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# Life history and description of the immature stages of *Eumerus purpurariae* (Diptera: Syrphidae) developing in *Opuntia maxima*

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**Syrphidae, *Eumerus purpurariae*, immature stages, morphology, feeding behaviour, *Opuntia maxima*, pest control, Mediterranean ecosystem**

**Abstract.** *Eumerus purpurariae*, described from the Canary Islands (Atlantic), has been reared from the stems (platyclades) of the cactus *Opuntia maxima* (the first known host) on Nueva Tabarca, a Mediterranean island close to the Iberian coast. The egg, larva and puparium of *E. purpurariae*, as well as its life cycle on the above host-plant are described. The feeding behaviour of the larva in relation to the cephalopharyngeal skeleton morphology is analysed. Based on the present data, comparative table containing the main morphological characteristics of the injurious *Eumerus* species of the Palaearctic region is presented.

## INTRODUCTION

Larvae of *Eumerus* have been found to be very destructive on a variety of host-plants of economic importance in Europe and America, known as insect pests on bulbs of Amaryllidaceae (narcissus), Liliaceae (onion and hyacinth), Iridaceae (iris), stems of Umbelliferae (parsnip and carrot), tubers of Solanaceae (potato), roots of Compositae (salsify), as well as bulbs and roots of Orobanchaceae [*Cistanche phelypaea* (L.) Cout. = *C. tinctoria* (Forskal) G. Beck] (Hodson, 1927; Assem & Nasr, 1967; Arzone, 1972; Waitzbauer, 1976; Farag & Doss, 1981; Dirickx, 1994). Furthermore, adults of *Eumerus strigatus* (Fallén, 1817) were also attracted to decomposing oatmeal bait (Doane, 1983).

Peck (1988) lists 140 Palaearctic *Eumerus* species, but only three occur in the Nearctic region: *E. tuberculatus* Rondani, 1857, *E. strigatus* (Fallén, 1817) and *E. narcissi* Smith, 1928, all three introduced by man from Europe, probably inside imported bulbs (Smith, 1928; Vockeroth & Thompson, 1987). Although *Eumerus* is the second largest syrphid genus in the Palaearctic region, the available information about larval morphology and biology is extremely limited, with few detailed studies (Waitzbauer, 1976; Arzone, 1972; Hodson, 1927). Information about the habits, ecology etc. of *Eumerus purpurariae* Baez, 1982 is lacking. The only available data is the original description of the adult from the Canary Islands (Baez, 1982). The present data indicate that the geographical distribution of *E. purpurariae* extends to the Mediterranean.

Prickly-pear cacti (*Opuntia* spp., Opuntiaceae) were introduced deliberately into Europe in the 16th century from the New World, in conjunction with the cochineal trade, for their edible fruits, drought resistance, the emergency forage value of certain spineless forms and as garden ornamentals. In several Mediterranean countries, certain species became serious agricultural pests (Dodd, 1940). Although species of *Copestylum* Macquart have been reared from *Opuntia* in the New World (Bugbee & Reigel, 1945), *E. purpurariae* and *Syritta pipens* (Linnaeus, 1758) are the first syrphid species found to develop in decaying platyclades (i.e., the stems) of *Opuntia maxima* Miller in the Mediterranean region.

The objectives of the present study were: (1) to describe the egg, larva (L3) and puparium of *E. purpurariae*; (2) to study the feeding behaviour in relation to the cephalopharyngeal skeleton morphology; (3) to describe the life cycle of *E. purpurariae* in the wild on *O. maxima*, and (4) to find out the differential characteristics of the larvae of *E. purpurariae*, in comparison with the larvae of the other *Eumerus* species.

## MATERIAL AND METHODS

Descriptions are based on immature stages collected in decaying platyclades of *Opuntia maxima* from Nueva Tabarca (38°9′57″N, 0°28′2″W; YH2027, YH2127), a small Mediterranean island (43 ha) off the coast of Alicante province (south-eastern Spain). Adults of *E. purpurariae* have repeatedly been observed on and around the platyclades of *O. maxima*. Examination of these platyclades revealed that the larvae and puparia of *E. purpurariae* were confined to damaged and decaying platyclades.

Descriptions of the immature stages are based on preserved specimens, with larval characters checked against living specimens in order to minimise errors due to preservation. Illustrations and dimensions (mean ± standard error) were made using a binocular microscope with an eyepiece micrometer and a drawing tube. The photographs were taken with a JEOL 840 scanning electron microscope (SEM) operated at 20 kV.

The eggs were preserved permanently in Pampel's solution (glacial acetic acid : formaldehyde 40% : alcohol 95% : distilled water, 4 : 6 : 15 : 30 in volume). Their description follows the terminology of Chandler (1968).

Rearing took place in a growth chamber at 16–22°C, 65–85% r. h. and a constant photo-regime with 15L : 9D photoperiod. Each larva was kept in a cylindrical plastic cage (40 mm high, 80 mm wide) half full of decaying material from *O. maxima* platyclades. Cages were checked weekly and food was supplied as required until pupation. Puparia were placed individually in 55 mm diameter dishes and inspected daily until the emergence of the adult. Adults were identified according to type material lent to us by the Department of Animal Biology, University of La Laguna, Canary Islands.

Third-instar larvae were selected for preservation. Typically, the larvae of this instar have two discs of differentiated cuticle on the dorsal surface of the first abdominal segment. For permanent preservation, larvae were placed in cold water and boiled slowly for about 4 min and transferred to 70% alcohol. Cuticular structures were rendered more visible by immersion in lactic acid for 24 h. The positions of the sensilla were numbered sequentially from the dorsal to the ventral surface for each segment (Rotheray, 1991). Terminology used for descriptions of the larvae follows Hartley (1961) and Rotheray (1993).

The cephalopharyngeal skeleton of the third instar was removed from the leading ventral edge of the interior of the puparia, steeped briefly in hot KOH, then preserved in glycerine until examination. Morphological terminology of this stage follows Whittington (1994).

Voucher specimens of adult and immature stages of *E. purpurariae* have been deposited in the Entomological Collection of Alicante University (CEUA).

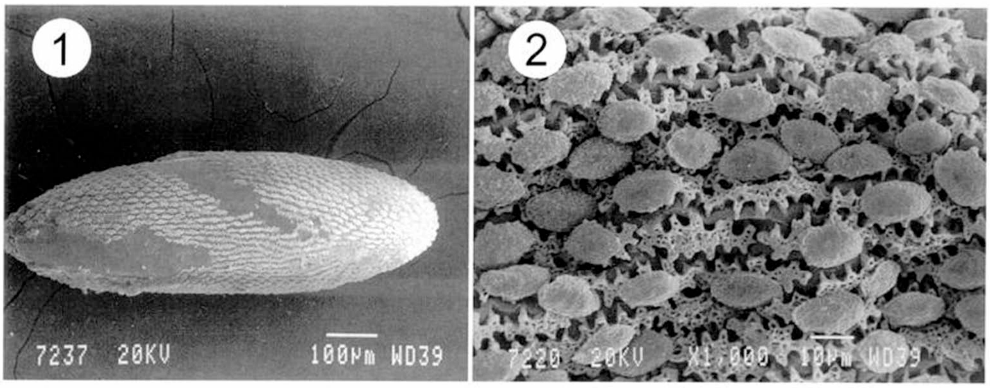
Internal platyclade temperatures were registered by a datalogger (StowAway XTI).

## RESULTS

### Description of the immature stages

#### Egg

Length 0.82 ± 0.012 mm, maximum width 0.29 ± 0.006 mm (N = 20). White in colour when recently laid, greying slightly on development. Elongated-oval in shape, rounded at both ends and slightly tapering towards anterior pole (Fig. 1). The ventral surface (in contact with the substratum) is slightly flattened while the dorsal surface is clearly convex.




Figs 1–2: *Eumerus purpurariae* egg. 1 – egg in dorsal view; 2 – ultrasculpture of the egg chorion.

The micropyle appears as an inconspicuous black spot on the anterior pole. The mid-dorsal and mid-ventral chorion ultrastructure examined under SEM show round units lined longitudinally with clear side-branches (Figs 1–2). The chorionic surface sculpturing under a light microscope (Chandler, 1968) shows dotted lines with margins infolded substantially.

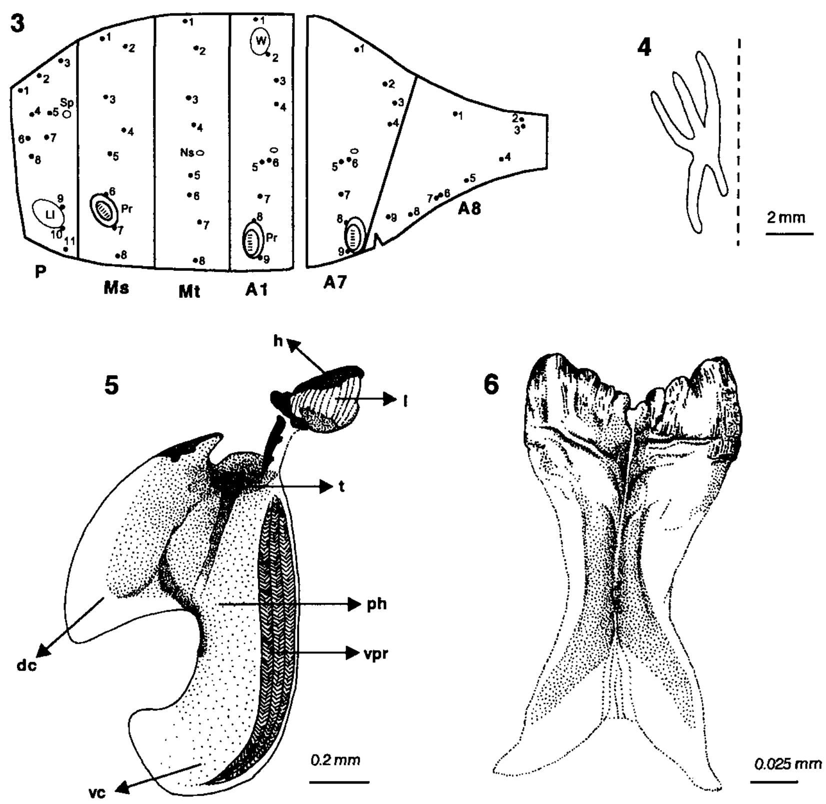
Third larval instar (L3)

Length 21.2 ± 0.48 mm, maximum width 2.3 ± 0.10 mm (N = 20). Overall appearance: Larva with external mouth-hooks and a short caudal process bearing a conspicuous pair of fleshy lappets just before the tip (Fig. 8). Subcylindrical in cross-section with flattened ventral surface, tapering slightly anteriorly and likewise, but strongly so, posteriorly. Cuticle translucent in life, cream to off-white after fixation. Hind gut green and visible through the translucent body in actively feeding individuals, otherwise hind gut obscured by white adipose tissue. General body surface coated in minute, pointed and unpigmented spicules backwardly directed which are shorter on the ventral surface except for the anal segment.

HEAD. Mouth-hooks (h) prominent externally with tips toothed and heavily sclerotised. Mandibular lobes (l) externally fleshy and slightly obscured. Dorsal lip with a covering of long and dense pubescence. Antenno-maxillary organs well developed (Fig. 13). Cephalopharyngeal skeleton: Mouth-hook crescent-shaped and toothed apically, dorsally not curved (Fig. 5). Mandibular lobes well developed, ribbed, with combs of filaments on inner ridges. Pharyngeal sclerite (ph) pigmented darkly medially and on tentorium (t), with dorsal cornu (dc) short and rounded, ventral cornu (vc) long and dorsally curved. Ventral pharyngeal ridges (vpr) with ribbed cibarial filter.

THORAX. Lateral lips (Ll) well developed (in profile projecting forward from the anterior part of the prothorax) and covered with long and fine setae (Fig. 3). Anterior respiratory process sclerotised weakly, short and narrow. Lateral margin of mesothorax (Ms) with two patches of sclerotised spicules surrounding sensilla 4 and 5. Prolegs (Pr) present on mesothorax.

ABDOMEN. Primordia of pupal spiracles obvious on dorsal surface of first abdominal segment. Ventral prolegs (Pr) well developed, 7 abdominal pairs present. Each proleg (including mesothoracic) with 2 or 3 rows of apically brown hooks (Fig. 7), directed rearward except on the last abdominal pair where they are anteriorly directed. Anal segment with a




Figs 3–6: *Eumerus purpurariae*, third-instar larva. 3 – map of the chaetotaxy showing the positions of the sensilla group on: P – prothorax; Ms – mesothorax; Mt – metathorax; A1, A7 – first and seventh abdominal segments; A8 – anal segment; Ns – nonfunctional spiracle; Ll – lateral lip; Pr – proleg; Sp – anterior functional spiracle; W – area of differentiated cuticule through which the pupal spiracle will be thrust. 4 – right halves of the evaginated anal papillae. 5 – cephalopharyngeal skeleton, lateral view: h – mouth-hooks; l – mandibular lobes; t – tentorium; dc – dorsal cornu; vc – ventral cornu; vpr – ventral pharyngeal ridges; ph – pharyngeal sclerite. 6 – mandibular sclerites, dorsal view.

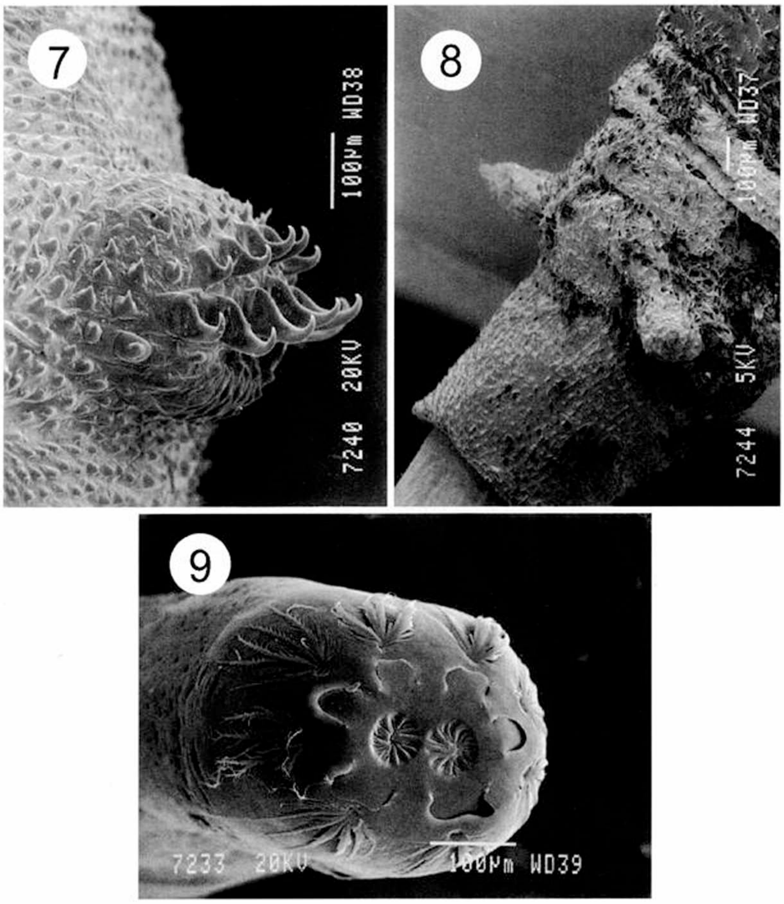
pair of fleshy lappets (Fig. 8). Anal papillae protruding, 6 anterior and 4 posterior filaments (Fig. 4).

Posterior respiratory process (prp). Length 1.6 ± 0.03 mm; width: at base 0.5 ± 0.01 mm, at tip 0.38 ± 0.009 mm (N = 20). Lustrous, brown in colour, with three spiracular slits arranged around two central scars. First and third spiracular slits with sinuous shape and second with a horse-shoe shape; all with their ends pointing towards the central scars. Four pairs of spiracular setae with at least five branches (Fig. 9).

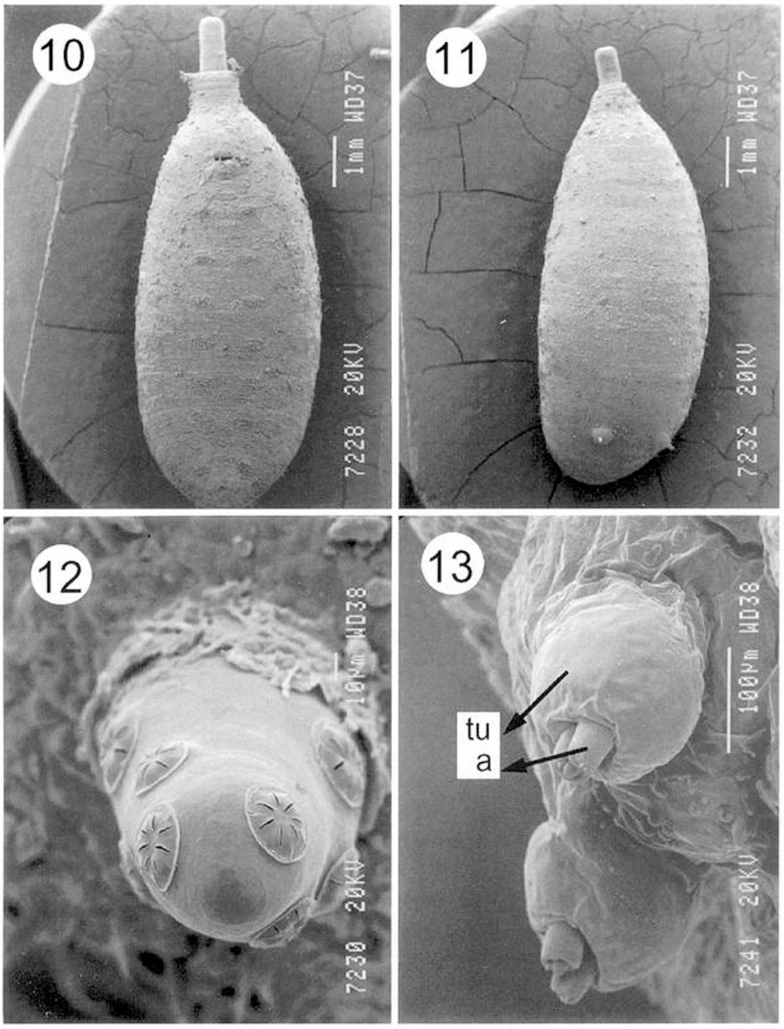
Chaetotaxy. Prothorax (P) with 11 pairs of sensilla; mesothorax (Ms) and metathorax (Mt) with 8 pairs; abdominal segments 1–7 with 9 pairs; anal segment with 9 pairs (Fig. 3).

Puparium

Length including posterior respiratory process 10.1 ± 0.29 mm, maximum width 3.5 ± 0.08 mm (N = 20). Subcylindrical in cross-section. Anterior extreme rounded, tapered posteriorly and flattened slightly ventrally (Fig. 10). Integument rough, with segmentation of larvae persisting as transverse folds and wrinkles. Dull brown in colour. Ventral surface with prolegs on mesothorax and first 7 abdominal segments (Fig. 10); each proleg with crochets in two parallel rows. Crochets in anterior row bigger than those in posterior row. Dorsally, the two thoracic respiratory processes protrude on the upper half of the operculum (Fig. 11). These processes are subconical structures (Fig. 12), pointed apically and with numerous disc-shaped spiracular openings, distributed irregularly on their surface.




Figs 7–9: *Eumerus purpurariae*, third-instar larva. 7 – second abdominal proleg, lateral view; 8 – dorsal view of the anal segment showing a pair of lappets; 9 – spiracular plate of the posterior respiratory process.




Figs 10–13: *Eumerus purpurariae*. 10–12: Puparium. 10 – ventral view; 11 – dorsal view; 12 – thoracic respiratory process. 13 – larva, antenno-maxillary organs: tu – tubercles; a – antenna.

Each disc has 6 to 10 oval apertures. Anal segment with a short tail and one pair of lappets. Posterior spiracular process as in the larva.

## Life-history

The eggs observed in the field were laid individually or in clutches, on the platyclades of *O. maxima*, either on their surface or in platyclade folds.

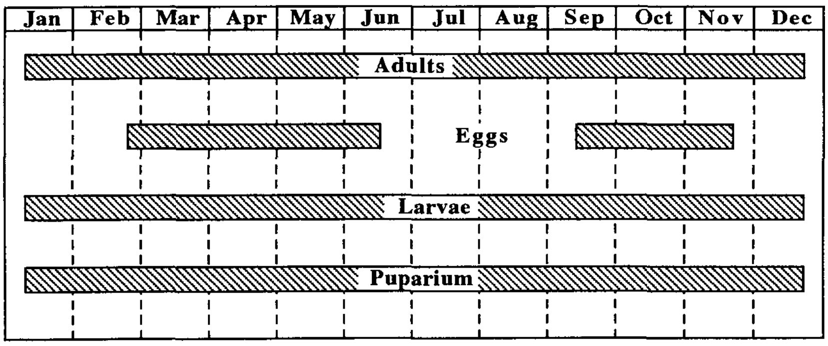



Fig. 14. Phenology of *Eumerus purpurariae*.

The larvae develop only inside decaying platyclades, both on the plant and fallen, where life cycle is completed. Generally, infested platyclades contain numerous larvae. This means that either females lay eggs in clutches or several females choose the same place to oviposit.

The puparia were frequently found inside old dried platyclades where the decaying process was over, as well as on the surrounding ground.

The eggs were laid in the field from early to late spring (February–June) and during autumn (September–November). However, larvae and puparia could be found throughout the whole year together with the adults (Fig. 14). The pupal period was 19–25 days.

Field observations suggest that *E. purpurariae* larvae have a wide tolerance to temperature from high temperatures in summer (45°C) to low temperatures in laboratory conditions (–4°C).

In the course of the present fieldwork in Nueva Tabarca, immature stages of the syrphid *Syritta pipiens*, as well as those of the family Milichiidae (Diptera) were also found to develop in decaying platyclades of *O. maxima*. Moreover, we have evidence that larvae of *E. purpurariae* and *S. pipiens* also develop inside *O. maxima* platyclades from other coastal areas of Alicante province.

## DISCUSSION

The gregarious behaviour of the larvae of *E. purpurariae* on *O. maxima* was similar to those of *E. strigatus, E. tuberculatus* and *E. amoenus* on their host plants (Hodson, 1927; Assem & Nasr, 1967). The spatio-temporal coincidence between the larvae of *Syritta pipiens* and *Eumerus* spp. was also found by Hodson (1931) in decaying bulbs of narcissus.

The larvae of *Eumerus* species may be distinguished according to the following characteristics: (1) number and relative positions of the lappets in the anal segment; (2) number and arrangement of teeth in the mouth-hook and (3) presence or absence of prolegs (Table 1).

The study of the third-instar larvae of *E. purpurariae* indicates similarities with those of *E. obliquus* (Fabricius, 1805). Morphological similarity between larvae of these two species is perhaps due to their similar food preferences (decaying fluids from plant tissues). Larvae of *E. obliquus* and *E. purpurariae* have well developed prolegs (which are absent

TABLE 1. Comparison of main morphological characters of third-instar larvae of *Eumerus* species.

| Character | Third-instar *Eumerus* larva | | | | | |
|---|---|---|---|---|---|---|
| | *E. purpurariae* | *E. tuberculatus* | *E. tricolor* | *E. strigatus* | *E. obliquus* | *E. compertus* |
| Spiracular setae (prp) | well developed | well developed | absent | well developed | well developed | absent ** |
| Lappets (projection around the anal segment) | only 1 pair of lappets | 3 pairs well developed (middle pair of lappets divided in two) | 1 pair of dorsal lappets ending in 1 or 2 tips | 3 pairs well developed (middle pair of lappets divided in two) | only 1 pair of lappets | 1 pair of dorsal lappets ending in 1 or 2 tips |
| Mouth-hooks | only inner margin toothed, with usually 3 prominent pairs of teeth | both margins toothed, with usually 5 prominent pairs of teeth | * | both margins toothed, with usually 7 prominent pairs of teeth | * | both margins toothed, inner margin with only 1 pair of teeth, external margin with usually 5 pairs of teeth |
| Prolegs | well developed, with 2 or 3 rows of crochets | absent or vestigial | absent or vestigial | absent or vestigial | well developed | absent or vestigial |
| Antenno-maxillary organs | antennae-bearing tubercles widely separated (cf. Fig. 13) | pronounced grooves between antennae-bearing tubercles | antennae-bearing tubercles widely separated | shallow or no grooves between antennae-bearing tubercles | antennae-bearing tubercles widely separated | antennae-bearing tubercles widely separated |

* Character not described for *E. tricolor* (Arzone, 1972) and *E. obliquus* (Moor, 1973).
** G.E. Rotheray, pers. comm.

in *E. strigatus*, *E. tuberculatus*, *E. compertus* and *E. tricolor*) (Dixon, 1959; Hartley, 1961; Rotheray, 1993), and only one pair of lappets around the anal segment (Table 1). Unfortunately, Moor (1973), in the original description of the immature stages of *E. obliquus*, did not include the description of the cephalopharyngeal skeleton. We studied specimens of the latter species but were not allowed to dissect them to fullfil Moor's description.

The present data from rearing of *E. purpurariae* in the laboratory and from observations in the wild indicate saprophagous feeding habits for the larva living and feeding inside decaying platyclades. Due to this habit, the larvae may accelerate the decomposition process of *O. maxima* platyclades as has been observed in other *Eumerus* species living on bulbs (Creager & Spruijt, 1935).

The morphology of the cephalopharyngeal skeleton of *E. purpurariae* accords well with the feeding data observed. Dowding (1967) reported that the presence of the ventral pharyngeal ridges indicates a saprophagous feeding habit. The ventral pharyngeal ridges select the appropriate food particle size, permitting partial digestion before swallowing of the particles and increasing efficiency of food utilisation by its concentration (Roberts, 1969). In fact, *E. tuberculatus* and *E. strigatus*, which also have ventral pharyngeal ridges, require the presence of certain living fungi, together with the bulb media, in order to complete their normal development (Creager & Spruijt, 1935). It appears that some of these lower organisms (bacteria, protozoa, fungal spores and yeast) or their digestion products are also ingested by the larvae. However, sclerotised mouth-hooks, toothed and protruding from the mouth, are typical of the phytophagous species (Rotheray, 1993). In conclusion, the present results indicate that morphological characters of larvae of *E. purpurariae* are related to both phytophagous and saprophagous hoverfly larvae.

Only a few Palaearctic syrphid genera have truly phytophagous larvae (some species of *Cheilosia* Meigen, 1822, *Portevinia* Goffe, 1944 and *Merodon* Meigen, 1803; see Speight, 1986). Generally, the mouthparts of larvae of *Eumerus* differ from those phytophagous by possessing less sclerotised, weaker mouth-hooks, used to rake the soft food, and mandibular lobes which are fleshy and covered with ridges for guiding the fluid food (Rotheray, 1993). Strictly phytophagous larvae, such as those of *Cheilosia grossa* (Fallén, 1817), bear mouth-hooks and mandibular lobes which are fused and heavily sclerotised, adapted to rasping relatively solid food (Rotheray, 1993). The fact that the larvae of *E. purpurariae* bear a combination of both phythophagous and saprophagous characteristics supports the hypothesis of Rotheray (1993) that *Eumerus* could be the evolutionary ancestor of phytophagous hoverflies.

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