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6.9 SOME ASPECTS OF FEEDING AND DIGESTION IN THE SOIL PREDATORY MITE *PERGAMASUS LONGICORNIS* (Berlese) (Parasitidae: Mesostigmata)

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INTRODUCTION

Pergamasids are some of the largest, and fastest moving, mesostigmatid mites inhabiting temperate forest leaf litter, meadow soils, and the upper reaches of both salt marshes and sea shore (Frager 1968, Halbert 1920, Kühnelt 1961, Luxton 1966a, b, 1967a, b). With *Veigaia* species, they are the major hemiedaphic carnivores, preying on a diverse range of microarthropods including collembola (Hurlbutt 1958, Sheals 1956a, b, 1957, Wallwork 1970), enchytraeids (Witalinski 1971), soil nematodes and other mesostigmatids (van de Bund 1972). Their size and enormous gluttony compensate for their only moderate density in determining their importance in the soil community (van de Drift 1951). They are probably *K*-type strategists (Krantz & Lindquist 1979). A common and widespread example in Britain is *Pergamasus longicornis* (Berlese) (Parasitidae)(Bhattacharyya 1962, 1963, Davis 1969, Turk 1953). In intermittently studying the feeding and digestion of this mite over the last five years, many new facts have emerged. This paper gives a first report on some of these.

FEEDING MECHANISM

Prey are quickly ruptured soon after the initial attack by the predator, and a large clear droplet of fluid immediately envelopes the prey in between the mite's two palps and hypostome, A substantial part of this liquid originates from the haemolymph of the prey. Whenever possible the prey is lifted completely off the substrate and held by the chelicerae within this droplet. The first pair of legs play no part in the actual feeding and are held high away, constantly waving like insect antennae. This first phase of feeding is characterized by the relatively slow, alternate deep insertion and retraction of the cheliceral chelae into the prey rending its tissues. The fluid droplet often possesses a rapidly pulsating meniscus. Occasionally, the prey tissues are 'ballooned-out' by a wash of clear fluid emanating from within the mite's gnathosomal area. This liquid cannot be regurgitated from the gut, as the mite's oesophagus protrudes papilla-like into its mid-gut where it is surrounded by many epithelial cells which act as a one-way valve. Extensive salivary glands (with at least five different cytological types) are present in the mite's anterior podosoma. Perhaps these secrete a copious watery saliva as described in ixodid ticks by Needham & Sauer (1975). The latter might contain digestive enzymes for extra-corporeal digestion, as only liquid material is ever found within this mite's gut. Over a period, this gnathosomal reservoir of fluid slowly vanishes and the prey volume is substantially reduced.

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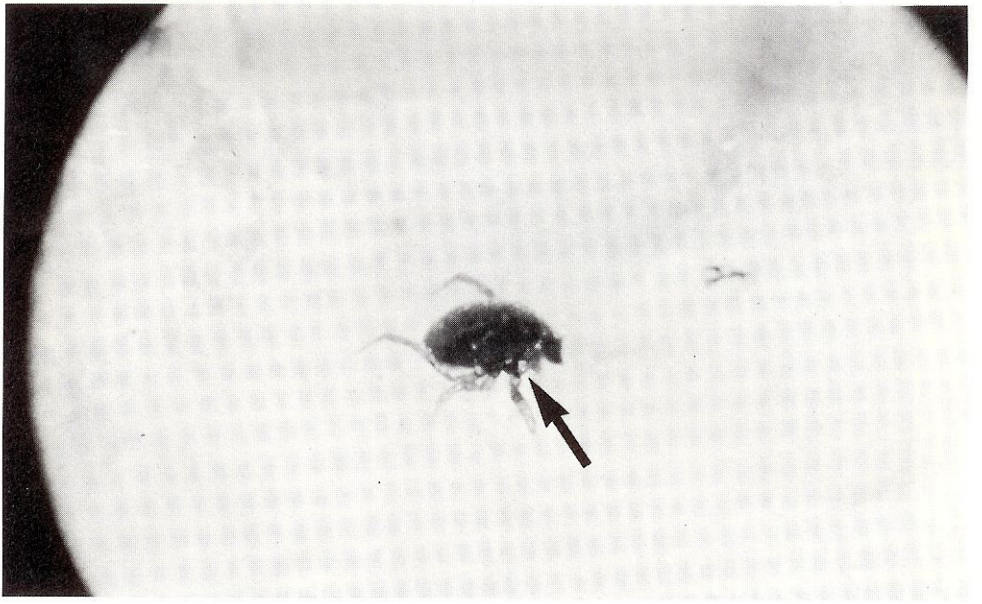

Figs. 1–3 – Growth of a coxal droplet (arrowed) during the course of feeding on a *Drosophila melanogaster* larva.

During the next phase of feeding, small fragments of prey tissue are manoeuvred into the region above the labrum by rapid, short, masticating bites of the chelicerae. Concommitantly, when feeding on large prey, clear fluid ('coxal') droplets slowly appear and grow in the region of the venter of coxae I (Figs. 1–3). These may form on either side, independently or together, and are variable in both their size and the time taken for them to be formed. Short, retractile, pumping actions of the whole gnathosoma often occur at this time. During this second phase of feeding, mites frequently dab their anal region on to the substrate and deposit small clear droplets of fluid containing a white granular material. This closely resembles the excretory guanine present in acarine Malpighian tubules. Feeding is terminated much later with the discard of the crushed cuticle of the sucked-out prey.

COXAL DROPLETS

Coxal droplets are removed by two mechanisms. More rarely, if the coxal droplet grows so large that it reaches up and over the peritreme, feeding temporarily stops. The droplet is manoeuvred by small leg movements on to the dorsal area of coxae II, the whole idiosoma is tilted sideways, and the drop is deposited on to the substrate, where it quickly flows away. Feeding then re-commences. Commonly however, on other occasions, feeding temporarily stops, and without any visible leg or cheliceral movements, the droplet quickly vanishes (within 1–2 s) and feeding recommences. Fluctuations in either the labrum or the pharynx (it is not clear which) are visible inside the gnathosoma ventrally when the droplet vanishes, suggesting that the liquid is being imbibed. No material was ever seen to flow down any of the mite's legs. Alternatively, as such coxal droplets have a high surface area to volume ratio, they could simply be quickly evaporating away once their production was halted. However, this seems unlikely since the feeding chamber's atmosphere was kept at saturation point constantly.

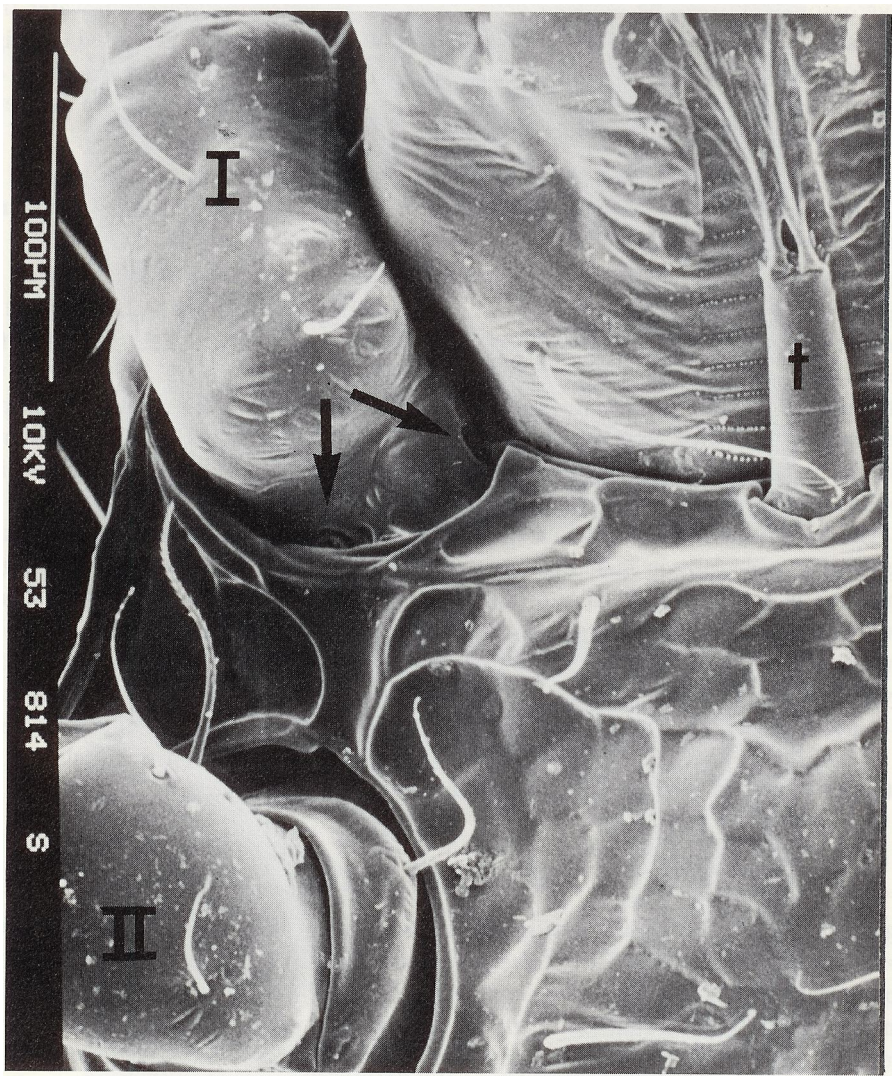

Fig. 4 - Glandular openings (arrowed) on the venter of coxa I. t = tritosternum.

'Coxal glands' are present in the venterolateral regions of the propodosoma in this mite. These debouch via chitinized ducts into the coxal articulations of leg I (Fig. 4). At least two tubular openings are present.

Three origins for these coxal droplets are possible:

(i) They represent simple overflow of prey fluids and act as a temporary reservoir during feeding. Wernz & Krantz (1976) ascribe a similar function for the gnathosomal articulation in *Parasitus coleoptratorum*. As such this could increase the efficiency of feeding by collecting any overspill of liquid nutrients and also allow a greater volume of liquid in which any extra-corporeal digestion could occur.

(ii) Hygroscopic salt may be secreted down these ducts, which then picks up water from the saturated atmosphere of the feeding chamber and is swallowed (as described in astigmatids by Wharton & Furumizo (1977)), the tritosternum again acting as a capillary conduit (Wernz & Krantz 1976). Water loss by transpiration is a major problem for terrestrial arthropods (Hocking 1971), and such a mechanism would obviate this.

(iii) They are formed by some sort of filtration of the haemolymph and thus provide a route for the permanent or temporary removal of excess water and solutes (as described in argasid ticks by Balashov (1968)).

Each hypothesis has its problems. Nutrient overflow is simple, but it is difficult to imagine a mechanism for fluid accumulation operating on only one side of the mite's body at a time. Further, it seems inefficient to throw such food-laden droplets away. The secretion of hygroscopic salt during feeding seems rather incongruous too. Large quantities of water are released from the prey on rupture which can easily be imbibed to replace water loss due to transpiration. Besides, no coxal droplets were observed when the mites were not feeding. A filtration mechanism via the coxal glands is a tempting conclusion, especially as this has been found in other arthropods. Yet re-imbibition while still feeding seems odd.

Existence within a heavily chitinized 'suit-of-armour' prevents substantial body expansion during feeding (especially in male pergamasids). Although the mid-gut volume of *P. longicornis* does increase as it stretches and fills during feeding (posterior sections first), only small amounts of liquid are discharged from its anus. Alkaline phosphatase activity is present in the lumenal borders of the stretched and flattened gut epithelial cells during the early part of feeding. This is a typical enzyme of transporting epithelia and thus may indicate that the gut contents are being concentrated by the removal of water into the haemolymph. The internal homeostasis could be adjusted by the expulsion of most of the excess water via the coxal glands, and the loss of some water during the discharge of excretory material via the anus.

GUT

The general organization of the gut is just as described by Jakeman (1961) for *Echinolaelaps echidninus* and by Young (1968) for *Haemogamasus ambulans*. Sexual dimorphism is apparent. Computerised projections of sectional reconstructions are given in Figs. 5-6. The epithelium is generally similar throughout all parts of the mid-gut although diverse cellular types are present. No clear categorization into digestive or secretory types was possible. Mitoses were detected in interstitial undifferentiated or 'replacement' cells. Digestion appears to be mainly intracellular and lasts for approximately one week after feeding on a last instar larva of *Drosophila melanogaster* at room temperature. Acidophilic, **PAS** positive, acid phosphatase positive food vacuoles (secondary lysosomes?) are a major histological feature of digestion. During the course of the digestion of a meal the visual amount of guanine in the Malpighian tubules increases.

Single or doublet 'giant cells' are present embedded in the mid-gut epithelium in three distinct paired areas: in the paraxial corners of the junction of the poster odor sal caeca with the mesenteron; the termini of the posteroventral caeca; and the termini of the posterodorsal caeca (Fig. 6). They are densely packed with acidophilic bodies looking just like small red blood corpuscles. Some differences in their organization were noted during a single digestive cycle. I denote these as 'Coons cells' after Lewis Coons who first described them in *Macrocheles muscaedomesticae* in 1978. Their origin and function are unknown, but they may be microbial in nature.

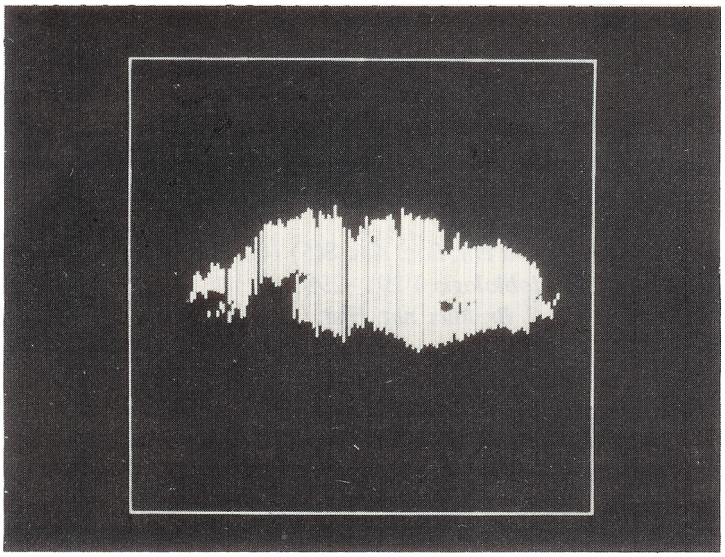

Fig. 5 - Lateral computer projection of the gut of a female *Pergamasus longicornis* 18 hours after feeding. Anterior to the left.

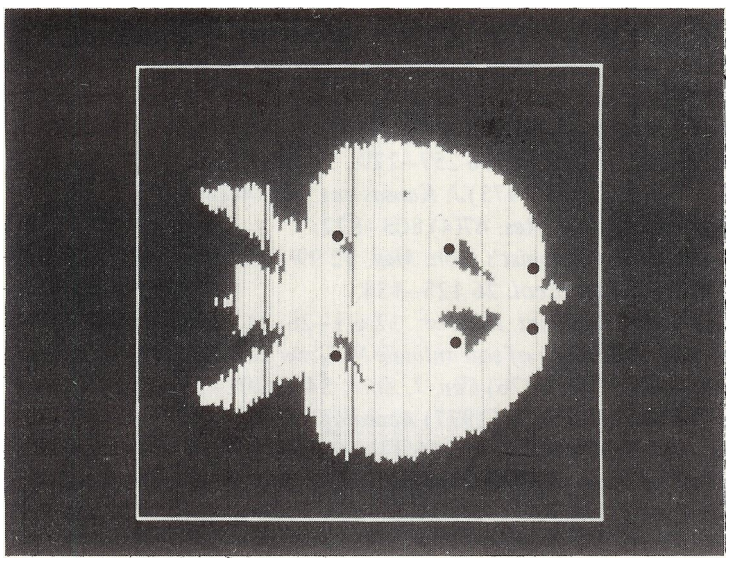

Fig. 6 - Dorsal computer projection of the gut of a female *Pergamasus longicornis* 18 hours after feeding. Anterior to the left, black spots indicate approximate position of 'Coons cells'.

SUMMARY

A short preliminary report on some new aspects of the feeding mechanism and gut structure in *Pergamasus longicomis* (Berlese) (Parasitidae: Mesostigmata) is presented. The formation and fate of coxal droplets during feeding is discussed. The gut, its epithelium and digestion are htiefly described. Giant cells ('Coons cells') of unknown function are found within the mid-gut.

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