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The larva of *Callicera spinolae* with a key to the larvae of British *Callicera* species (Diptera, Syrphidae)

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Introduction

Adult *Callicera* are spectacular hoverflies with their relatively large size and bright, colourful bee-like body patterns. Worldwide the genus is quite small consisting of nineteen species (Zimina, 1986). Speight (1991) clarifies the taxonomy of the European representatives and recognises six species of which three occur in Britain. All *Callicera* species are considered rare and the British species are in endangered or vulnerable categories in the Red Data Book (Insects) (Shirt, 1987) and in endangered or rare categories in the more recent review of scarce and threatened Diptera (Falk, 1991). Speight (1989) includes the three British species in a list of insects useful in identifying woodlands of international importance to conservation.

Larval stages are poorly known. The first to be described was that of *Callicera rufa* Schummel from rot holes in *Pinus sylvestris* L. in Scotland (Coe, 1938). For many years this was the only information until Zimina (1986) reported finding larvae of *Callicera spinolae* Rondani in a water-filled hollow from a "turanga" tree (*Populus* sp.) in southern Tadzhikstan, Russia. Recently the larva of a second British species, *Callicera aurata* (Rossi) (=*aenea auct. partim nec* Fabricius, see Speight (1991)) was described by Rotheray (1991) from rot-holes in *Fagus sylvestris* L. in the New Forest, Hampshire.

In Britain, the third species, *C. spinolae*, is known only from East Anglia (Stubbs & Falk 1983) where its distribution and occurrences are enigmatic. It was first recorded in 1928 at Southwold on the Suffolk coast (Stubbs & Falk, 1983). Since then it has been recorded from only six other sites spreading westwards into Cambridgeshire (Falk, 1991). Whether this represents a wave of migration or whether stable populations exist across East Anglia is unknown. However one of us (IP) observed probable oviposition at a site in Cambridgeshire and where, later, with Alan Stubbs, we found first stage larvae. In July 1993 we obtained a mature third stage larva. In this paper the larva of *C. spinolae* is described and a key to the larval stages of the three British species provided.

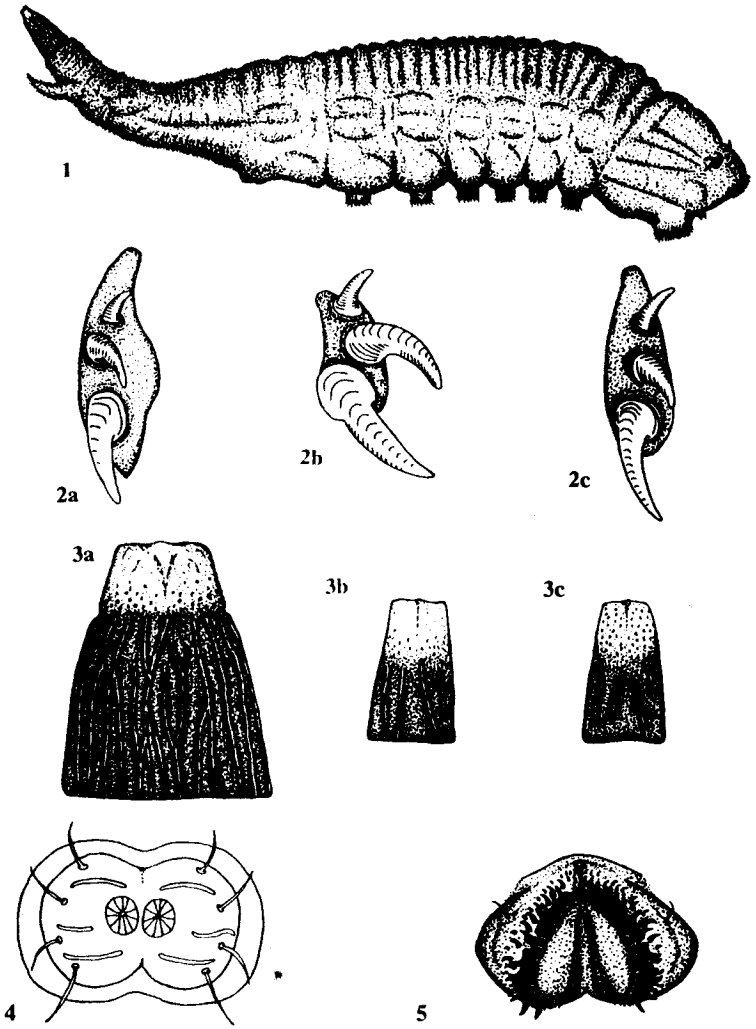
Description of the third (=final) larval stage of *Callicera spinolae*

Unless otherwise stated, larval terms follow Hartley (1961) and Rotheray (1991).

Overall appearance: Larva with internal mouthparts of the saprophagous type (Roberts, 1970) and a short "tail" bearing a conspicuous pair of fleshy projections just before the tip, partially fused prolegs and two groups of three hooks, each group on a common base lateral to the anterior spiracles on the thorax (Fig. 1).

Length: 27mm; width 4mm; subcyclindrical in cross-section, truncate anteriorly, tapering posteriorly; mandibles and mandibular lobes internal; lateral lips well developed, i.e. in profile they project forward of the anterior part of the prothorax and are delineated by integumental folds from the rest of the prothorax; base of lateral lips with broad setae at base and fine setae at tip; body coated in short (up to 0.1mm long), mostly backwardly directed pubescence which is longer (up to 0.2mm long) on the anal segment, aggregations of longer setae (up to 1.5mm long) surrounding sensilla groups 7 and 8 on abdominal segments 1-7; anterior fold of the prothorax with a narrow (less than 50% of the anterior fold) band of backwardly directed, sclerotised spicules which become progressively shorter from front to back (0.3mm to 0.1mm); thorax broader than abdomen and somewhat dorso-ventrally flattened with integumental folds bearing sensilla 4-5 and 6-7 dorsal rather than lateral in position as on abdominal segments 1-6; lateral margins of the thorax with longitudinal furrows; anterior spiracles on the dorsal surface of the prothorax; dorsum of mesothorax rectangular; sensilla 2 of mesothorax posterior and lateral to sensilla 1; two groups of three strong black hooks each group on a common base anterior to mesothoracic sensilla 3 and 4 and posterior to prothoracic fold bearing sensilla 6 and 7; hooks becoming progressively larger towards the outer hook (Fig.2a): length of inner hook 0.4mm, middle hook 1.1mm, outer hook 1.3mm; prolegs present on mesothorax and first six abdominal segments; crochets multiserial, i.e. with up to six rows of progressively smaller crochets from tip to base; each pair of prolegs fused medially forming a single oval structure (Fig. 5); on each proleg crochets arranged in a lateral penellipse, i.e. break in ring of crochets on inner (mid-ventral) margin; anterior margin of each pair of prolegs with a break in crochets becoming progressively reduced on abdominal segments 1-5 with crochets continuous on segment 6; abdominal segment 7 extended dorsally so that, in profile, sensilla 2 and 4 lie posterior to anal opening and sensilla 3 above anal opening; base of anal segment to pair of lappets (fleshly projections) at tip (Fig. 1) about twice as long as segment 6; posterior respiratory process (Fig. 3a): length: 2.5mm, width: at base 2.4mm, at tip 0.9mm; shiny just below tip then broadening abruptly to base and matt with closely aligned longitudinal ridges; tip with three pairs of transverse spiracular openings (Fig. 4).

Material examined: Wandlebury, Gog Magog Hills, Cambridgeshire, 20 July 1993, one larva ex rot-hole about 0.75m up a live *Fagus* tree.



Figs. 1-5. Third stage *Callicera* larvae:
Fig. 1: *Callicera spinolae*, lateral view, whole larva; Fig. 2: Thoracic hooks; 2a: *Callicera spinolae*; 2b: *Callicera aurata*; 2c: *Callicera rufa*; Fig. 3: Posterior breathing tubes, anterior view; 3a: *Callicera spinolae*; 3b: *Callicera aurata*; 3c: *Callicera rufa*; Fig. 4: *Callicera spinolae*, posterior breathing tube, dorsal view; Fig. 5: *Callicera rufa*, partially fused prolegs of sixth abdominal segment, dorsal view.

Key to the third stage larvae of British *Callicera* species

1 prolegs partially fused to form a single oval structure (Fig. 5) on the first six abdominal segments (Fig. 1); thorax with two groups of 3 or 4 hooks lateral to the anterior spiracles (Figs. 1&2); spicules becoming shorter from front to back on the anterior part of the prothorax; posterior breathing tube with transverse spiracular openings (Fig. 4) ..... ***Callicera* 2**

– prolegs absent or, if present, appearing as pairs of oval-shaped structures on abdominal segments 1-6; thorax with a different arrangement of hooks or hooks absent; prothorax with spicules absent or other arrangements than becoming shorter from front to back: spiracular openings not transverse ..... ***other syrphid larvae***

2 posterior breathing tube with a constriction below tip and below constriction, matt with closely aligned longitudinal ridges (Fig. 3a) ... ***Callicera spinolae*** *rot-holes in* ***Fagus; East Anglia***

– posterior breathing tube without a constriction just below tip and with only a few short and indistinct ridges (Fig. 3b,c) **3**

3 thoracic hooks more or less aligned (Fig. 2c); dorsal surface of posterior breathing tube just below tip coated in nodulations (Fig. 3c); small crochets continuous on the anterior margin of last proleg on abdominal segment 6 (Fig. 5) ..... ***Callicera rufa*** *rot-holes in* ***Pinus; Scotland***

– thoracic hooks not aligned (Fig. 2b); posterior breathing tube with dorsal surface mostly smooth with a few nodulations confined to narrow strip above the longitudinal ridges (Fig. 3b); anterior margin of last proleg with a gap between the small crochets ..... ***Callicera aurata*** *rot-holes in* ***Fagus; southern Britain***

Discussion

Larval *Callicera* are among the most distinctive of Syrphidae with their hooks, fused prolegs, prothorax with spicules becoming shorter from front to back and posterior respiratory process with transverse spiracular openings. Fused prolegs and transverse spiracular openings are present in all three larval stages and in puparia.

Hooks on the thorax occur in several syrphid genera eg. *Brachypalpoides* Hippa, *Brachypalpus* Macquart, *Chalcosyrphus* Curran and *Criorhina* Meigen where their number and arrangement appears to be genus specific. Hooks assist larvae in locomotion through particle-filled fluids found in rot-holes and similar "wet" microhabitats in wood (Rotheray, 1991). The functional significance of partially

fused prolegs is unclear but presumably enhances the ability to grip the substrate. This could be important as air in the breathing tubes of syrphid larvae increases their buoyancy and unless they have a firm grip of the substrate, they float and become exposed at the surface (Grieg, 1989). The distinctive arrangement of spicules on the prothorax may help reduce wear as the larvae spend much time tunnelling through accumulated material at the bottom of rot-holes.

Callicera species are important for conservation not only because many species appear to be rare and are in need of practical conservation, but also because their presence at a site indicates that it is of high value for saproxylic plants and animals (Speight, 1989). Rotheray & MacGowan (1990) investigated the status of *C. rufa* in Scotland, but searched for larvae rather than adults. Many new sites were found, sufficient for Falk (1991) to revise the status of *C. rufa* from a category 1 endangered species to a category 3 rare species. As with *C. rufa*, the solution to assessing the status of *C. aurata* and *C. spinolae* may lie in searching for larvae rather than adults. Few such attempts have been made but now that breeding sites are known, assessments using larvae become feasible.

Furthermore, larval stages are present all year round. This is because they often require more than a year to develop, so assessments are not restricted to the short, adult flight period. Even during the flight period, adults are elusive and unpredictable in occurrence. In general rare hoverflies breeding in well defined microhabitats such as rot-holes, are probably easier to find in the larval rather than the adult stage. *Callicera aurata* and *C. spinolae* are two such species and surveys of rot-holes in *Fagus* and possibly other deciduous trees will undoubtedly reveal new sites for these stunningly beautiful insects.

Coe (1941) found that some larvae of *C. rufa* took up to five years to develop. This long period does not appear to be obligatory. From observations of larvae in the field and in the laboratory, development can take place from egg to adult within two years. For example when we first searched the rot-hole at Wandlebury on 24 November 1993 we only found first stage *C. spinolae* larvae but eight months later, on 23 July 1993, third stage larvae were present. Furthermore, on the dorsal surface of the first abdominal segment of the larva we collected, were a pair of differentiated discs. These discs only appear when the larva is about to pupate. It is through these discs that the pupal spiracles protrude (Hartley, 1961). *Callicera* larvae are probably feeding on micro-organisms in the rot-hole and if food is in short supply, as might occur in laboratory cultures, larvae may take longer to develop. A differential rate of development based on food supply could explain the long larval period observed by Coe (1941).

Such a means of development is probably advantageous for larvae living in places where dispersal to new feeding sites is unlikely and where levels of food tend to fluctuate such as when rot-holes fill with rain-water and "dilute" the density of micro-organisms.

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Summary

The third stage larva of *Callicera spinolae* Rondani is described and compared with the larval stages of the two other *Callicera* species occurring in Britain. A key is provided to the third stage larvae of the British *Callicera* species. All three species breed in rot-holes on trees. *Callicera* larvae are very distinctive among syrphids in possessing partially fused prolegs, two groups of 3-4 hooks on the thorax, prothorax with spicules becoming shorter from front to back and posterior respiratory process with transverse spiracular openings. The functional significance of some of these characters is discussed. All three species are accorded Red Data Book categories and are considered rate. Larvae are easier to find than adults and we suggest that future assessments should be made using larval, rather than adult stages.

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Was it a migration – the exceptional abundance of the large white butterfly *Pieris brassicae* (L.) in 1992

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Introduction and Methods

It has long been considered that immigration to Britain plays a major role in determining the abundance here of the large white butterfly *Pieris brassicae* (L.) (eg. South, 1906; Frohawk, 1934; Ford, 1945; Emmet & Heath, 1989). There have been many sightings (eg. those discussed by Williams, 1930, 1958 and by Feltwell, 1982) of very large numbers of these butterflies flying in the same direction. It has been inferred from these sightings that mass migrations occur.

Baker (1968, 1978) suggested that all individuals of *P. brassicae* (and those of many other butterfly species) are more or less continually migrating; that is, between activities such as feeding at flowers, mating, oviposition and overnight roosting. The direction of migratory flight in *P. brassicae* was found by Baker to be to the north in the early part of the summer and later to the south, with the change occurring in mid-July.

Pollard & Yates (1993), using data from the Butterfly Monitoring Scheme, showed that, over the period 1976-1991, numbers of *P. brassicae* recorded in the second (summer) generation in Britain were significantly correlated with numbers in the first (spring) generation ($r = 0.59$, $p < 0.05$). That is, high numbers in spring were often followed by high numbers in summer, a feature suggesting the importance of population dynamics within Britain.

In 1992, *P. brassicae* was exceptionally abundant in parts of Britain and mass movements were reported. In this year counts were made at 97 sites in the Butterfly Monitoring Scheme (Fig. 1). Full details of the methods used in the scheme are provided by Pollard & Yates (1993). Counts are made along a fixed route at each site when weather conditions meet specified criteria. The counts are made in 26 recording weeks from April to September inclusive. In some weeks counts are missed because of unsuitable weather or for other reasons; in 1992 an average of 80 sites was recorded each week. Thus, for the first time, *P. brassicae* was monitored systematically during what appeared to be a major immigration.

Reports of mass movements used here are those submitted to Butterfly Conservation. These were anecdotal reports, apart from counts made at Felixstowe Docks on the coast of East Anglia (Fig. 2). The Felixstowe records are typical of many coastal movements reported over the years and these have been generally