The early stages and breeding sites of four rare saproxylic hoverflies (Diptera: Syrphidae) from Spain

ANTONIO RICARTE1, Mª ANGELES MARCOS-GARCÍA1, CELESTE PÉREZ-BAÑÓN1 & GRAHAM E. ROTHERAY2

1Instituto de Investigación de la Biodiversidad CIBIO, Universidad de Alicante, Alicante, Spain, and 2National Museums Collection Centre, National Museums of Scotland, Edinburgh, UK

(Accepted 1 June 2007)

Abstract
The puparial stage is described for each of four saproxylic hoverflies (Diptera, Syrphidae): Ferdinandea fumipennis Kassebeer, 1999, Mallota dusmeti Andréu, 1926, Myolepta difformis Strobl, 1909, and Myolepta obscura Becher, 1882. Early stages were collected at Cabañeros National Park in Ciudad Real province, central Spain. Mallota dusmeti, M. difformis, and M. obscura were found in water-filled holes of live Fraxinus angustifolia Vahl. trees and the larva of F. fumipennis was found in a sap run on a live Quercus pyrenaica Wild. tree. Larvae were identified by rearing them to the adult stage. Puparia of these species possessed generic-level characters found in congeners. Apparent species-level characters separating them from early stages of congeners are proposed. The records reported here are the first for the Iberian Peninsula of M. obscura. Mallota dusmeti, M. difformis, and Myolepta obscura are extremely rare in Europe with M. dusmeti classed as “vulnerable” in the Spanish Invertebrate Red Data Book.

Keywords: Conservation, immature stage, Mediterranean ecosystem, morphology, sap-run, tree–hole

Introduction
Organisms dependent on dead wood or decaying material associated with the woody parts of trees are known as saproxylic (Speight 1989; Rotheray et al. 2001). Saproxylic Syrphidae are important for biodiversity and conservation in various ways. Some have been proposed as indicators of woodland quality (Morris 1998; Speight 1989). This is because they are restricted to ancient woodland where woodland cover has been continuous for hundreds, possibly thousands, of years and where all growth stages of trees, particularly overmature trees and fallen wood, accumulate under largely natural processes and are mostly left undisturbed or managed using traditional techniques (Reemer 2005). Furthermore, many saproxylic Syrphidae are large and conspicuous and utilize a wide range of dead wood microhabitats. As such they can act as “flagships” for the wider community of saproxylic organisms, so that by conserving these syrphids, many additional species also benefit.
Finally, saproxylic syrphids are included in the red lists of many European countries and deserve individual conservation because they are endangered or possess unique ecological and other features over and above their value for site quality assessment and as flagship species. Despite the importance of saproxylic Syrphidae for conservation, protocols for managing ancient woodland to monitor and encourage dependent organisms like saproxylic Syrphidae are little developed (Rotheray and MacGowan 2000). The only saproxylic Syrphidae known to us which are being targeted for individual conservation are Callicera spinolae Rondani, Blera fallax (L.), and Hammerschmidtia ferruginea (Fallén) which are included in the Biodiversity Action Plan Process of the UK.

Utilizing saproxylic Syrphidae for conservation depends on how well they are known. In particular, basic species taxonomy must be worked out and assessments made of each species distribution and status across Europe, within individual countries and within regions of individual countries. Also required are details of adult and larval requirements of which a minimum necessity is knowing the breeding site. Despite the fact that Syrphidae are a popular group of insects and knowledge is increasing across Europe, lack of these basic data is a continuing barrier to progress.

In this paper, we contribute to the ongoing process of providing basic data on saproxylic Syrphidae by describing the puparial stage of four rare species: Ferdinandaea fumipennis Kassebeer, 1999, Mallota dusmeti Andréu, 1926, Myolepta difformis Strobl, 1909, and Myolepta obscura Becher, 1882. In addition, breeding sites and the distribution of each species is assessed.

**Material and methods**

Larvae of M. dusmeti, M. difformis, and M. obscura were found in water–filled holes on overmature, live Fraxinus angustifolia Vahl. tree trunks and larvae of F. fumipennis were found in sap exudations on live Quercus pyrenaica Willd. tree trunks at Cabañeros National Park (39°23′47″N, 4°29′14″W) in the north-west of Ciudad Real province in central Spain. The park consists of about 40,000 ha of well-preserved Mediterranean ecosystems including a range of woodland types. In the past, many of the woodlands have been managed using traditional techniques including coppicing and pollarding.

Due to lack of taxonomic data, larvae could be identified to genus level, not species level, and were reared in the laboratory to obtain the adult stage for identifying the species. Rearing took place in the dark in a controlled chamber at 20°C, 65–85% humidity. Larvae were reared in plastic boxes with a hole cut in the lid for netting which allowed air exchange, and containing material from the tree hole or sap run in which they were found. Boxes were checked daily to ensure they were sufficiently wet and to remove puparia, which were reared individually on damp tissue in 55 mm diameter Petri dishes and checked daily until adults emerged.

Adults were identified using the keys and descriptions in Andréu (1926), Kassebeer (1999), and Reemer et al. (2004) and checked against named specimens in the collections of the University of Alicante. Descriptions are based on the puparial stage which retains all the features of the third stage larva with the addition of the pupalspiracles (Rotheray 1993). Illustrations were made using a binocular microscope fitted with a drawing tube. Measurements were made using an eyepiece micrometer. Puparium length was measured on the ventral surface from the anterior margin to the anus. Width was the maximum of all structures measured. The length of the posterior respiratory process (prp), or posterior breathing tube, is a useful diagnostic character but it is not measurable along its entire length because in most specimens the base is hidden within the folds of the anal segment.
To overcome this difficulty, comparisons between species were made by measuring the length of the prp above the transverse band to the apex and expressing the result as a proportion of the width of the prp at the transverse band. The transverse band encircles the prp below the apex. It is a characteristic feature of the prp in Eristalinae (Syrphidae) and has various states from a raised ridge, a narrow band of striations or other distinctive surface sculpture to an indented groove (Rotheray and Gilbert 1999). Photomicrographs were obtained using a Hitachi S3000N scanning electron microscope (SEM) operated at 20 kV.

*Myolepta* puparia were often coated in a white substance excreted by the larva at the time of pupariation. This coating obscured integumental detail and was removed by boiling affected puparia in a solution of KOH for 5 min and picking off loosened deposit with pins. Head skeletons were examined by softening a puparium in a cold solution of KOH for about 30 min and removing them from the antero-ventral margin of the puparium using pins.

Terminology follows Hartley (1961) and Rotheray (1993) for gross morphology and Hartley (1963), Roberts (1970), and Rotheray and Gilbert (1999) for head skeleton structure. Voucher specimens of adult and immature stages of all species have been deposited in the Colección Entomológica de la Universidad de Alicante (CEUA).

**Results: description of early stages**

*Ferdinandea fumipennis* Kassebeer

**Puparium**

*Overall appearance.* Short-tailed larva with mouthparts of the saprophagous type (Rotheray and Gilbert 1999); truncate anteriorly, slightly tapered posteriorly; prolegs absent, vestiture of fine setae becoming longer towards the anal segment; head skeleton with mandibles and tentorial bar heavily sclerotized (Figure 2); prp short, slightly longer than wide from transverse band to apex and slightly tapering with a transverse indentation just below the apex (Figure 2).

*Dimensions.* Length 8.17 mm; width 4.24 mm.

*Head.* Mouth-hooks present but inconspicuous; mandibular lobes partially external (Rotheray and Gilbert 1999) and dorsal lip coated in setae.

Figures 1, 2. Mandibular sclerite detail from closely related *Ferdinandea* species head skeletons in lateral view. (1) *Ferdinandea cuprea*. (2) *Ferdinandea fumipennis*. Scale bar: 1 mm.
Head skeleton (Figure 2). Basal sclerite lightly sclerotized; ventral cornu about three times as long as dorsal cornu, bar-shaped with ventral pharyngeal ridges and grinding mill (Hartley 1963) present; dorsal cornu rounded apically; dorsal bridge not heavily sclerotized; in lateral view, tentorial bar about three times wider in front of the tentorial bridge than behind; mandibular sclerite T-shaped with apodeme about twice as narrow as the longer and heavily sclerotized mouthhook.

Prothorax. Anterior fold coated with setae.

Anterior spiracles. Anterior spiracles 0.05 mm long by 0.04 mm wide, inconspicuous, light-brown with four or five oval openings across the apex.

Mesothorax. Prolegs absent.

Abdomen. Vestiture of a uniform coating of fine, pale brown setae varying in length from 0.04 to 0.1 mm and becoming longer towards the anal segment; ventral surface of the anal segment with one transverse fold between the anus and the tip of the segment; abdominal segment 7 with sensilla 1–6 on fleshy, rounded papillae; anal segment truncate and inclined dorso-ventrally; first two pairs of lappets on the anterior section of the anal segment and the third pair of lappets on the posterior section; prolegs absent.

Pupal spiracles. Separated by a distance of about 2.5 times their length; each spiracle 0.42 mm long and 0.18 mm wide, brown, sub-cylindrical, inclined postero-laterally; irregularly spaced tubercles bearing spiracular openings extending halfway down the antero-dorsal surface; between tubercles surface smooth but sculptured at base.

Posterior respiratory process (Figures 5, 6). Short, with visible section about as long as wide; dark brown; matt with a distinct transverse band and a striated indentation below the apex; length between transverse band and spiracular plate 0.35 mm; tapered towards the apex.

Figures 3–6. Closely related Ferdinandea species posterior respiratory processes (prp) showing the tube sculpture and the spiracular plate, in dorsal and apical views, respectively. (3, 4) Ferdinandea cuprea. (5, 6) Ferdinandea fumipennis. Scale bars: 1 mm.
with width at transverse band 0.5 mm; spiracular plates separated by a deep, dorso-ventral indentation; each plate bearing three horse shoe-shaped spiracular openings.

Material examined

One puparium reared from larva collected 8 April 2005 from a 1.25 m high, south facing, exudation of sap on a Quercus pyrenaica tree trunk, Spain, Ciudad Real, Cabañeros National Park, Santiago valley, C. Pérez-Bañón, G. Rotheray, and M. A. Marcos-García, puparium formed 14 April 2005, male emerged 29 April 2005.

Mallota dusmeti Andréu

Puparium

Overall appearance. Long-tailed larva with mouthparts of the saprophagous type (Rotheray and Gilbert 1999); puparium with a boat-shaped profile (Figure 7) (Rotheray 1993); truncate anteriorly, tapering posteriorly, slightly dorso-ventrally flattened, pale yellow in colour, vestiture light and ventral surface bare; lateral margin with a distinct ridge becoming more pronounced posteriorly and incorporating dark, fleshy projections incorporating segmental sensilla 4–6 (Figure 10).

Dimensions. Length 13.67 mm; width 6.17 mm.

Head skeleton (Figure 8). Basal sclerite at junction of dorsal and ventral cornea black and heavily but unevenly sclerotized; dorsal cornu straight dorsally and tapered posteriorly; ventral cornu inflated posteriorly and 2.5 times as long as dorsal cornu; parastomal bars bordering the epipharyngeal plate clearly visible at the antero-dorsal part of the head skeleton, otherwise sclerotization lacking between the dorsal bridge and the tentorial bar; dorsal bridge and ventral pharyngeal ridges present; ventral bridge linking the tentorial bars broader than tentorial bar; mandibular sclerite T-shaped.

Prothorax. Anterior fold evenly coated in red-brown spicules, translucent at apex.

Figure 7. Typical Mallota-shaped puparium of M. dusmeti, lacking the detachable thoracic plate and the draw-omitted long tail in lateral view, with head to the left. Scale bar: 4 mm.
Anterior spiracles (Figure 11). Length=0.56 mm; width=0.2 mm, yellow brown, less than three times as long as base is wide with pointed and slightly recurved tip; at least 14 spiracular openings present at the apex of the spiracular plate; openings arranged in a curved row.

Mesothorax. Prolegs present with three or more rows of crochets; five crochets in the primary rows.

Abdomen. Vestiture sparse and vestiture absent on ventral surface; prolegs with three rows of crochets present on the first six segments; five crochets in the primary row decreasing to three on segment 6; lateral margin with two aligned projections per segment; segments 1–6 with projections bearing sensilla 4+5 and 6 and segment 7 projections incorporating sensilla 7+8 and 9; anal segment elongate, more than body length, bearing three pairs of approximately equidistant lappets.

Pupal spiracles (Figures 12, 13). Separated by 0.67 times their length; 1.96 mm long, subcylindrical, yellowish brown, postero-laterally curved with small, circular, irregularly spaced openings extending almost to the base; sculpture between openings conspicuously punctured.

Posterior respiratory process. Elongate, shiny brown with each spiracular plate bearing three pairs of curved spiracular openings; transverse band not distinct.

Material examined
Two puparia from larvae collected 19 March 2004 and 28 May 2004, from tree holes containing standing water in live *Fraxinus angustifolia* and *F. angustifolia* or *Quercus faginea*. 

Figures 8, 9. Head skeletons in lateral view. (8) *Mallota dusmeti*. (9) *Myolepta difformis*. Scale bar: 1.2 mm.
trees, respectively, Spain, Ciudad Real, Cabañeros National Park, Canalejas valley, M. A. Marcos-García, G. Rotheray, and G. Hancock, and M. A. Marcos-García and C. Pérez-Bañón, respectively; puparia formed 22 March 2004 and 6 April 2004, male and female emerged 21 June 2004 and 3 July 2004, respectively.

**Myolepta difformis** Strobl

**Puparium**

**Overall appearance.** Short-tailed larva with mouthparts of the saprophagous type (Rotheray and Gilbert 1999); sub-cylindrical in cross-section, truncate anteriorly, tapering posteriorly; prolegs bearing crochets present on mesothorax and first six abdominal segments; anal segment coated in papillae bearing tufts of setae; pupal spiracles club-tipped with basal sculpture of dome-shaped projections; prp narrow and yellow-brown.

**Dimensions.** Length 6.56 mm, range 6.17–6.83 mm; width 3.04 mm, range 2.64–3.36 (n=3).

**Head skeleton** (Figure 9). Basal sclerite at junction of dorsal and ventral cornea only heavily sclerotized posteriorly; dorsal cornu rounded dorsally and posteriorly; ventral cornu
bar-shaped, not inflated and about four times as long as dorsal cornu; parastomal bars bordering epipharyngeal plate not distinct; sclerotization lacking between dorsal bridge and tentorial bar; dorsal bridge and ventral pharyngeal ridges present; ventral bridge as wide as tentorial bar; mandibular sclerite T-shaped.

Prothorax. Anterior fold with setae not spicules.

Anterior spiracles (Figure 14). Anterior spiracles 0.06 mm long, truncate apically, brown, with a pair of oval, spiracular openings at the apex.

Mesothorax. Prolegs present with two rows of crochets.

Abdomen. Vestiture varying in size from 0.03 to 0.12 mm, fine, pale brown setae, except on the ventral surface, where pubescence is inconspicuous; anal segment coated in papillae with tufts of setae at their tips; first and second pairs of lappets indistinct but third pair of lappets conspicuous, 0.28 mm long; prolegs with two rows of crochets present on the first six abdominal segments.

Figures 14–17. Myolepta spp. SEMs. (14) M. difformis anterior spiracle. (15) M. difformis pupal spiracle in dorsal view. (16) M. difformis prp apical end showing laterally the spiracular plate and setae (notice the white patches, always coating extensively Myolepta species puparia). (17) M. obscura prp showing remains of the typical Myolepta white coating (dorsal view). Scale and other photo data are shown at the bottom of each figure.
**Pupal spiracles (Figure 15).** Separated by a distance twice their length, 0.46 mm long, yellow-brown in colour, club-tipped with irregularly spaced, rounded tubercles bearing three or four radially arranged spiracular openings on the enlarged apex; base sculptured with dome-shaped projections.

**Posterior respiratory process (Figure 16).** Length 1.96 mm; width at transverse band 0.22 mm (n=3); smooth, without sculpturing, yellowish brown in colour, with an indistinct transverse band and each spiracular plate bearing three pairs of gently curved, spiracular openings, interspiracular setae consisting of three or four long and conspicuous setal branches and a pit between the dorsal and dorso-lateral interspiracular setae.

**Material examined**

One puparium from larva collected 23 March 2004, from a 1.3 m high hole containing standing water on a F. angustifolia tree, Spain, Ciudad Real, Cabañeros National Park, Fresneda de Gargantilla, C. Pérez-Bañón and M. A. Marcos-García, puparium formed 3 May 2004, female emerged 19 May 2004; two puparia from larvae collected 19 March 2004, from a 2 m high hole with standing water from either a F. angustifolia or a Q. faginea tree, Spain, Ciudad Real, Cabañeros National Park, Cañalejas valley, M. A. Marcos-García, G. Rotheray, and G. Hancock, puparia formed 1 April 2004 and females emerged 14–15 April 2000.

**Myolepta obscura** Becher

**Puparium**

**Overall appearance.** Short-tailed larva with mouthparts of the saprophagous type (Rotheray and Gilbert 1999); sub-cylindrical in cross-section, truncate anteriorly, tapering posteriorly; prolegs bearing crochets present on mesothorax and first six abdominal segments; anal segment coated in papillae bearing tufts of setae; pupal spiracles tapered, not club-tipped and curved backwards; prp broad and black-brown.

**Dimensions.** Length 8.55 mm, range 8.42–8.67 mm; width 3.46 mm, range 3.17–3.75 mm (n=2).

**Head skeleton.** Similar in detail to *M. difformis* head skeleton (Figure 9).

**Anterior spiracles.** Similar to *M. difformis* (Figure 14); 0.08 mm long.

**Prothorax.** Anterior fold with setae not spicules.

**Mesothorax.** Prolegs present with two rows of crochets.

**Abdomen.** Vestiture varying in size from 0.04 to 0.09 mm, fine, pale brown setae except on the ventral surface, where pubescence is inconspicuous; anal segment coated in papillae with tufts of setae at their tips; first and second pairs of lappets indistinct but third pair of lappets conspicuous, 0.32 mm long; prolegs with two rows of crochets present on the first six abdominal segments.
Pupal spiracles (see M. difformis spiracles in Figure 15). Separated by a distance twice their length, 0.3 mm long, dark brown except yellow at apex, tapered and curved backwards with irregularly spaced, protruding, and rounded tubercles bearing three or four spiracular openings crowded at the apex of the dorsal surface; sculpture shiny but vaguely indicated dome-shaped projections at base.

Posterior respiratory process (Figure 17). Length 1.96 mm, range 1.92–2 mm; width at transverse band: 0.3 (n=2); smooth, without sculpturing, blackish brown in colour, with an indistinct transverse band and each spiracular plate bearing three pairs of gently curved, spiracular openings, interspiracular setae consisting of three or four long and conspicuous setal branches and a pit between the dorsal and dorso-lateral interspiracular setae.

Material examined

Two puparia from larvae collected 25 February 2006, in a wet hole of an east-orientated, live F. angustifolia tree trunk, España, Ciudad Real, Cabañeros National Park, Fresneda de Gargantilla, two males emerged 15 March 2006.

Discussion

This study is part of a wider project to investigate the Syrphidae of Cabañeros National Park in central Spain. As with previous studies (Rotheray et al. 2006) we concentrated on finding early stages as well as sampling adults using Malaise traps and other techniques. The value of including early stages in biodiversity and faunistic studies is revealed by the fact that in 2 years of trapping and searching, no adults of three of the four species considered here were obtained (M. dusmeti, M. difformis, and M. obscura).

Scanning electron microscopy has been important for finding diagnostic characters in syrphid early stages at both generic and species levels (Pérez-Bañón and Marcos-García 2000; Marcos-García and Pérez-Bañón 2001; Pérez-Bañón et al. 2003; Rotheray et al. 2006). Mallota species have long-tailed larvae (>body length) in contrast to Ferdinandea species which have larvae with contracted anal segments (<0.5 body length) and Myolepta species which have short-tailed larvae (from half, to as long as, body length). Mallota larvae can be distinguished from other long-tailed syrphid larvae by the smooth integument, lacking or almost lacking vestiture and by sensilla 7–9 aligned and often on a pair of fleshy projections, along the lateral margins of the 7th abdominal segment (Rotheray 1993). The puparium described as Milesia crabroniformis (Fabricius) by Matile and Leclercq (1992) shares these characters but we have examined this specimen and it is Mallota cimibiciformis (Fallén), as was also pointed out by Maibach and Goeldlin de Tiefenau (1989). Ferdinandea larvae can be distinguished from other saprophagous syrphids with contracted anal segments by lack of protruding mouthhooks and partially external, fleshy mandibular lobes on either side of the mouth (Rotheray and Gilbert 1999). Myolepta larvae can be distinguished from other short-tailed saprophagous larvae by fleshy papillae bearing tufts of setae that coat the anal segment and setae not spicules on the prothoracic anterior fold (Rotheray 1993). The puparia of the four species described here possess these distinguishing characters which adds support to their value in separating early stages at the generic level.

The early stages of M. dusmeti can be separated from those of M. cimibiciformis—the only other west European species with described early stages (Hartley 1961; Maibach and Goeldlin de Tiefenau 1989)—by the number of openings on the anterior spiracles. There
are 14 openings in *M. dusmeti* but 25 in *M. cimbiciformis*. Also the lateral ridge bears dark, fleshy projections on all abdominal segments whereas *M. cimbiciformis* has an inconspicuous ridge and projections are absent except on the 7th abdominal and anal segments. The early stages of an east European species, *Mallota eurasiatica* Stackelberg, have been described by Sivova et al. (1999). However, it is not possible from the description to separate the early stages of this species. The only other *Mallota* early stages described are from the Nearctic: *M. bautias* (Walker) and *M. posticata* (F.) (Snow 1949 in Maier 1978). The puparium of *M. bautias* apparently differs in having dorsally curved pupal spiracles (Maier 1978). The puparium of *M. posticata* differs from the other three species by not having a depressed and tapering prothorax and a “boat-shaped” profile (Figure 7). All *Mallota* species reared to date have been found in tree holes containing standing water. However, in addition to this breeding site, Sivova et al. (1999) record *M. eurasiatica* from sap under bark of *Ulmus* trees.

*F. fumipennis* can be separated from *F. cuprea*—the only other *Ferdinandea* species with early stages described (Lundbeck 1916; Hartley 1961; Dušek and Láska 1988; Rotheray and Gilbert 1999)—by the form of the prp and sclerotization of head skeleton. In *F. fumipennis*, there is a striated transverse indentation between the transverse band and the apex of the prp, whereas in *F. cuprea* this indentation is absent and the prp above the transverse band smoothly tapers to the apex (Figures 3, 4). The head skeletons of both species are similar but there are differences in the degree of sclerotization of the mandibular sclerite and the width of the tentorial bar anterior to the tentorial bridge. The mandibular sclerite is less heavily sclerotized and the tentorial bar anterior to the tentorial bridge is narrower in *F. cuprea* (Figures 1, 2).

In addition to *F. fumipennis* only two other *Ferdinandea* species have been reared. *F. cuprea* larvae are found in exudations of sap on the trunks of a wide range of deciduous trees (Rotheray 1993) and in roots of artichokes previously attacked by larvae of *Cheilosia vulpina* (Meigen) (Brunel and Cadou 1994). *F. ruficornis* has been reared from a *Cossus* sap run on *Populus* (Lundbeck 1916). The breeding record of *F. fumipennis* supports the idea that *Ferdinandea* larvae are associated with exudations of tree sap (Rotheray and Gilbert 1999). However, the extent to which other media, such as that found by Brunel and Cadou (1994), are used has yet to be evaluated.

The early stages of the two *Myolepta* species described here can be distinguished from each other by the pupal spiracles which are club-tipped in *M. difformis* and straight in *M. obscura* and from the colour of the prp which is yellowish brown in *M. difformis* and blackish brown in *M. obscura*. The only other *Myolepta* species with early stages described are *M. luteola* (Gmelin) (Becher 1882; Dušek and Láska 1960; Hartley 1961), *M. potens* (Harris) (Rotheray 1991) and *M. vara* (Panzer) (Sivova et al. 1999, figured by Dussaix 1997). The early stages of *M. vara* apparently differ from those of other *Myolepta* species by having three not two rows of crochets on the abdominal segments. *M. potens* differs from other species in having a lateral fringe of setae as long as the lappets on the anal segment and *M. luteola* differs by having the dorsal pair of spiracular openings at the apex of the prp longer than the other two pairs. In other *Myolepta* species a setal fringe on the anal segment is absent and the spiracular openings of the prp are more or less equal in length.

All reared species of *Myolepta* have been from tree holes, often small and containing wet decaying sapwood and vegetation: *M. obscura* in *Populus* (Becher 1882), *Acer, Fagus*, and *Populus* (Dušek and Láska 1960); *M. luteola* in *Fagus* and *Populus* (Hartley 1963); *M. potens* in *Fagus* (Rotheray 1991); *M. vara* in *Quercus* (Dussaix 1997) and *Ulmus* (Sivova et al. 1999). The breeding records of *M. difformis* and *M. obscura* support previous results that tree holes are the breeding site of *Myolepta* species.
Syrphids are rapidly becoming established as one of only a few key insect groups used for environmental assessment. Such assessments rely almost entirely on sampling the adult stage, for example using Malaise, sticky, or pan traps (Reemer 2005; Schweiger et al. 2005, 2007; Dziock 2006; Ouin et al. 2006; Burgio and Sommaggio 2007). These techniques tend to be biased, however, in that they will miss adults of species with restricted flight preferences. Unfortunately, adults of syrphid species that have greatest value for environmental assessment because they are rare and their habitats have suffered from losses and fragmentation, such as saproxylics, appear to fall into this category and are missed. Our results show such a sampling bias. We also show that such biases can be overcome by including searches for early stages. Furthermore, finding and assessing the quality and quantity of breeding sites is a critical requirement required to manage habitats for Syrphidae. To bring out and use syrphids to the full potential as a key assessment group, it is essential that early stages are included.

*F. fumipennis* was known only from Algeria, Morocco, and Tunisia (Kassebeer 1999) but Ricarte and Marcos-García (forthcoming) have recently recorded this species for Europe with material from the Iberian Peninsula and Balearic Islands. *M. obscura* has not been recorded previously from Spain (Marcos-García et al. 2002; Speight 2006) and is rare throughout its range of northern France through central Europe, the Balkans, and the Transcaucasus (Reemer et al. 2004). The records presented here extend the western range of this species into Spain. *M. difformis* has a range similar to *F. fumipennis* of Algeria, Morocco, and Tunisia, and Spain in Europe (Reemer et al. 2004). Within Spain *M. difformis* is known from Madrid, Valencia, Cáceres, Cádiz, and Salamanca (Marcos-García 1986). *M. dusmeti* is known from Spain and also from Tunisia (Speight 2006). In Spain it is classified as “vulnerable” in the Invertebrate Red Data book (Marcos-García 2006), being known only from Burgos, Cáceres, Madrid, and Salamanca (Marcos-García 1986). The shared ranges of North Africa and Europe for *F. fumipennis*, *M. difformis*, and *M. dusmeti* demonstrate a clear faunal link between these continents in terms of Syrphidae. The fact that the most northerly point of distribution of these species is Spain makes their conservation particularly important in that country. For this to be achieved, a key task will be the preservation of overmature trees where larvae of these species develop. Sympathetic management of woodlands with special attention to old trees would allow protection of these Syrphidae and other dependent saproxylic insects that have yet to be assessed in Spain. As our results, and also those of others such as the newly discovered weevil species (Coleoptera, Curculionidae) breeding in saproxylic macrofungi (Micó, personal communication) show, the potential for new discoveries remains high in Spanish woodlands.

**Acknowledgements**

We are very grateful to the director and staff of the Cabañeros National Park. Financial support for this work was provided by the Spanish Ministerio de Medio Ambiente (MMA-040/2002), the Spanish Ministerio de Educación y Ciencia (CGL2005-0713/BOS and grant number AP 2003-4001), and Generalitat Valenciana (ACOMP06/063) 017609. Thanks to J. Ordoñez for helping with the figure plates.

**References**

Andréu J. 1926. Una lista de sirfidos para contribuir al conocimiento de los dipteros de España. Boletín de la Sociedad Entomológica Española 9(5):98–126.
Becher E. 1882. Ueber die ersten Stande einiger Syrphiden und eine neue Myolepta Art. Wiener Entomologische Zeitung 1:249–254.

Brunel E, Cadou D. 1994. Syrphid larvae (Diptera: Syrphidae) mining the roots of artichoke (Cynara scolymus L.) in Brittany. Dipterists Digest 1:69–71.

Burgio G, Sommaggio D. 2007. Syrphids as landscape bioindicators in Italian agroecosystems. Agriculture Ecosystems and Environment 120:416–422.

Dzioczek F. 2006. Life-history data in bioindication procedures, using the example of hoverflies (Diptera, Syrphidae) in the Elbe floodplain. International Review of Hydrobiology 91(4):341–363.

Dušek J, Láska P. 1960. Beitrag zur Kenntnis der Schwebfliegen-Larven II. Právodovědny Časopis Slezský 21:299–320.

Dušek J, Láska P. 1988. Saprophage Larven von Ferdinandea cuprea und Brachypalpus valgus (Diptera, Syrphidae). Acta Entomologica Bohemoslovaca 85:307–312.

Dussaix C. 1997. Myolepta vara (Diptera, Syrphidae) reared in France (Dép. Sarthe). Dipterists Digest 4:18–19.

Hartley JC. 1961. A taxonomic account of the larvae of some British Syrphidae. Proceedings of the Zoological Society of London 136:505–573.

Hartley JC. 1963. The head apparatus of syrphid larvae and its relationship to other diptera. Proceedings of the Zoological Society of London 141:261–280.

Kassebeer CF. 1999. Eine neue Art der Gattung Ferdinandea Rondani, 1844 (Diptera: Syrphidae) aus Nordafrika. Dipteron 2:153–162.

Lundbeck W. 1916. Diptera Danica, 5 (Lonchopteridae, Syrphidae). Copenhagen: GEC Gad, p 591.

Maiach A, Goeldlin-de-Tiefenau P. 1989. Mallota cimbiciformis (Fallen) nouvelle pour la faune de Suisse: morphologie du dernier stade larvaire, de la pupe et notes biologiques (Diptera, Syrphidae). Bulletin de la Société Entomologique Suisse 62:67–78.

Maier CT. 1978. The immature stages and biology of Mallota posticata (Fabricius) (Diptera: Syrphidae). Proceedings of the Entomological Society of Washington 80(3):424–440.

Marcos-García MA. 1986. Nuevas citas para la fauna ibérica de Sirfidos (Diptera). Miscellanea Zoológica 10:205–211.

Marcos-García MA. 2006. Mallota dusmeti Andréu, 1926. In: Verdú JR, Galante E, editors. Libro Rojo de los invertebrados de España. Madrid: Ministerio de Medio Ambiente, Dirección General para la Biodiversidad. p 175.

Marcos-García MA, Pérez-Bañón C. 2001. Immature stages, morphology and feeding behaviour of the saprophytic syrphids Copesylum tamaulipanum and Copesylum lentum (Diptera: Syrphidae). European Journal of Entomology 98:375–385.

Marcos-García MA, Rojo S, Pérez-Bañón C. 2002. Family Syrphidae. In: Sociedad Entomológica Aragonesa (SEA), editor. Catálogo de los Dipteros de España, Portugal y Andorra (Insecta). Zaragoza: Sociedad Entomológica Aragonesa. p 132–136.(Monografías SEA; 8).

Matile L, Leclercq M. 1992. Répartition en France de Milesia crabroniformis (F.) et semiluctifera (Villers) et description de la pupe et des pièces buccales larvaires de M. crabroniformis (Dipt. Syrphidae Milesiinae). Entomologica Gallica 3:101–105.

Morris RKA. 1998. Hoverflies of Surrey. Woking: Surrey Wildlife Trust. 244 p.

Ouin A, Sarthou JP, Bouyjou B, Deconchat M, Lacombe JP, Monteil C. 2006. The species–area relationship in the hoverfly (Diptera, Syrphidae) communities of forest fragments in southern France. Ecography 29:183–190.

Pérez-Bañón C, Marcos-García MA. 2000. Description of the immature stages of Syritta flaviventris (Diptera: Syrphidae). European Journal of Entomology 97:131–136.

Pérez-Bañón C, Rojo S, Sátls G, Marcos-García MA. 2003. Taxonomy of European Eristalinus Fabricius, 1805 (Diptera: Syrphidae) using larval morphology and molecular data. European Journal of Entomology 100:417–428.

Reemer M. 2005. Saproxylic hoverflies benefit by modern forest management (Diptera: Syrphidae). Journal of Insect Conservation 9:49–59.

Reemer M, Hauser M, Speight MCD. 2004. The genus Myolepta Newman in the West-Palaearctic region (Diptera, Syrphidae). Studia Dipterologica 11:553–580.

Ricarte A, Marcos-García MA. 2007. Ferdinandea fumipennis Kassebeer, 1999 (Diptera: Syrphidae): new species for the European continent. Boletín de la Asociación Española de Entomología 31(1–2):205–208.

Roberts MJ. 1970. The structures of the mouthparts of syrphid larvae (Diptera) in relation to feeding habits. Acta Zoologica 51:43–65.

Rotheray GE. 1991. Larval stages of 17 rare and poorly known British hoverflies (Diptera: Syrphidae). Journal of Natural History 25:945–969.
Rotheray GE. 1993. Colour guide to hoverfly larvae (Diptera: Syrphidae). Sheffield: Derek Whitely, 155 p.

Rotheray GE, Dussaix C, Marcos-Garcia MA, Pérez-Bañón C. 2006. The early stages of three Palearctic species of saproxylic hoverflies (Syrphidae, Diptera). Micron 37:73–80.

Rotheray GE, Gilbert F. 1999. Phylogeny of Palearctic Syrphidae (Diptera): evidence from larval stages. Zoological Journal of the Linnean Society 127:1–112.

Rotheray GE, Hancock G, Hewitt S, Horsfield D, MacGowman I. 2001. The biodiversity and conservation of saproxylic Dipetra in Scotland. Journal of Insect Conservation 5:77–85.

Rotheray GE, MacGowman I. 2000. Status and breeding sites of three presumed endangered Scottish saproxylic syrphids (Diptera, Syrphidae). Journal of Insect Conservation 4:215–223.

Schweiger O, Maelfait JP, van Wingerden W, Hendrickx F, Billeter R, Speelmans M, Augenstein I, Aukema B, Aviron S, Bailey D, Bukacek R, Burel F, Diekötter T, Dirksen J, Frenzel M, Herzog F, Liira J, Roubalova M, Bugter R. 2005. Quantifying the impact of environmental factors on arthropod communities in agricultural landscapes across organizational levels and spatial scales. Journal of Applied Ecology 42:1129–1139.

Schweiger O, Musche M, Bailey D, Billeter R, Diekötter T, Hendrickx F, Herzog F, Liira J, Maelfait JP, Speelmans M, Dziock F. 2007. Functional richness of local hoverfly communities (Diptera, Syrphidae) in response to land use across temperate Europe. Oikos 116(3):461–472.

Sivova AV, Mutin VA, Gritskevich DI. 1999. Syrphid larvae (Diptera: Syrphidae) living in Ulmus pumila L. in Komsomolsk-on-Amur. Far Eastern Entomologist 71:1–8.

Speight MCD. 1989. Saproxylic invertebrates and their conservation. Strasbourg: Council of Europe. (Nature and Environment Series; 42).

Speight MCD. 2006. Species accounts of European Syrphidae (Diptera), Ferrara 2006. In: Speight MCD, Castella E, Sarthou J-P, Monteil C, editors. Syrph the Net, the database of European Syrphidae. Volume 54, Dublin: Syrph the Net Publications, 252 p.

Strobl G. 1909. Neue österreichische Muscidae Acalyptratae II. Weiner Entomologische Zeitung 28:283–301.