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Larval stages of the predatory hoverflies *Trichopsomyia flavitarsis* (Meigen), *Platycheirus melanopsis* Loew and *Parasyrphus nigritarsis* (Zetterstedt) (Diptera: Syrphidae)

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Despite recent progress, many syrphid species are still unknown from the larval stages. In Britain, the best-known region of all, the larvae of about 60% of species have been described; however, in the rest of Europe, only about 14% of species are known from larval stages (Rotheray, 1993).

The ecology and behaviour of larvae require investigation with as much vigour as adult stages if knowledge is to advance. For example larvae are an important source of phylogenetic data (Rotheray & Gilbert, 1989) and as many larvae as possible need to be described for analysis. Furthermore, accurate larval descriptions facilitate a range of comparative studies apart from those involved in finding characters for identification. Those syrphids with predatory larval stages are of added interest because of their potential for biological control (Chambers & Adams, 1986).

The larval stages of the three syrphids considered here are undescribed or poorly described and their biologies little studied. They are unusual among Syrphinae (sensu Stubbs & Falk, 1983) in not being predators of aphids. *Parasyrphus nigritarsus* (Zetterstedt) is accorded the highest category of threat, RDB 1 'endangered', by Shirt (1987) and Falk (1991). Paradoxically, despite its rarity, the biology of this species is the best known of those considered here. Its larva is a predator of the early stages of certain arboreal chrysomelids (Coleoptera: Chrysomelidae) (Keller, 1917; Kanervo, 1946; Grandori & Domenichini, 1952; Schneider, 1953). *Trichopsomyia flavitarsis* (Meigen) is a northern species in Britain and is fairly common in Scotland on moorlands and wet heaths (Stubbs & Falk, 1983). The only information regarding the early stages of *Trichopsomyia* is of an undescribed species found in nests of Australian weaver ants (*Polyrhachis* Smith) where they are said to be scavengers and ant-brood predators (Hölldobler & Wilson, 1990).

Species of *Platycheirus* Lepeletier & Serville have a range of larval feeding strategies. Some, like *Platycheirus albimanus* (Fabricius) and *Platycheirus clypeatus* (Meigen), may be generalised predators in leaf litter while others are more specialised. For example, *Platycheirus scutatus* (Meigen) feeds on a wide range of ground layer aphids (Rotheray, 1979) and *Platycheirus fulviventris* (Macquart) is more specialised and is particularly associated with *Hyalopterus pruni* (Geoffroy), an aphid species on monocotyledonous plants in wetland sites (Rotheray & Dobson, 1987). *Platycheirus melanopsis* Loew, the species considered here, is a RDB category 3 'rare' species (Falk, 1991) and the only representative in Britain of a small group of upland *Platycheirus* species in Europe.

Descriptions of third (= final) stage larvae

The third stage larva in predatory syrphids can be recognised from the first

two stages by the posterior breathing tubes. In the third stage they are fused to form a single, chitinised structure, the posterior respiratory process (prp), which projects from the upper part of the anal segment (Rotheray, 1993). Morphological terms follow Dixon (1960) and Rotheray (1993).

Trichopsomyia flavitarsis (Meigen)

Overall appearance

A pale translucent larva with internal mouthparts (Roberts, 1970); a pair of rounded projections at the tip of the anal segment (Fig. 1); integument smooth without a coating of setae and a longer than broad prp without dorsal spurs.

Description

Length 9–11 mm; breadth 2–3 mm; height 1.5–2.0 mm; subcylindrical in cross section; truncate posteriorly; tapering anteriorly; body cream-coloured; integument coated in dome-shaped papillae that are larger on the 7th and anal segments, small and patchily distributed on the ventral surface and absent on the mesothorax and prothorax; segmental sensilla mounted on cylindrical papillae about 0.05 mm long with single accompanying setae also about 0.05 mm long; each abdominal segment with dorsal transverse fold bearing sensilla 2 divided in middle; tip of anal segment with a pair of projections about 0.3 mm long at the base of which, just anterior to a transverse groove, are a pair of sensilla (Fig. 1); prp (Fig. 2): length 0.6 mm; breadth at base 0.3 mm; basal two-thirds pale brown and nodular, upper third dark brown and shiny; spiracular plates separated by a medial groove; three pairs of spiracular openings mounted on carinae (Fig. 3).

Material examined

Six larvae within galls of the psyllid *Livia juncorum* (Latreille) (Homoptera: Psylloidea), on the rush *Juncus articulatus* L. (Juncaceae) collected by Keith Bland on 4 August 1992 from the Strone, Glen Clova, Angus, Scotland. One male emerged 7 June 1993 and one female emerged 9 June 1993, four larvae preserved.

Platycheirus melanopsis Loew

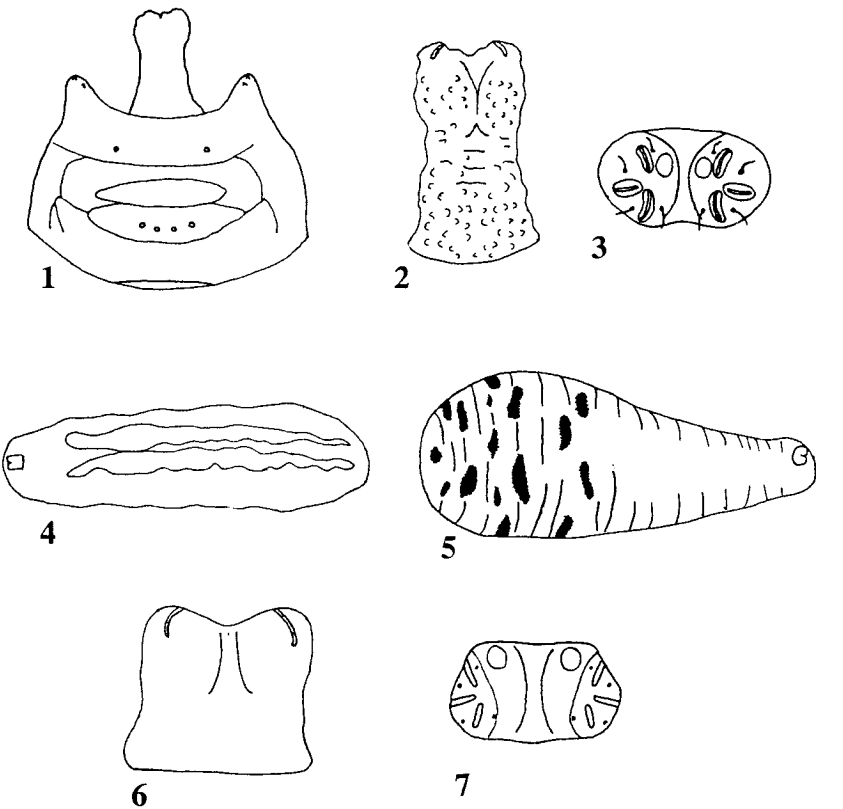
Overall appearance

A pale translucent larva with internal moutparts (Roberts, 1970); dorsal surface with a pair of broad white stripes tapering towards the head and larva tinged orange; prp about as long as broad, without dorsal spurs.

Description

Length 8 mm; breadth 2 mm; height 2 mm; subrectangular in cross-section; long narrow larva tapering only from thorax to head; truncate posteriorly; outline smooth from above; anal segment dorso-ventrally flattened, 1.50 × 0.35 mm; tip of anal segment with one pair of medial locomotory lobes and a smaller pair on the ventro-lateral margin; dorsal vestiture of dome-shaped

papillae; larva with a pair of pale mid-dorsal stripes that dorsally are out-turned and slightly diverging at the posterior end (Fig. 4); overlying these stripes is a series of indistinct orange chevrons on segments 1–6; upper and lower lateral stripes interrupted and thin; posterior half of abdomen tinged with aggregation of reddish fat particles and whole body flecked with white and red particles of fat; prp (Fig. 5): length 0.17 mm; breadth 0.28 mm; pale brown and shiny; spiracular openings with opening 2 closer to 3 than to 1; circular scar anterior in position (Fig. 6). Inflated anterior end of puparium with a series of black markings (Fig. 7).



Figs 1–7. Early stages of predatory Syrphidae. 1–3, *Trichopsomyia flavitarsis*: (1) anal segment, ventral view; (2) prp, dorsal view; (3) prp, apical view. 4–7, *Platycheirus melanopsis*: (4) whole larva, dorso-lateral view; (5) puparium, dorso-lateral view; (6) prp, dorsal view; (7) prp, apical view.

Material examined

Two empty puparia found on the underside of leaves of *Vaccinium myrtillus* L. (Ericaceae) shoots and one larva found, by David Horsfield, on the underside of a dead sterile frond of *Blechnum spicant* (L.) (Polypodiaceae) on 18 April 1993 at about 650 m on Carn Liath, Creag Meagaidh NNR, Inverness-shire. A female *P. melanopsis* emerged on 21 June 1993.

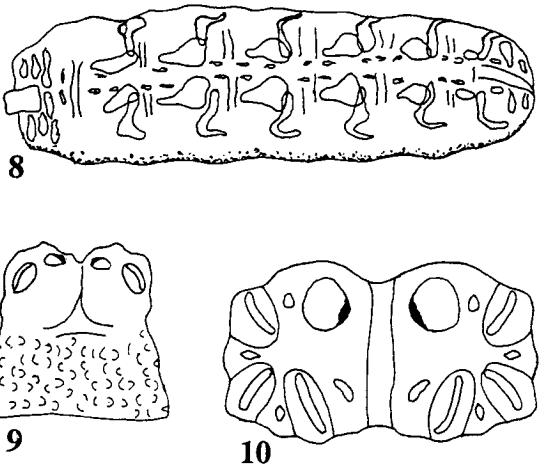
Parasyrphus nigritarsis (Zetterstedt)

Overall appearance

A mottled yellow/brown larva with internal mouthparts (Roberts, 1970), 5–6 pairs of triangular markings on the dorsal surface and a prp with inconspicuous dorsal spurs.

Description

Length 14–16 mm; breadth 3 mm; height 3 mm; subtriangular in cross-section; tapering anteriorly; truncate posteriorly; outline smooth from above; integument translucent and coated in dome-shaped papillae; papillae larger on medial sections of ridges and smaller or absent on the ventral surface, meso-thorax and prothorax; colour pattern complex, pairs of mid-dorsal, triangular yellow (brown in overwintering individuals) markings on abdominal segments 1–6, overlying these markings is a series of separate, thin, dark brown inclined stripes just anterior to each triangular marking; the posterior end of these dark brown stripes extends forward to form an interrupted upper lateral stripe and immediately behind and below this anterior extension is a yellow marking of



Figs 8–10. Third stage larva of *Parasyrphus nigritarsis*. 8, whole larva, dorso-lateral view; 9, prp, dorsal view; 10, prp, apical view.

similar length; lower lateral line consisting of a loose aggregate of white fat particles (Fig. 8); whole body flecked with white and dark brown particles of fat; tip of anal segment with two pairs of lobes; prp (Fig. 10): length 0.82 mm; breadth at base 0.66 mm; basal two-thirds nodular, apical third clear and shining; dorsal spurs short, less than diameter of circular scar; medial groove extending round apical third of prp; 3 pairs of spiracular openings which slope down the sides of the prp (Fig. 10).

Material examined

Fourteen larvae collected by David Robertson and GER, 18 June 1992, from foliage of *Alnus glutinosa* (L.) Gaertner infested with eggs and larvae of *Chrysomela aenea* L. (Coleoptera: Chrysomelidae) growing on the banks of the R. Dove at Farndale NR, near Gillamoor, North Yorkshire. Four males and four females emerged during the period 25 May to 5 June 1993. Two male parasitic cynipids, *Melanips opacus* (Hartig) (Hymenoptera: Cynipoidea), were also reared.

Discussion

The larva of *P. nigritarsis* is very distinctive with a species-specific colour pattern of pairs of triangular yellow or brown markings with a separate thin, brown stripe on the inner margin of each triangular marking (Fig. 8; photograph in Rotheray (1993)). The body broadens posteriorly and is subtriangular in cross-section. This body shape and colour pattern are unlike other *Parasyrphus* larvae which are parallel-sided and cylindrical in cross-section (Goeldlin de Tiefenau, 1974; Rotheray & Gilbert, 1989). The prp is similar to that of other *Parasyrphus*, however. In colour pattern and shape, the larva of *P. nigritarsis* most closely resembles those of the genus *Syrphus* from which *P. nigritarsis* is easily separated by the longer than broad prp.

Keller (1917) was apparently the first to record syrphid larvae feeding on chrysomelid beetle larvae; he describes how the syrphid larva feeds from the underside of the prey and he found them to be voracious. Kanervo (1946) and Grandori & Domenichini (1952) also reported syrphid larvae feeding on chrysomelid larvae. Schneider (1953) identified the syrphid involved as *Syrphus* (= *Parasyrphus*) *nigritarsis*. Kanervo (1946) recorded that a single *P. nigritarsis* larva that was given particular stages of its prey, *Chrysomela aenea*, required for its development 300 eggs/first stage beetle larvae or 100 second stage or 35 third stage larvae. Schneider (1953) recorded *P. nigritarsis* feeding on an additional beetle, *Chrysomela* (= *Melasoma*) *virgintipunctata* Scopoli on *Salix*. Schneider (1953) collected *P. nigritarsis* eggs from the field on 7 May 1949 and found that after feeding, larvae diapaused in the third stage until April–May of the following year.

My observations of *P. nigritarsis* larvae feeding also showed them to be particularly voracious. In Petri dishes chrysomelid larvae were captured rapidly and often several predators fed from the same item of prey. This was also observed in the field. Feeding rates appeared high in relation to *Parasyrphus punctulatus* (Verrall) and other aphid-feeding syrphid larvae, although measurements were not taken. A surprising feature was the lack of cannibalism.

Aphidophagous syrphids are frequently cannibalistic (Schneider, 1969). The Nearctic syrphid, *Parasyrphus melanderi* Curran, which is also a predator of chrysomelid beetles, is similarly voracious and also appears not to be cannibalistic (Nathan Rank, pers. comm.). Our observations showed that third stage *P. nigritarsis* larvae attacked larvae of both *C. aenea* and *C. virgintipunctata* in a characteristic manner. The front part of the thorax was usually draped over the prey and retracted partially. This twisted the beetle to expose its undersurface into which the mouthparts were inserted. This mode of capture appears to prevent the prey from running away and enables the predator to insert its mouthparts on a part of the prey that is not defended by integumental projections and glandular secretions.

As third stage larvae age the paired yellow triangular markings on the dorsal surface become orange and the inner brown stripes darken. These changes appear to increase crypsis. When viewed against leaves skeletonized by beetle larvae, *P. nigritarsis* larvae, to human eyes, merge successfully into the background.

As Schneider (1953) found, *P. nigritarsis* diapause after feeding and the hind gut is emptied. *Parasyrphus nigritarsis* is a very rare species in Britain and in other European countries (Stubbs & Falk, 1983; MacGowan & Watt, 1994; Torp, 1984), although it is apparently not uncommon in the Italian Alps (Verlinden & Decleer, 1987). Speight (1991) suggests that it is under-recorded. At the site where we found larvae it was abundant with almost every *Alnus* tree along the shaded part of the river bank having beetle and syrphid larvae. Possibly, a high proportion of larvae diapause for more than one winter. Its appearance in space or time would then be unpredictable. However, we did not revisit the site in 1993 to check if larvae were again abundant nor did any of the larvae we reared diapause for more than a year.

The larva of *P. melanopsis* is similar to other *Platycheirus* larvae in having longitudinal stripes, chevrons, a shorter than long prp with oval-shaped spiracular openings and being flecked with particles of fat. It may be separated from other *Platycheirus* larvae by its pale colour pattern tinged dorsally with orange and the out-turned posterior ends of the dorsal stripes (Fig. 4). The puparium has, apparently, a species-specific pattern of black markings on the dorsal surface (Fig. 5). Black markings occur on the puparia of other *Platycheirus* species but they are not as extensive.

The larva we found was overwintering and had an empty hind gut. However, the larva of *P. melanopsis* possibly feeds on the montane scale insect, *Arctorthezia cataphracta* (Olafsen) (Homoptera: Ortheziidae) which was frequent among the roots of montane plants at Carn Liath, and is fairly widespread throughout upland areas of northern Britain. The empty puparia we found were on leaves well above the ground. During winter larvae are probably fairly deep within leaf litter and move up to pupate. This is consistent with the behaviour of the larva we collected: it remained still until a day or so before it pupated. Based on captures of adults in pitfall traps on Carn Liath, the species occurs between 510–770 m from mid-June to early July (David Horsfield and Iain MacGowan, pers. comm.).

The larva of *T. flavitarsis* is most similar to larvae of *Pipiza* in having a pair of

rounded projections at the tip of the body, a longer than broad prp with spiracular openings mounted on carinae and long, upright interspiracular setae. The translucent colour pattern and smooth integument distinguish the larva of *T. flavitarsis* from *Pipiza* larvae which are either green or brown and coated in setae.

In Australia an undescribed *Trichopsomyia* species is said to be a scavenger and a brood predator in ant nests (Hölldobler & Wilson, 1990) but *T. flavitarsis* is a predator of gall-forming psyllids on rushes. Second and third stage *T. flavitarsis* larvae were observed capturing and eating nymphs and adults of *L. juncorum*. The pale larva of the syrphid is remarkably adept at locomotion between the tightly packed leaf scales of the gall. The third stage larvae that were reared diapaused in late autumn after emptying their hind guts and then emerged in the following year. Some individuals remained in the galls, others moved away. The pale colour of the larva of *T. flavitarsis* is unusual among pipizines (sensu Stubbs & Falk, 1983). Most other pipizine larvae are either green or brown (Rotheray, 1986). The pale colour is cryptic against the inner parts of the galled plant tissue.

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