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### Third stage larvae of four species of saproxylic Syrphidae (Diptera), with a key to the larvae of British *Criorhina* species

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Saproxylic invertebrates are those dependent during some part of their life cycle upon the dead or dying wood of moribund or dead trees (standing or fallen) or upon wood-inhabiting fungi or upon the presence of other saproxylics (Speight, 1989). In Britain there are over 600 saproxylic Diptera (Perry & Stubbs, 1978; K. Alexander, *pers. comm.*), a high proportion of which are accorded RDB status (Falk, 1991). A particularly important group are the hoverflies (Syrphidae). Of the 37 British species associated with dead or decaying wood, 27 (73%) are accorded RDB status – a higher proportion than most saproxylic groups. Hoverflies are one of the groups recommended by Speight (1989) as indicators of woodland of international conservation interest. In general, saproxylic hoverflies bred in 'wet' microhabitats such as rot-holes, sap-runs and wet decaying wood. This is in contrast to dry, dead wood which is typical of saproxylic Coleoptera (Crowson, 1981).

In relation to saproxylic Coleoptera, saproxylic hoverflies are poorly known with rudimentary understanding of their breeding requirements. Dead-wood habitats, and in particular, wet microhabitats, are often missed completely or are under-represented in evaluations of biodiversity in woodlands (Stubbs, 1982). Thus the conservation of saproxylic Diptera, including hoverflies, is in a neglected state. Finding breeding sites is a critical first step.

In this paper we describe breeding sites and early stages of four saproxylic hoverflies. This should enable others to locate these and possibly other species occupying similar breeding sites, which is often the best way to find them (Rotheray & MacGowan, 1990). The description of the third larval stage and/or puparium will assist further investigations of the biology of these poorly known species.

#### Materials and methods

Larvae and puparia of all four species were collected in the field in Scotland and Germany (D). Details of rearing and preservation methods can be found in Rotheray (1993). Measurements were made using a measuring eyepiece fixed to a binocular microscope. Puparia retain all the larval characters but the process of pupariation results in contraction of body length and inflation of body breadth and height. In *Blera fallax* and *Criorhina asilica* where descriptions are based on puparia, measurements of puparia were corrected to give an estimate of larval dimensions by comparing the sizes of preserved third stage larvae and

puparia in related or congeneric species. Body length was measured mid-dorsally from the anterior margin of the prothorax to the tip of the anal segment. Unless stated otherwise, breadth is maximum breadth of the structure being measured. Descriptive terms follow Hartley (1961) and Rotheray (1993). All material is in the collections of the National Museums of Scotland (NMS) or in the private collection of J.-H. Stuke (JHS).

### Descriptions of third stage larvae and puparia

#### *Blera fallax* (Linnaeus, 1758)

One of us (GER) found larvae of several *Blera* species in stumps of *Pseudotsuga menziesii* (Mirbel) Franco decayed by heart-rot in Oregon, U.S.A. This prompted a search of heart-rotted stumps of *Pinus* in Scotland and Germany which resulted in our finding puparia. In Germany stumps were examined at sites where *B. fallax* adults were regularly seen. These puparia were identified by comparison with *Blera* puparia from Oregon.

#### MATERIAL EXAMINED

One puparium, 04.vi.1996, Dulnain Bridge, Strathspey, in detritus in a hole caused by heart-rot fungi at the centre of a *Pinus sylvestris* L. stump, GER; 3 puparia, 26.vii.1996, D-Baden-Württemberg, NSG Feldberg, Toter Mann, at the base of a conifer stump, JHS.

#### Description

A long-tailed larva, length 15–17 mm + 8–10 mm for the anal segment, breadth 3.5 mm; subcylindrical, truncate anteriorly, elongate and tapering posteriorly. **Thorax:** without hooks, base of lateral lips with broad setae and fine setae at tip, anterior fold with broad band (>75%) of spicules comprising 5–6 rows, one group each of spicules anterior to sensilla 4 and 5 of mesothorax, prolegs on mesothorax. **Mouthparts:** of the filter-feeding type. **Abdomen:** vestiture of short (up to 0.06 mm) fine setae becoming longer towards posterior end (up to 0.08 mm); prolegs on first six abdominal segments, crochets multi-serial, 8–10 primary crochets, crochet arrangement gradually changing from posterior penellipse (i.e. crochets complete around posterior margin of proleg) on abdominal segment one to lateral penellipse (i.e. crochets complete on outer lateral margin) on abdominal segment 6; dorsal section of abdominal segment 7 extending over anal segment with sensilla 2, 3 and 4 above anus. **Anal segment:** with unequal distances between lappets: first two pairs of lappets close to each other at base of anal segment with the third at the tip (Fig. 1). **Posterior respiratory process** (Fig. 3): length 0.83 mm, breadth at tip 0.16 mm, pale brown and shining, three pairs of straight, oval, spiracular slits (Fig. 4). **Pupal spiracles:** length 0.6 mm; breadth 0.3 mm, straight, with openings on elongate nodules in upper half only (Fig. 2).

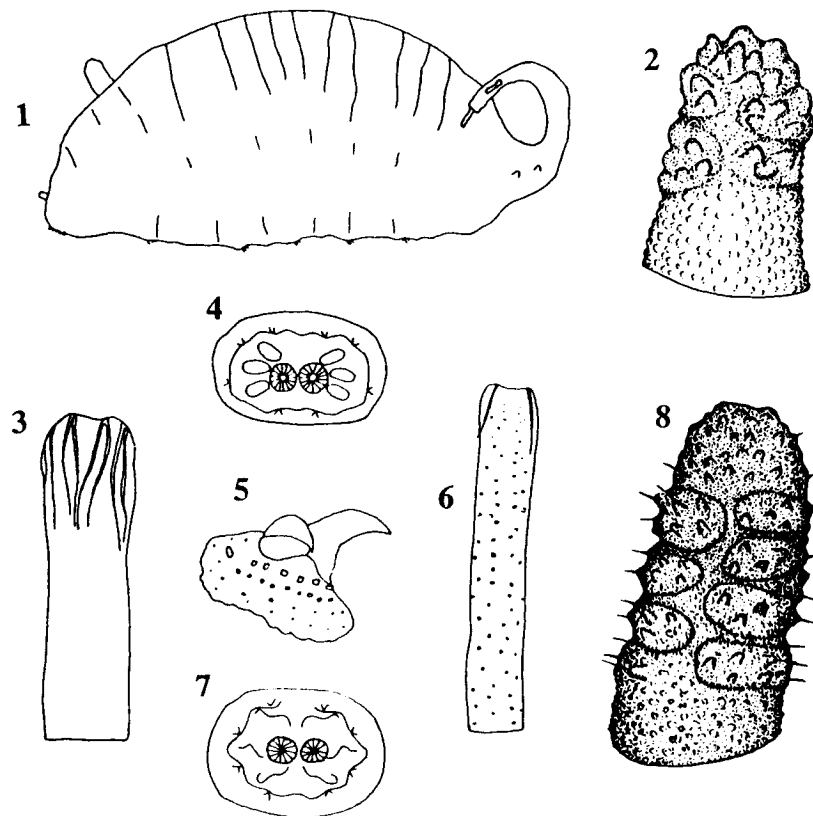
#### Identification

The larva of *B. fallax* most closely resembles those of *Caliprobola* Rondani and *Lejota* Rondani in having prolegs with crochets, a thorax with spicules, not hooks, and an anal segment with unequal distances between the lappets: the first two pairs of lappets are close to each other at the base of the anal segment with

the third at the tip (Fig. 1). It may be possible to separate larvae of these three genera by the pupal spiracles: the tip is inclined backwards in *Lejota* and elongate nodules bearing spiracular openings are present almost to the base of the spiracles in *Caliprobola*.

#### Biology

Observations supporting the idea that *B. fallax* is saproxylic have been suggested previously (Barkemeyer, 1994; Schuhmacher, 1968). Our findings confirm this, showing that an association exists with *P. sylvestris* in Scotland, with additional conifer species probable in Germany.



Figs 1–8. Saproxylic Syrphidae, early stages. 1–4, *Blera fallax*: 1, puparium, lateral view; 2, pupal spiracle, anterior view; 3, posterior respiratory process, dorsal view; 4, posterior respiratory process, apical view. 5–8, *Brachypalpoides lentus*: 5, thoracic hooks, posterior view; 6, posterior respiratory process, dorsal view; 7, posterior respiratory process, apical view; 8, pupal spiracle, anterior view.

*Brachypalpoides lentus* (Meigen, 1822)

During a Malloch Society field meeting, David Horsfield noticed a teneral specimen of *B. lentus* resting on a live *Fagus* tree. On one side of this tree we found an area of exposed, wet decaying heartwood at ground level. By searching this decayed area, the larva of *B. lentus* was located. In Germany *B. lentus* was found in areas of wet decaying heartwood of various tree stumps.

## MATERIAL EXAMINED

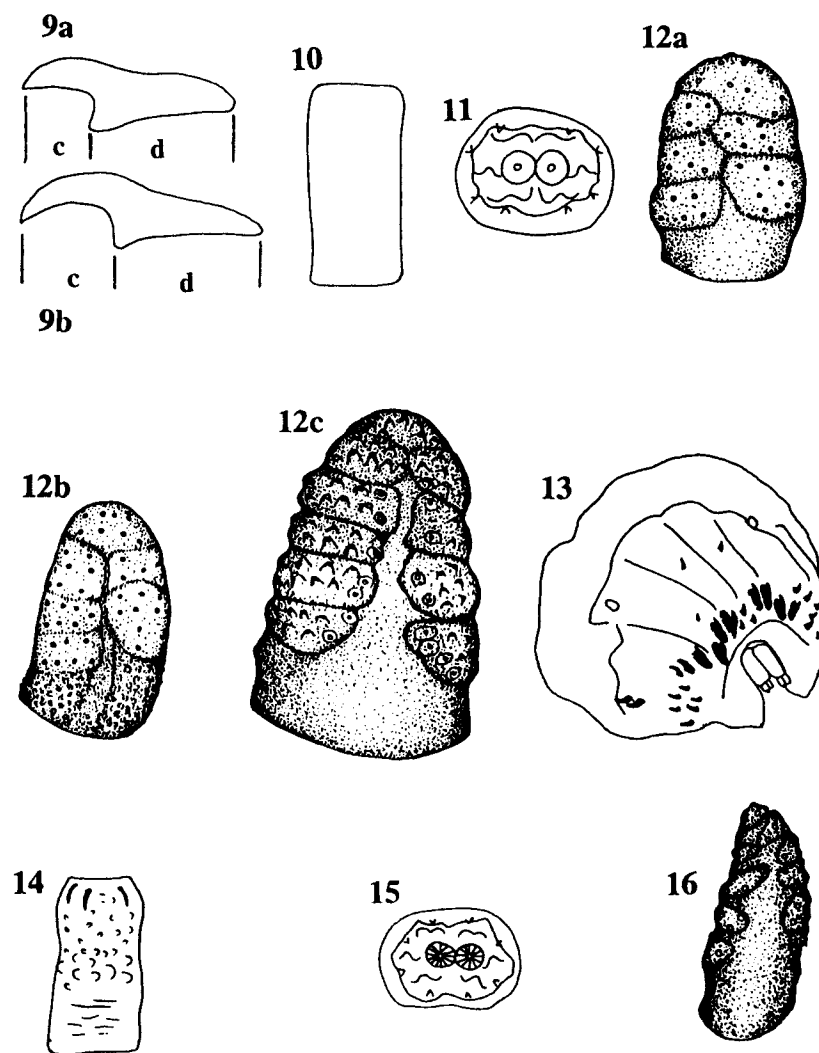
Seven larvae, 22.v.1993 and one puparium 23.iv.1995 (female emerged May 1994) Arniston, Midlothian, from area of wet decaying heartwood exposed at the base of a live *Fagus* tree, GER; 1 larva, 06.v.1996 and 3 larvae, 23.xi.1996, D-Bremen, Stadtwald, in wet decaying heartwood of a *Populus* stump, JHS; 1 larva, 26.v.1996 and 3 larvae, 11.vi.1996, D-Niedersachsen, Landkreis Rotenburg, Trochel, in wet decaying heartwood of a *Benula* stump, JHS; 3 larvae, 26.v.1996 and 3 puparia, 04.iv.1996, D-Baden-Württemberg, Oberrheinebene, Burkheim, in wet decaying heartwood of a *Populus* stump, 1 male and 2 females emerged 1996, JHS.

## Description

A short-tailed larva, subcylindrical in cross-section, length 15–17 mm, breadth 3–4 mm, height 3 mm, truncate anteriorly, tapering posteriorly. **Thorax:** base of lateral lips coated in broad, tapering setae and tip coated in fine setae; anterior fold of prothorax with a narrow (about 40% of anterior fold) spicule band comprising 5–7 rows, the anterior two rows about half length of those behind, lines of sclerotized spicules extending onto dorsal folds of prothorax, mesothorax and metathorax with antero-ventral band of spicules; prothorax with two groups of red-brown hooks on an equally red-brown sclerotized base just anterior and lateral to anterior spiracles and anterior to mesothoracic fold bearing sensilla 5, each group of hooks consisting of a pair of equal-sized large hooks on anterior margin of the sclerotized base about 0.24 mm long, one directed backwards and one directed laterally (Fig. 5), posterior to each pair of hooks, the sclerotized base coated in rows of blunt nodules barely projecting from surface (Fig. 5); prolegs present on mesothorax. **Mouthparts:** of the filter-feeding type. **Abdomen:** vestiture of fine setae up to about 0.12 mm long on abdominal segments 2–8 and up to 0.06 mm on first abdominal segment and thorax; prolegs on abdominal segments 1–6, crochets multi-serial, primary crochets largest with darkened tip, crochet arrangement gradually changing from posterior penellipse (i.e. crochets complete around posterior margin of proleg) on abdominal segment one to lateral penellipse (i.e. crochets complete on outer lateral margin) on abdominal segment 6; abdominal segment 7 with dorso-lateral margins extended over anal segment so that sensilla 2, 3 and 4 above anus. **Anal segment:** with three pairs of equally spaced lappets, middle pair the shortest: dorsally anal segment 4 times as long as abdominal segment six. **Posterior respiratory process** (Fig. 6): length 2 mm, breadth just below tip 0.41 mm, smooth and shiny and evenly coated in pits, three pairs of sinuous spiracular openings (Fig. 7). **Pupal spiracles:** length 0.7 mm; breadth at base 0.3 mm, base nodular, spiracular openings on basal nodules and many with an associated seta (Fig. 8).

## Identification

The larva of *B. lentus* is similar to those of *Chalcosyrphus* Curran and *Brachypalpus* Macquart. It differs in having two groups of thoracic hooks, each consisting of a pair of hooks which are red-brown in colour (Rotheray, 1993). Thoracic hooks in other syrphid genera are black.



Figs 9–16. Saproxyllic Syrphidae, early stages. 9a, *Criorhina asilica*, lateral thoracic hook, anterior view. 9b, *Criorhina floccosa*, lateral thoracic hook, anterior view; length of hook = c, length of base = d. 10–12a, *Criorhina asilica*: 10, posterior respiratory process, dorsal view; 11, posterior respiratory process, apical view; 12a, pupal spiracle, anterior view. 12b, *Criorhina floccosa*, pupal spiracle, anterior view. 12c, *Criorhina ranunculi*, pupal spiracle, anterior view. 13–16, *Xylota coeruleiventris*: 13, prothorax, anterior view; 14, posterior respiratory process, dorsal view; 15, posterior respiratory process, apical view; 16, pupal spiracle, anterior view.

### Biology

*Brachypalpoides lentus* larvae have been recorded from *Acer* (Scholz, 1850; Lundbeck, 1916), *Fagus sylvatica* L. (Schuhmacher, 1968; Speight & Lucas, 1992), *Picea abies* (L.) Karsten (Kassebeer, 1993). We also found it in association with *Populus* and *Betula*. The larva occurs in areas of wet decaying heartwood in roots or at the base of dead and live trees.

### *Criorhina asilica* (Fallén, 1816)

One of us (JHS) found puparia of *C. asilica* in a rotten hole of a *Betula* stump. The larvae had probably been feeding in wet decaying heartwood in the roots and had ascended to pupate.

#### MATERIAL EXAMINED

Two puparia, 04.v.1996, D-Niedersachsen, Landkreis Rotenburg, Trochel, in a rotting hole of a *Betula* stump, 2 males emerged 08.v.1996, JHS.

### Description

A short-tailed larva, subcylindrical in cross-section. Length 15–18 mm, breadth 3–4 mm, height 3 mm, truncate anteriorly, tapering posteriorly. **Thorax:** lateral lips with base coated in spicules and tip coated in fine setae; anterior fold of prothorax with a broad (>75% of anterior fold) spicule band comprising >5 rows, mesothorax and metathorax with antero-ventral band of spicules; prothorax with black, sclerotized, Y-shaped base bearing a pair of hooks, stem of Y-shape between folds bearing sensilla 1–3 and arms extending onto anterior fold, spicules between arms longer than those elsewhere on spicule band, at the junction of the stem and arms a pair of large (0.36 mm long) closely set and not diverging, backwardly directed, black hooks; prothorax with fold bearing sensilla 4 and 5 narrow and almost transverse, with sensilla 4 and 5 approximated and very close to sensilla 1, behind each anterior spiracle a large, laterally directed black hook, shiny at tip, matt at base, length in dorsal view including base 0.64 mm, in anterior view, length of this hook less than half length of base (0.18 : 0.46 mm) (Fig. 9a); prolegs present on mesothorax. **Mouthparts:** of the filter-feeding type. **Abdomen:** with vestiture of short (up to 0.06 mm long) fine setae; prolegs on abdominal segments 1–6, crochets multi-serial, pale and inconspicuous, primary crochets largest with darkened tip, crochet arrangement gradually changing from posterior penellipse (i.e. crochets complete around posterior margin of proleg) on abdominal segment one to lateral penellipse (i.e. crochets complete on outer lateral margin) on abdominal segment 6; abdominal segment 7 with dorso-lateral margins extended over anal segment so that sensilla 2, 3 and 4 above anus. **Anal segment:** dorsally about 3–4 times as long as abdominal segment six with three pairs of equally spaced lappets, posterior pair longest. **Posterior respiratory process** (Fig. 10): length 1.5 mm, breadth at base 0.41 mm, at tip 0.38 mm, basal two-thirds matt, apical third smooth and shiny, three pairs of sinuous spiracular openings (Fig. 11). **Pupal spiracles:** length 0.6 mm; breadth at base 0.3 mm, smooth and shiny without raised areas with nodules bearing spiracular openings (Fig. 12a).

### Identification

*Criorhina* larvae can be recognised by the characters in the first couplet of the key. The larva of *C. asilica* is most similar to that of *C. floccosa* but can be separated by the characters in the key.

- 1 Short-tailed larva with internal mouthparts, inconspicuous prolegs and pale crochets; anterior margin of prothorax with backwardly directed hooks on a sclerotized Y or triangular base and a pair of laterally directed hooks behind anterior spiracles ..... *Criorhina* 2
- Not as above ..... other syrphid taxa
- 2 Pairs of mid-dorsal hooks on a triangular base and a small pair of hooks behind ..... *Criorhina berberina*
- One pair of hooks on a Y-shaped base, no smaller hooks behind ..... 3
- 3 Base of lateral hooks reddish; tip of posterior respiratory process with pits; pupal spiracle tapering and matt with raised areas bearing groups of nodular openings (Fig. 12c) ..... *Criorhina ranunculi*
- Base of lateral hooks black; tip of posterior respiratory process smooth, without pits; pupal spiracle rounded and shiny, without raised areas (Fig. 12 a, b) .... 4
- 4 Length of lateral hooks more than half length of base (c:d in Fig. 9b); mid-dorsal hooks diverging at tip ..... *Criorhina floccosa*
- Length of lateral hooks less than half length of base (c:d in Fig. 9a); mid-dorsal hooks converging at tip ..... *Criorhina asilica*

### Biology

Although we only found the puparium of *C. asilica*, the larva undoubtedly lives in a situation similar to those of other British *Criorhina* species, i.e. in wet decaying heartwood of deciduous trees.

### *Xylota coeruleiventris* Zetterstedt, 1838

In 1991 Kenn Watt noticed large numbers of adult *X. coeruleiventris* in a recently felled conifer plantation. Prompted by this, we later searched fallen conifer trees, cut logs and stumps at this site in microhabitats where *Xylota* larvae of other species had been found. We eventually found *X. coeruleiventris* larvae under the bark of conifer stumps.

#### MATERIAL EXAMINED

Three larvae, 30.x.1991 and 1 larva, xi.1991, adult emerged 31.v.1992, Castle O'er forest, nr Eskdalemuir, Dumfries-shire, GER; 1 larva, 17.vi.1993, Glen Nevis, West Inverness-shire, K. Watt; all larvae from sap-filled borings of the curculionid, *Hylobius abietis* (L.) (Coleoptera: Curculionidae) under the bark of about 12-month-old unidentified conifer stumps in commercial plantations.

### Description

A short-tailed larva, subcylindrical in cross-section, length 11–13 mm, breadth 3 mm, height 3 mm, truncate anteriorly, tapering posteriorly. **Thorax:** base of lateral lips with a few spatulate setae just projecting from surface, then spicules and finally fine setae at tip, all these spicules and setae shorter than setae surrounding sensilla 9

on dorsum of lateral lips; medially, anterior fold of prothorax with a row of 6–8 large spicules on elongate sclerotized bases (bases about 0.18 mm long, spicules about 0.07 mm high (Fig. 13)), either side of this row of large spicules a patch of smaller spicules, one or two pairs of isolated spicules on longitudinal folds of prothorax and isolated patches of spicules anterior to sensilla 4 and 5 of mesothorax; barely projecting prolegs present on mesothorax. **Mouthparts:** of the filter-feeding type. **Abdomen:** vestiture of fine setae up to about 0.07 mm long on abdominal segments 2–8 and up to 0.02 mm on first abdominal segment; prolegs present on abdominal segments 1–6, crochets in two rows, 3 primary crochets, second row extending across elongate inner margin of proleg. **Anal segment:** dorsally as long as abdominal segment six with three pairs of equally spaced, equally long lappets. **Posterior respiratory process** (Fig. 14): length 1 mm, breadth just below tip 0.3 mm, apical half coated in nodules, basal half smooth with slight longitudinal ridges, three pairs of sinuous spiracular openings (Fig. 15). **Pupal spiracles:** length 0.5 mm, breadth at base 0.16 mm, tapering, spiracular openings on raised areas round upper two-thirds of pupal spiracle and a broad, clear area in front (Fig. 16).

#### Identification

The larva of *X. coeruleiventris* is similar to other *Xylota* larvae in having prolegs with crochets, an anal segment with equally-sized, equally-spaced lappets and an anterior fold coated in spicules of varying sizes, but can be distinguished by the 6–8 large hook-like spicules on the anterior fold of the prothorax (Fig. 11). Other *Xylota* larvae have different arrangements of spicules on the anterior fold and none so large.

#### Biology

*Xylota* larvae have a range of feeding habits from decaying vegetation to decaying tree sap and heartwood (Rotheray, 1993). However, this is apparently the first time *Xylota* larvae have been found in association with a sap-producing insect. Previously, the only such records are *Brachyopa* Meigen, *Volucella* Geoffroy and *Ferdinandea* Rondani larvae feeding in sap-filled tunnels excavated by the Goat Moth, *Cossus cossus* (L.) (Lepidoptera: Cossidae) (Rotheray, 1993). Also present with *X. coeruleiventris* were larvae of *Xylota segnis* (L.).

#### Acknowledgements

We are grateful to Kenn Watt, David Robertson, Iain MacGowan, David Horsfield, Geoff Hancock and other members of the Malloch Society for help in searching for syrphid larvae and for the pleasure of their company in the field. GER is grateful to WWF and SNH for financial assistance towards the costs of fieldwork.

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