ARCTOSEIUS CETRATUS (SELLNICK) (ACARINA : ASCIDAE) PHORETIC ON MUSHROOM SCIARID FLIES

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Associations with invertebrates are frequent among ascid mites (LINDQUIST and EVANS, 1965 ; LINDQUIST, 1970). Thus the genus *Proctolaelaps* includes species which prey on the eggs and larvae of insects, on mites and on nematodes (LINDQUIST and HUNTER, 1965). Phoretic relationships between species of *Proctolaelaps* and *Blattisocius* and moths have been observed by TREAT (1969) and between *Hoploseius* and microdrosophilids, associated with polyporus fungi, by LINDQUIST (1970).

Mites found preying on the eggs of the mushroom sciarid *Lycoriella auripila* Winn. (Diptera : Lycoriidae) during laboratory experiments were identified as *Arctoseius cetratus* (Sellnick) [Mesostigmata : Ascidae]. Examination of *L. auripila* showed that the female mite was often carried by female sciarids.

In general the biology of the Arctoseiinae is unknown beyond what may be inferred from their anatomy (LINDQUIST and EVANS, 1965) and their distribution. Phoretic relationships have not been suspected in this, the least specialised of ascid subfamilies, and obvious adaptations, for example, for host-finding or attachment, are not exhibited in *Arctoseius* spp.

Observations were made on phoresy and on the feeding of *A. cetratus*. Details of these and information on the ecology of mite and host are brought together.

THE HOST INSECT

Phoresy was initially observed in a chamber in which trays of unspawned mushroom compost were maintained for sciarid rearing. No attempt was made to relate the presence of mites or flies to the ageing of the compost, though it appeared that sciarids were associated with an earlier stage of organic decay than were collembola or oligochaetes. Large numbers of scatopsid flies (*Scatopse fuscipes* Mg., Diptera : Scatopsidae) developed alongside the sciarids though none of the adults was found to carry *A. cetratus*.

While a major pest of the cultivated mushroom (*Agaricus bisporus*) (HUSSEY and GURNEY, 1968), the occurrence of *L. auripila* away from mushroom houses is virtually unknown. As with many species of mycetophilid, larvae may be associated with the sporophore but this is of less economic consequence than damage caused by fouling of the compost and destruction of mushroom primordia (THOMAS, 1942). Larvae feeding in the compost may eat mycelium only incidentally and some evidence suggests that sciarid infestation is deterred by growing myce-

lium (HUSSEY and GURNEY, 1968). Thus, larvae can be reared on crushed oat or soya bean mixed with acid peat or filter paper pulp (BINNS, 1973) or, less reliably, on unspawned compost partially sterilised by heat (HUSSEY and GURNEY, 1968). *L. auripila* was also reared from 10-day old « light stable manure » exposed in grassland ; other species preferred a slightly older or fresher material (HUSSEY and WYATT, 1958). Though all these materials were free from mushroom mycelium, it cannot be assumed that other microorganisms, some of which may be required for sciarid colonisation, were absent.

ASSOCIATION BETWEEN *Arctoseius* AND *Lycoriella*

Sciarid flies, from the walls of a dark chamber containing trays (6ft²) of compost, were collected in glass vials and placed in a refrigerator at - 7°C. Phoretic mites could then be examined *in situ* without loss. In a one month period, over 500 female *L. auripila* were examined, in batches of about 25 flies, of which 25 per cent carried mites. Counts of mites per fly were made for 370 flies of which 97 carried 192 mites with a maximum of six per fly. The numerical distribution of mite attachments within the fly population (Table 1) was consistent with an adaptation for mite dispersion (KARG, 1967). Thus a better fit of the probabilities of the numbers of mites per fly is given by a « clumped » or negative binomial than by a Poisson distribution (KENDALL and STUART, 1958). The greater number of mites found in pairs (60 mites) than as single individuals (44) therefore suggests that some flies were more « susceptible » than others, possibly as a result of exposure to locally high populations of the mite. Phoresy may thus result in dispersion away from areas of high mite density.

TABLE 1. — Distribution of attachments of *Arctoseius cetratus* in a population of female *Lycoriella auripila*.

	Number of mites attached per fly (score)						
	0	1	2	3	4	5	6
Flies per score (totals)..	273	44	30	11	7	3	2
Experimental probability.	0.739	0.119	0.081	0.030	0.019	0.008	0.005
Fitted negative binomial.....	0.711	0.169	0.066	0.029	0.013	0.006	0.003
Fitted Poisson	0.595	0.309	0.080	0.014	0.002	0.000	0.000

Non-randon distribution of mites was even more striking among flies taken from a mushroom cropping house. Of 472 female *L. auripila* examined over 2 days, 37 (8 per cent) carried mites ; 10 having one mite only, 10 between two and four mites, and six between 10 and 26 mites each. Four male sciarids, taken at the same time, each carried a single mite attached in the typical position (see below) though none of the 250 males from the chamber population examined previously carried mites. All mites identified were adult females.

In the typical orientation, Fig. 1, the sagittal planes of the phoretic mite and its host intersected at right angles. The idiosoma occupied the pleural region of the host abdomen which, depending on its degree of distention, was thrown into longitudinal folds. The gnathosoma, which was more or less retracted in frozen specimens, usually lay immediately below the lateral margin of the tergal plates. In some cases however, a slightly more dorsal position was chosen,

the gnathosoma then lying between adjacent tergites. Single individuals attached at the anterior of the abdomen, where the pleural folds persist in all but the most gravid female flies, and additional mites were closely juxtaposed in successively posterior positions up to a maximum of about 10 mites on either side. Bilaterally symmetrical arrangements predominated, as may be inferred from a preference for the anterior position, but some irregular and asymmetrical arrangements were also found. Thus, at high numbers of mite per fly, partial double lateral ranks were found and attachments to the anterior venter of the abdomen also occurred. The disposition of the mite with respect of the soft, unsclerotised portions of the host abdomen was constant, however, and suggested that the mouth-parts were involved in attachment. Thus, while the legs were easily dislodged (leg I is strongly arched and not attached) and float free if the host is immersed, the gnathosoma remained firmly attached. Examination of specimens, previously frozen and stored in 70 per cent alcohol, under stereoscopic magnification (× 100), confirmed that mites attached to the pleural integument by their chelicerae. Due to its small and slender build, the male sciarid presents a more limited area of soft cuticle for attachment which may thus restrict the number of such associations.

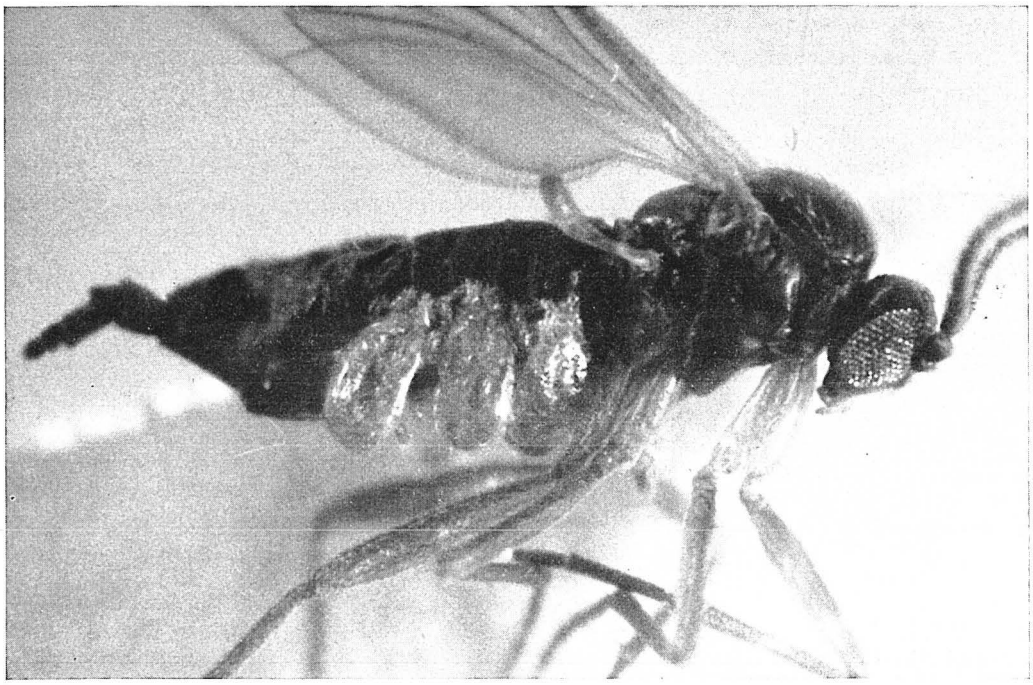

FIG. 1. — *Arctoseius cetratus* attached in lateral row to pleural integument of female *Lycoriella auripila*. (Frozen specimen)

Some individuals rapidly resumed full mobility and left the host ; for example, in response to carbon dioxide (though they did so less readily than did other mite species (see below)). Without such treatment they were not easily detached and, as indicated by their « clumped » distribution (Table 1), there appeared to be little interchange of mites between active sciarids. Thus, confining flies together in tubes rarely resulted in free mites and non-random distributions persisted despite shaking and jostling (cf. KILLINGTON and BATHE, 1946). It therefore appears probable that attachment occurs at a teneral stage of development ; pupation of the host being completed at the compost surface (THOMAS, 1942). The observed maximum of 26 mites on

one fly did not appear to impede the host nor, since apparently identical flies carried divergent numbers of mites, was there any obvious link between the presence of mites and host condition. In only two cases, where the point of attachment was surrounded by a coagulated exudate, was the host cuticle obviously penetrated. One mite was attached to a particularly swollen sciarid, the other showed an abnormal distension of the idiosoma which usually occurred after a period of feeding following detachment. Another sciarid carried 10 mites, each of which bore a considerable amount of semi-solid material in the anal region. The orientation of this group of mites was atypical since they were clustered upon each other and may have interfered with elimination of excreta, though the exact nature of the material was uncertain. Otherwise, no evidence was obtained of feeding on the host. Although the pleura were sometimes abraded by the chelicerae, no exudate appeared when the host abdomen was pressed after dislodging mites, so that predation during attachment is probably exceptional.

Feeding and distribution of *Arctoseius*

Arctoseiids are the predominant Mesostigmata in Alaskan tundra, both absolutely and in variety of species (Lindquist, 1961). In soil, they live mainly at the surface but may penetrate deeper layers (Evans, Sheals and Macfarlane, 1961). *Arctoseius cetratus* occurs widely in a variety of situations in the U. S. A. (Lindquist, 1961) and was described as « not scarce » in compost, turf, *Calluna* and *Sphagnum* (Berhnard, 1963). Karg (1961) found it plentiful in arable and grassland soils. It is sometimes numerous in mushroom houses (N. W. Hussey, personal communication) and small numbers were extracted from compost during these observations.

Lindquist (1961) referred to the association of *Arctoseius* with other mites and collembola but his extractions revealed no clear relationships. However, feeding experiments, in which the following soil organisms were offered to *A. cetratus*, showed its prey to include larvae and nymphs of smaller collembola (*Folsomia*) and oribatids. Nematodes and sciarid larvae were apparently not taken (Karg, 1961).

Mites, removed from flies after CO_2 anaesthetization, fed almost immediately on sciarid eggs and soon became distended. During penetration, which was virtually instantaneous in some cases, the palps were laid over the eggs while the extended chelicerae were applied. Withdrawal of the contents was assisted by a scissor-like, grasping movement of the chelicerae working as a pair or alternately. Once an egg was located, feeding behaviour continued, in some cases, for 10 min or more. Exceptionally, the egg, which measures 0.7 × 0.3 mm, was completely evacuated at a single feeding. Mites, apparently in search of suitable feeding places, were frequently seen carrying whole eggs or a partially collapsed chorion beneath the palps.

Adult mites were also seen to feed on first instar larvae of *L. auripila*, on the eggs and first instar larvae of *Drosophila melonagaster* (Diptera : Drosophilidae), small larvae of *Heteropeza pygmaea* (Diptera : Cecidomyiidae) and small nematodes collected from decaying organic matter and cultured over, moist sand. Of the organisms tested, only eggs of the housefly *Musca domestica* (Diptera : Muscidea)were not accepted. The remains of adults sciarid flies were often found to harbour numbers of larval *A. cetratus* sufficient to suggest saprobic activity. Unpublished observations of B. Gurney (personal communication, 1966) showed that predation by *A. cetratus* limited populations of *Tarsonemus myceliophagus* Hussey (Acarina : Tarsonemidae) feeding on mushroom mycelium on agar plates.

Laboratory rearing met with limited success. Larvae were numerous within 48 h when female mites, taken from flies, were fed on nematodes or when flies bearing mites were caged

over moist, acid peat on which the flies laid their eggs. A small second generation was reared when suchl arvae, confined over moist plaster of Paris, were given peat bearing sciarid eggs (BINNS, 1973). Cultures tended to decline however, not least because of the mites' voracious appetite. The only male seen was produced in the laboratory and perhaps indicated sub-optimal conditions. Similarly, while phoretic mites were invariably non-gravid, a female taken from a culture contained a welldeveloped egg. Otherwise no eggs were seen.

OTHER MITE-SCIARID ASSOCIATIONS

A stereotyped pattern of attachment, as in *A. cetratus*, which is thought to indicate host-specific or *stenoxenic* associations (TREAT, 1969), was less evident in two other mite species found associating with *L. auripila*. Thus compost samples containing 1-200 deutonymphs of *Digamasellus* (fallax Leitner) [Mesostigmata : Digmasellidae] per 20 g, produced sciarids of both

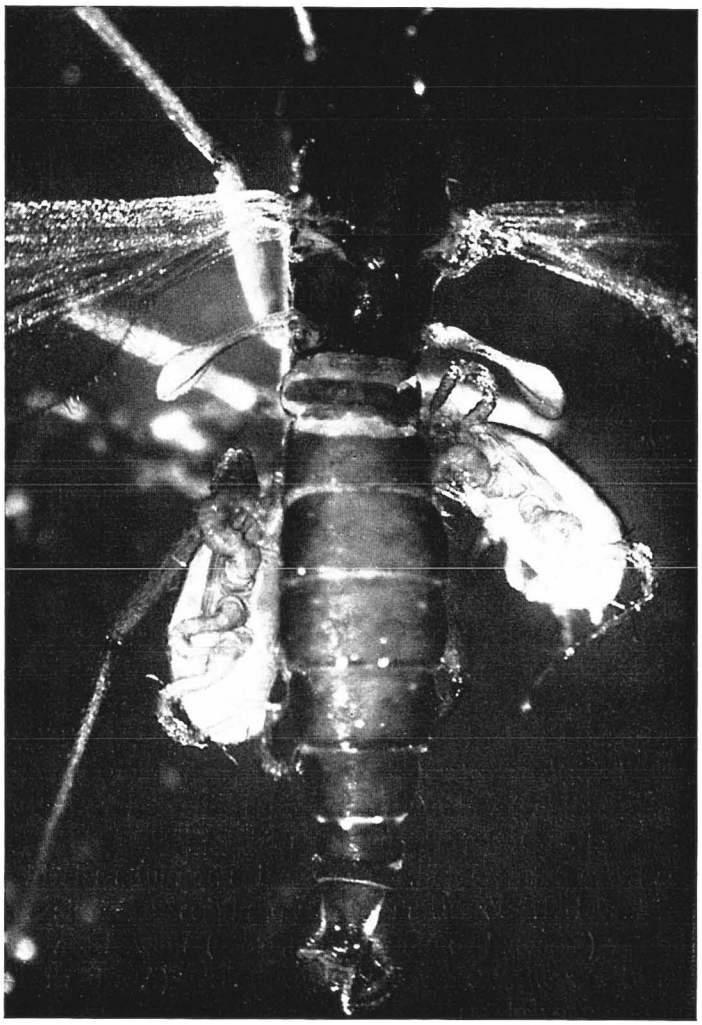

FIG. 2. — *Gamasodes spiniger* attached to pleural integument of male *Lycoriella auripila* showing strong arching of leg II of mite. (Frozen specimens under alcohol).

sexes carrying large numbers of nymphs clustered at random round the anterior abdomen. LINDQUIST (1970) considered *Digamasellus* spp. to be habitat -, rather than host - specific in relation to associations with bark-beetles.

Similarly, the large deutonymphs of *Gamasodes spiniger* (Tragd.) [Mesostigmata : Parasitidae], up to three of which were found straddling the abdomen of male and female sciarids, did not show a characteristic site of attachment. Phoresy has not been previously recorded in the deutonymph of this mite though leg II is greatly enlarged and spurred, apparently for grasping the host. Examination of frozen specimens or after anaesthetizing the host suggested that the legs are subsidiary to the chelicerae in attachment to sciarids, Fig. 2. Again the soft pleural regions was often chosen for attachment though mites on the dorsal surface held the edges of the tergites. Mites of this species were readily detached and it seemed possible that the legs are adapted for mounting a mobile host. Deutonymphs of *G. spiniger* were also found attached to scatopsid flies of either sex (*Scatopse fuscipes* Mg.) (See page 350).

DISCUSSION

Since little is known of the biology of either *Arctoseius cetratus* or *Lycoriella auripila*, the discovery of a phoretic relationship is of potential significance in understanding the ecology of each species.

Observations relating to mushroom culture suggest that the larvae of *L. auripila* initiate the saprozoic breakdown of some organic materials, as do other sciarids, for example, those known to occur in the F and H layers of woodland soils (BRAUNS, 1954), and thus invite association with an edaphic mite such as *A. cetratus*. However, KARG (1967), suggested that, in general, phoresy assisted dispersion between discrete, transient habitats (e.g. dung), and was largely superfluous in stable, uniform environments (e.g. soil or litter) where food is in constant supply. The evidence presented here suggests that, while the host favours unstable habitats of the former type, *A. cetratus* occurs more widely (BERHNARD, 1963 : KARG, 1961). Despite a lack of obvious structural modification for phoresy, behavioural adaptation, as described here, is strongly evident in *A. cetratus* and suggests that dispersion by sciarids is a usual process in this mite.

Thus, while comparison with closely allied species of mite is not possible, the choice made by *A. cetratus* in respect of host species and sex, as well as its site and frequency of attachment (Table 1), contrasts with more « casual » mite-insect associations described, for example, by TREAT (1969) and KILLINGTON and BATHE (1946). The associations between the deutonymphs of *Digamsellus* and *Gamasodes* and sciarids, described earlier, are possibly of the « casual » type.

In addition to their role of feeding, the mouthparts play a major role in the attachment of *A. cetratus* to its host and cheliceral dentition requires consideration in this connection. It seems likely that a limited number of well-developed opposable teeth, as in *Arctoseius*, is advantageous both for grasping the host and for chewing (EVANS, SHEALS and MACFARLANE, 1961).

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SUMMARY

A well-developed phoretic association between the adult female of *Arctoseius cetratus* (SELLNICK) [Acarina : Ascidae] and female of *Lycoriella auripila* Winn. [Diptera : Lycoriidae] is described. The mite was also seen to prey on eggs and larvae of insects, including those of the host, and on nematodes. Ecological information on mite and host is examined in relation to these findings.

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