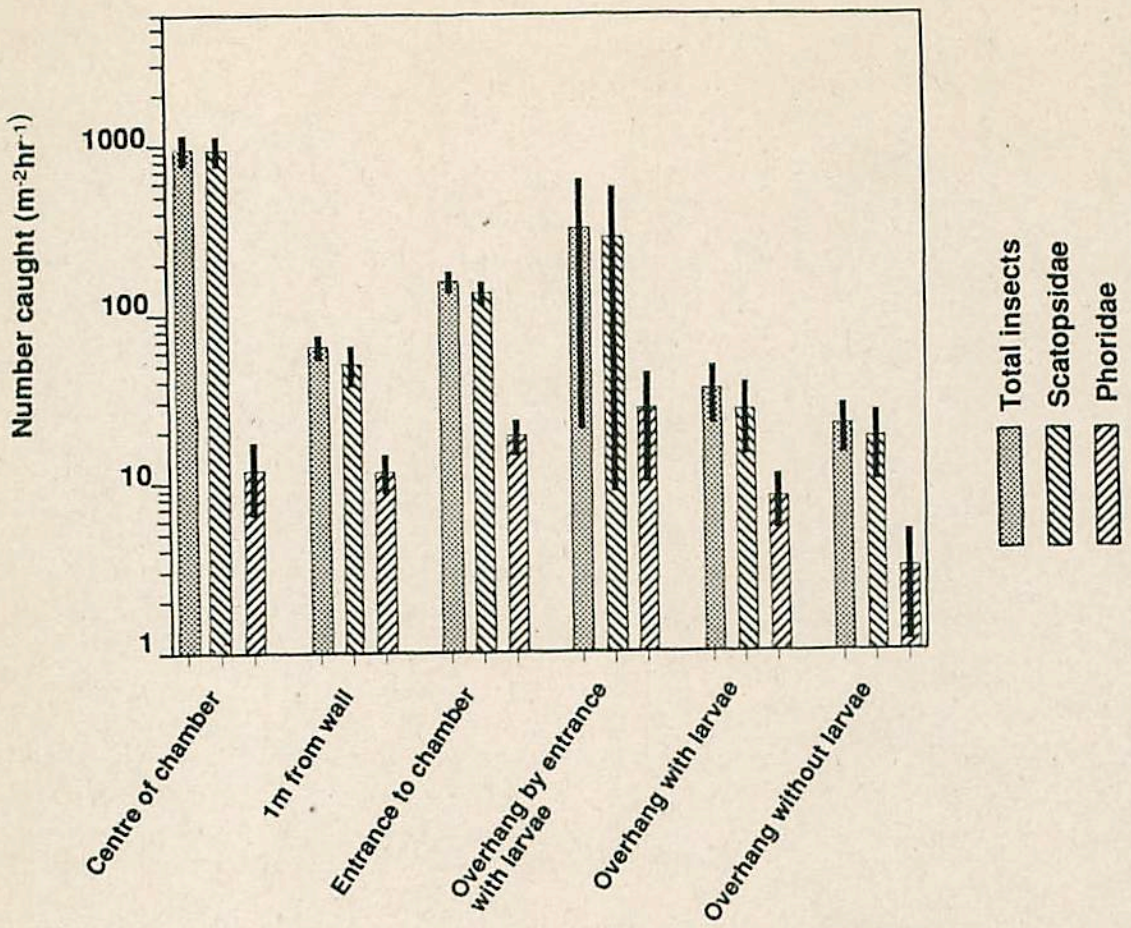

Fig. 5. Density of flying insects trapped in different regions of chamber E, Dromilly cave. Traps were set for 20 h from 1400 hours on 5 December 1992. Bars indicate ± 1 SE.

and damp filter paper by adults in the laboratory (unpublished data).

Regarding potential predators of *N. farri* in Dromilly Cave, the most obvious were cave crickets (*Uvaroviella cavicolla* Chopard), reddish brown cobweb spiders (Theridiidae), and whip-spiders (Amblypygi). The crickets and occasionally the amblypygids were seen within 0.5 m of *N. farri* webs, but none was ever observed among the webs. Predation, at least on larger larvae, seemed unlikely because most of the larvae sharing the same overhang were similar in size and, because they remained relatively large for some months before pupating, any appreciable reduction in their numbers would have been noticed.

Both cave crickets and whip-spiders were fast, strong, and agile arthropods that could destroy or damage the delicate *N. farri* webs by accident. However, these bigger species of cave arthropods preferred vertical surfaces rather than overhangs and, thus, tended to occupy a different niche. On the whole, the theridiid spiders, likewise, avoided overhangs and constructed their webs in more exposed sites.

Most of the families of flying insects trapped in Dromilly Cave were associated with bat guano (Peck 1975, 1992). Larvae of Scatopsidae, Milichiidae, and Phoridae generally live in decaying material or excrement (Borror et al. 1989) and the numbers of Scatopsidae and Milichiidae we caught in Dromilly Cave certainly appeared subjectively to be related both to the amount of fresh bat feces present and to the numbers of bats roosting nearby. Phoridae, however, were the most evenly distributed flies within Dromilly Cave but overall were less numerous than scatopsids and milichiids. A similar situation was reported in a Kentucky bat cave by Conn and Marshall (1991), who found that the phorid *Magaselia cavernicola* Brues was more uniformly dispersed between guano and detritus areas than 2 sphaerocerid flies.

In summary, this investigation showed that despite superficially similar lifestyles and methods of catching prey in the 2 mycetophilid species *A. luminosa* and *N. farri*, important differences exist with regard to the factors influencing distribution. Cave populations of *A. luminosa* live in bat-free caves and attract waterborne insect prey into their

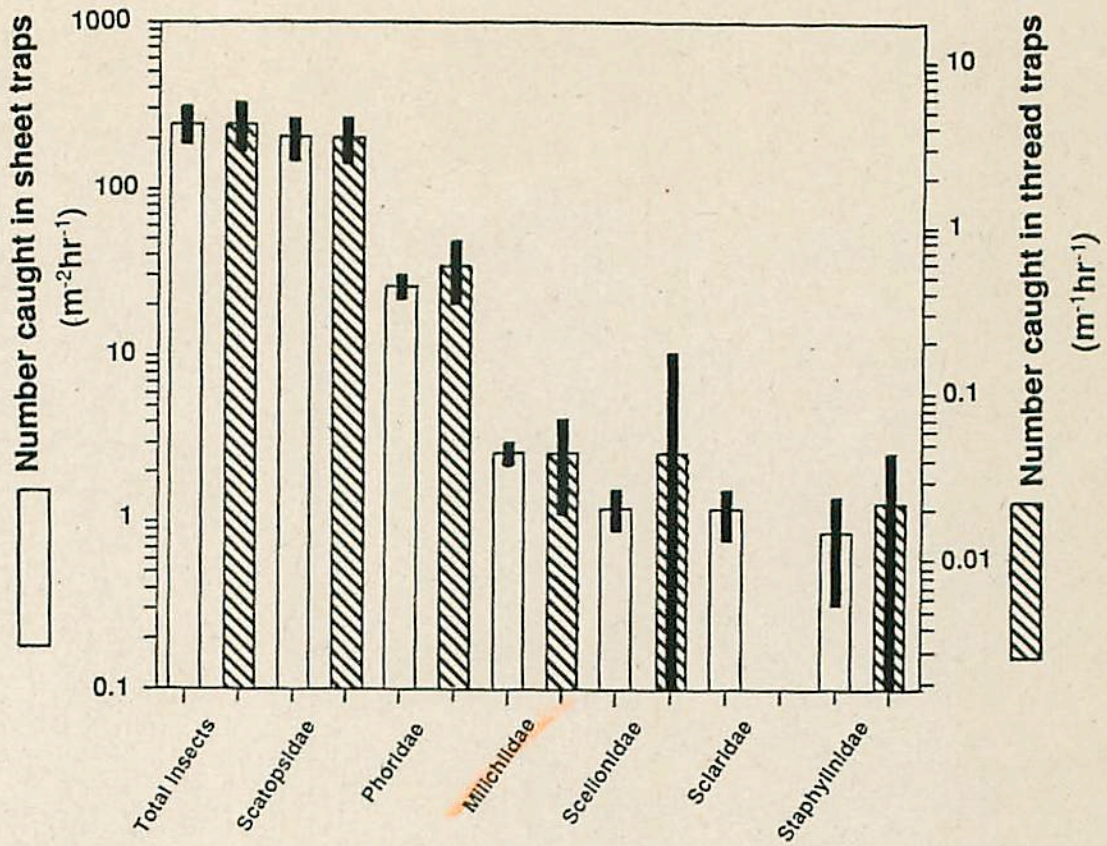

Fig. 6. Comparisons between numbers of flying insects trapped on sheet adhesive traps and thread adhesive traps in chamber E, Dromilly cave. Traps were set for 20 h from 1400 hours on 5 December 1992. Ordinate scales adjusted to equalize histogram heights of the total numbers of insects caught by both methods. Bars indicate ± 1 SE.

webs by light. Suitable overhangs above water, high humidity, and absence of fungal pathogens appear to be the most essential requirements for *A. luminosa* larvae to thrive. *N. farri*, however, coexists with large numbers of bats in tropical caves of high humidity and does not attract prey into its web by any means. To catch sufficient prey to survive, *N. farri* larvae have to colonize suitable overhangs near bat guano, but must avoid places where flying bats can disturb the webs. The distribution of *N. farri* larvae is thus governed primarily by the availability of food and absence of wind. Although for *A. luminosa* there is no evidence that younger individuals are more at risk from starvation, it appears that in *N. farri* especially the 1st instars are vulnerable (their few and short fishing lines, without the aid of bioluminescence, catch less than the traps of the older larvae). The question why bioluminescence did not arise in *N. farri* can, of course, not be answered with certainty, but the overall much greater abundance of flying insects in tropical caves inhabited by bats, seems to make attraction of prey by any means a much less essential requirement there than it does for occupants of bat-free (and, therefore, guanoless) caves of temperate regions.

Table 4. Dimensions of webs and fishing lines from *N. farri* larvae in Dromilly Cave

Variate	Mean ± SE	Range
Length of gallery, cm	15.3 ± 2.89	8.5– 30
No. fishing lines per web	17.0 ± 1.68	8 – 24
Length of fishing lines, cm	8.38 ± 0.45	0.5– 29
Total length of fishing line per web, cm	142 ± 17.3	65.5–213

Table 5. Estimated number of flies caught per day (mean ± SD) by *N. farri* larvae in different regions of Dromilly Cave

Chamber	Large larvae	Small larvae (5 cm of fishing line)	
	Center of chamber	Center of chamber	Chamber wall mean no. days per capture
A	16.9 ± 11.5	0.5 ± 0.34	25.1
B	7.6 ± 4.5	0.27 ± 0.13	54.9
C	55.2 ± 42.2	1.94 ± 1.30	7.6
D	37.1 ± 32.5	1.31 ± 1.04	11.3
E	377 ± 325	13.3 ± 11.5	1.1
F	5.9 ± 9.4	0.29 ± 0.32	51.1

Acknowledgments

We thank Pamela Clark, Michelle Samuels, Wayne Forbes (Zoology Department, University of the West Indies), and Hugh Wilson for help with field work, and David Lee for introducing us to the cave. Identifications were kindly done by E. I. Coher (Long Island University, Southhampton Campus) (Mycetophilidae), D. R. Davis (National Museum of Natural History, Smithsonian Institution, Washington, DC) (Tineidae), J. H. Frank (IFAS, The University of Florida) (Staphylinidae), and C. W. Sabrosky (Systematic Entomology Laboratory, USDA, Beltsville). We also thank R. Barker and E. A. Grant (Massey University, New Zealand) for statistical analyses and diagrams, respectively. Transport was provided by the Zoology Department, University of the West Indies.

References Cited

Borror, D. J., C. A. Triplehorn, and N. F. Johnson. 1989. An introduction to the study of insects, 6th ed. Saunders, Philadelphia.

Coher, E. I. 1996. Cave-associated tropical American *Neoditomyia* (Diptera: Mycetophilidae). Pan-Pac. Entomol. 72: 152–159.

Conn, D. B., and S. A. Marshall. 1991. Microdistribution of scavenging flies in relation to detritus and guano deposits in a Kentucky bat cave. Entomol. News 102: 127–129.

Craig, C. L., Okubo, A. L., and Andreasen, V. 1985. Effect of spider orb-web and insect oscillations on prey interception. J. Theor. Biol. 115: 201–211.

Fincham, A. G., G. Wadge, and G. Draper. 1977. Jamaica underground: a register of caves of Jamaica. Geological Society of Jamaica, Kingston.

Hudson, G. V. 1950. Fragments of New Zealand entomology. Furguson & Osborn, Wellington, N.Z.

Kermode, L. 1974. The New Zealand glowworm *Arachnocampa luminosa* a summary. N.Z. Speleol. Bull. 5: 313–328.

Lane, J., and H. Sturm. 1958. A new genus of "ditomyiinae". Description of two new species with bionomical notes (Diptera, Mycetophilidae). Rev. Brasil. Biol. 18: 199–207.

Matile, L. 1977. Un Keroplatinae cavernicole nouveau de Cuba (Diptera, Mycetophilidae), pp. 369–371. *In* T. Orghidan, A. Núñez Jiménez, V. Decou, Şt. Negrea, and N. V. Bayés. [eds.], Résultats des expéditions biospeologiques Cubano-Roumaines á Cuba, vol 2. Academiei Republicii Socialiste România, Bucharest.

Peck, S. B. 1975. The invertebrate fauna of tropical American caves, Part III: Jamaica, an introduction. Int. J. Speleol. 7: 303–326.

1992. A synopsis of the invertebrate cave fauna of Jamaica. Nat. Speleol. Soc. Bull. 54: 37–60.

Peck, S. B. and D. R. Russell. 1976. Life history of the fungus gnat *Macrocera nobilis* in American caves (Diptera: Mycetophilidae). Can. Entomol. 108: 1235–1241.

Pugsley, C. W. 1980. Ecology of the New Zealand glowworm *Arachnocampa luminosa* (Skuse) (Diptera: Mycetophilidae) in tourist caves at Waitomo. Ph.D. dissertation, University of Auckland, Auckland, N.Z.

1983. Literature review of the New Zealand glowworm *Arachnocampa luminosa* (Diptera: Keroplatidae) and related cave-dwelling Diptera. N.Z. Entomol. 7: 419–424.

1984. Ecology of the New Zealand glowworm, *Arachnocampa luminosa* (Diptera: Keroplatidae), in the Glowworm Cave, Waitomo. J. R. Soc. N.Z. 14: 387–407.

Richards, A. M. 1960. Observations on the New Zealand glow-worm *Arachnocampa luminosa* (Skuse) 1890. Trans. R. Soc. N. Z. 88: 559–574.

1964. The New Zealand glowworm. Stud. Speleol. 1: 38–41.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, 2nd ed. Charles Griffin, London.

Sivinski, J. 1982. Prey attraction by luminous larvae of the fungus gnat *Orfelia fultoni*.
Ecol. Entomol. 7: 443–446.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry, 2nd ed. Freeman, New York.

Speleoclub SC33. 1993. 1993 Jamaica expedition. Speleoclub SC33, Heule, Belgium.

Stringer, I.A.N., and V. B. Meyer-Rochow. 1993. Fishing in the dark: the unusual habits of a Jamaican fly. Jam. Nat. 3: 17–18.

1994. Attraction of flying insects to light of different wavelengths in a Jamaican cave. Mem. Biospeol. 21: 133–139.

Sturm, H. 1973. Fanggespinste und Verhalten der Larven von *Neoditomyia andina* und *N. colombiana* Lane (Diptera, Mycetophilidae). Zool. Anz. 191: 61–86.

Vandel, A. 1965. Biospeleology: the biology of cavernicolous animals. B. E. Freeman, translator. Pergamon, Oxford.

Received for publication 17 October 1995; accepted 23 July 1996.