Ingestion of sooty mould fungi by some New Zealand stream insects

K. J. COLLIER*
Zoology Department, University of Canterbury, Private Bag, Christchurch, New Zealand

ABSTRACT

Ingestion of sooty mould fungi by freshwater stream insects is reported for the first time from New Zealand. Sooty moulds comprised 2-11% (with one outlier of 65%) and 39-72% of gut contents in the stoneflies *Austroperla cyrene* and *Zelandobius confusus*, respectively, from 2 South Westland streams. The high relative abundance of sooty moulds in the guts of some aquatic insects suggests that they could be an important food resource in streams where riparian vegetation is heavily infested with these fungi.

Keywords: sooty moulds, Metacapnodiaceae, Euantennariaceae, stream insects, gut contents, Westland, New Zealand.

INTRODUCTION

In parts of New Zealand, particularly the South Island, many trees are infested by sooty mould fungi of the families Euantennariaceae and Metacapnodiaceae (Hughes 1972). More than 5 species can grow together in apparent harmony, and often form characteristic black wefts (up to 20 mm deep) on the trunks, branches, leaves and twigs of infested trees (Crozier 1981; Wardle 1984). Sooty moulds are not parasitic on trees, but obtain their nutrition from honeydew secreted by the scale insects *Inglisia fagi* Maskell and *Ultracoelostoma assimile* (Maskell) (Wardle 1984; Morales *et al.* 1988). The latter species infests mainly black beech (*Nothofagus solandri solandri* (Hook f.) Oerst.) and mountain beech (*N. solandri cliffortioides* (Hook f.) Poole) in Canterbury and parts of Westland and Nelson (Gaze & Clout 1983), although sooty moulds are also found on other tree species (Wardle 1984; pers. obs.).

This paper reports the discovery of sooty mould fungi in the guts of 2 stonefly species, *Austroperla cyrene* (Newman) and *Zelandobius confusus* (Hare), found during a study of insect ingestion patterns in acid and alkaline streams of South Westland (see Collier 1988). In addition, the paper includes information from M. J. Winterbourn, University of Canterbury, on the incidence of sooty moulds in the guts of other stream insects.

Study area

Larvae whose guts were examined were taken from 2 lowland (80-95 m asl), brownwater streams (Steep Creek and Suspect Stream) in the Okarito region of South Westland. Both sites drain infertile "Pakihi" wetland before passing through mixed podocarp forest which is infested with sooty mould fungi. Riparian vegetation at the Steep Creek sampling site (NZMS1 S71 870896) is mainly kamahi (*Weinmannia racemosa* Linn. f.), rimu (*Dacrydium cupressinum* Lamb.) and the ferns *Cyathea smithii* Hook. f. and *Blechnum discolor* (Forst. f.) Keys. The last species, manuka (*Leptospermum scoparium* J.R. et G. Forst) and juvenile Hall's totara (*Podocarpus hallii* Kirk) predominate at the Suspect Stream site (NZMS1 S71 864902).

Channel width and gradient averaged 2.4 m and 1-2°, respectively, in both sampling reaches. Annual water temperature ranges were 5-14°C in Steep Creek and 4-17°C in Suspect Stream. Details of physical characteristics, water chemistry and benthic invertebrate populations of these sites are given by Collier & Winterbourn (1987).

* Present address: Department of Conservation, P.O. Box 10-420, Wellington, New Zealand.

METHODS

Benthic invertebrates were collected in November 1986 and May 1987 by agitating the benthos in front of a triangular net (0.8 mm mesh). Samples were preserved immediately in 10% formalin, and later, larvae of the stoneflies A. *cyrene,* Z. *confusus* and *Stenoperla maclellani* Zwick, and the mayflies *Deleatidium* spp. were picked out for gut content analyses. No larvae of *A. cyrene* were collected in May and no Z. *confusus* larvae were taken in November from Suspect Stream.

Sizes (body lengths for *A. cyrene;* head widths for all other taxa) oflarvae were measured with a calibrated eye-piece graticule and guts were excised from up to 10 larvae of similar size from each site. Contents of mid guts and/or foreguts (dependent on number of larvae and degree of gut fullness) were pooled, dispersed for 45-60 seconds with a Mettler electronic ultrasonic cleaner and filtered on to a membrane filter (0.45 μm). Filters containing gut contents were mounted on slides in lactophenol-PV A stained with lignin pink and dried at 37 °C for 5 weeks before examination.

Filters mounted on slides were viewed at 400 × magnification with a Wild Heerbrugg M20 phase-contrast microscope fitted with a grid eyepiece. On each slide, 20-30 randomly selected fields were viewed and items cut by 10 cross hairs on a transect were recorded. The proportion of sooty moulds present was expressed as a percentage of total food items cut by cross hairs in all fields of view combined.

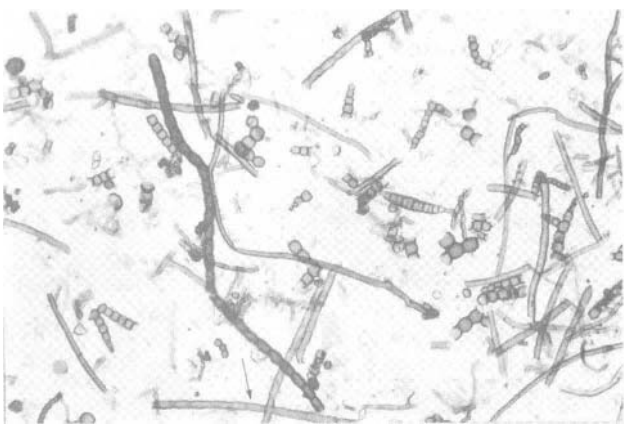

Fig. 1: Photograph (100 × mag.) of sooty mould fungi in pooled gut contents of *Zelandobius confusus* larvae collected from Suspect Stream in May 1987. Arrow indicates an aquatic hyphomycete.

RESULTS AND DISCUSSION

Sooty mould fungi (see Fig. 1) comprised 39-72% of total gut contents of Z. *confusus* larvae and 2-11 % (with one outlier of 65 %) of gut contents of *A. cyrene* larvae (Table 1). Sooty moulds were not found in guts of *Deleatidium* spp. or S. *maclellani.* Although high relative abundance of an item in the digestive tract does not prove its nutritional importance, it does implicate it as a major component of the diet and gives clues to important feeding sites of different taxa.

The potential importance of sooty mould fungi in the diets of some stream insects is supported by observations of M. J. Winterbourn, University of Canterbury (pers. comm.), who has noted their frequent occurrence in the guts of several species of stonefly and mayfly larvae collected from streams in the Maimai Experimental Area, North Westland (Table 2). Overall, sooty moulds were most frequently seen in guts of Z. *confusus* (present in 71 % of larvae examined), followed by *Zephlebia* sp. (59% of larvae), and *Stenoperla prasina* (Newman), *Spaniocerca zelandica* Tillyard and *Ameletopsis perscitus* (Eaton) (33-38% of larvae; Table 2). In contrast to my findings in the South Westland streams, Winterbourn also found sooty moulds in the guts of *Deleatidium* sp.

Zealandobius confusus and *A. cyrene* larvae are nominally collector-browsers (Winterbourn *et al.*. 1984; Winterbourn & Rounick 1985) but can also be opportunistic shredders (Cowie 1980; Winterbourn 1982). They may have ingested sooty mould fungi from woody debris

Table 1: Sizes of larvae (head widths, *Zelandobius confusus*; body lengths, *Austroperla cyrene*) used for gut content analyses, the number of larvae dissected, the number of food items counted, and the relative abundance of sooty mould fungi (as a proportion of total pooled gut contents). N, November 1986; M, May 1987. —, not applicable.

		Size (mm)	No. of larvae	No. of food items	% sooty moulds
Steep Creek:					
Zelandobius confusus	N	0.9-1.3	10	273	39
	M	0.8-1.1	10	220	52
Austroperla cyrene	N	8.5-11.2	4	217	2
	M	4.8-7.0	2	254	11
Suspect Stream:					
Zelandobius confusus	N	—	0	0	—
	M	0.9-1.0	10	247	72
Austroperla cyrene	N	11.5	1	245	65
	M	—	0	0	—

Table 2: Number and percentage of guts containing sooty moulds for insect larvae collected from site 215 (November 1981, April, January, September and November 1982) and sites 205 and 208 (September 1982) of the Maimai Experimental Area, North Westland (M. J. Winterbourn pers. comm.). A description of these sites is given in Winterbourn (1986).

Taxon	Number of larvae examined	Number of guts with sooty moulds	Percent with sooty moulds
Plecoptera			
Zelandobius confusus	21	15	71
Stenoperla prasina	34	13	38
Spaniocerca zelandica	22	8	36
Ephemeroptera			
Zephlebia sp.	27	16	59
Deleatidium sp.	46	9	20
Ameletopsis perscitus	6	2	33
Trichoptera			
Hydrobiosella sp.	12	0	0
Triplectides sp.	11	0	0
Oeconesus sp.	5	0	0

trapped in channels or in association with leaf litter that had fallen or been blown into the South Westland streams. Alternatively, fragments of sooty mould may have been ingested as detritus deposited between stones or on stream margins where water movement was slow. Interestingly, Winterbourn (see Table 2) did not find sooty moulds in the guts of an obligate shredder, *Triplectides* sp., in the North Westland streams. This, and the occurrence of sooty moulds in the guts of fine particle feeders such as *Deleatidium* sp. and *S. zelandica*, suggests that detritus may have been a major source of these fungi in the Maimai streams.

Crozier (1981) found that densities of the scale insect *U. assimile* (and by implication degree of sooty mould infestation) in the South Island were lower at higher altitudes and were greater on trees more exposed to high intensity sunlight, such as those on stream banks. Thus, many lowland streams and rivers are likely to receive inputs of sooty mould fungi from leaves and branches that fall into channels from infested trees. Where riparian forest has been removed, these inputs would be considerably reduced and sooty moulds are rarely found in guts of aquatic insects (Winterbourn pers. comm.).

The role of terrestrial leaf microbes in the nutrition of detritivorous stream invertebrates has received little attention, although their presence on decaying litter has been noted

by some workers (e.g. Barlocher & Kendrick 1974). However, their potential nutritional importance is implicated by the fact that aquatic microbes (especially Hyphomycetes) can contain 2-4 times more nourishment than the leaf tissue itself (Barlocher 1985). The high relative abundance and frequent occurrence of sooty moulds in the guts of some stream insects (especially *Z. confusus*) suggests that these fungi could be an important food resource in many forested lowland South Island streams.

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