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APHIDOPHAGOUS PREDATOR DIAGNOSIS: KEY TO GENERA OF EUROPEAN CHRYSOPID LARVAE *(NEUR. : CHRYSOPIDAE)*

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Keys, based on the morphology of first- and third-instar larvae, are described for distinguishing the 13 genera of European Chrysopidae. The eggs, first-instar larvae and third-instar larvae of all genera are illustrated. Data on the biology and behaviour of the larvae are also presented.

KEY-WORDS: Chrysopidae, larvae, eggs, key, Europe.

The family Chrysopidae Schneider, 1851 is one of the largest and most economically important families of the Neuroptera. Chrysopid larvae feed on aphids, coccids and other harmful arthropods and, for this reason, several species have received special attention as biological control agents. Among these are the common green lacewing *Chrysoperla carnea* (Stephens, 1836) and a few species of the genus *Chrysopa* Leach, 1815. However, information on other species which could prove to be important predators in biological control programmes is rather scant.

In Europe the family Chrysopidae is represented by 13 genera, which contain a total of 63 species (Aspöck, 1992; Monserrat & Rodrigo, 1992). The classification of the Chrysopidae has been based largely on adult morphology (Brooks & Barnard, 1990) and consequently relatively little information is available on larval morphology. However, in recent years several papers have been published on the taxonomy of chrysopid larvae found in Central Europe (Gepp, 1983), in France (Canard & Labrique, 1989; Labrique & Canard, 1989; Labrique, 1990) and in the Iberian Peninsula (Monserrat, 1984, 1989; Diaz-Aranda & Monserrat, 1988, 1990a, 1990b, 1991, 1992, 1994, 1995). Nevertheless, the data are sparse and there is still a considerable lack of knowledge concerning the pre-imaginal stages.

In the search for natural predators of aphids that could possibly be used as biological control agents, it is usual to consider a habitat as suitable for a particular species when eggs, mature larvae and ovipositing adults can all be found in the habitat (Coderre & Tourneur, 1986). The aim of the present work is to illustrate how to identify the pre-imaginal stages of the various genera of the European chrysopids and to provide additional information on the egg-deposition and the behaviour of larvae.

MATERIAL AND METHODS

In this paper the first-, second- and third-instar larvae of 38 species from the 13 European genera are described. Specimens were examined from at least half the species within each

genus. For completeness, although the larval stages of some species had been described in considerable detail by other authors (see Aspök *et al.*, 1980 and Brooks & Barnard, 1990) they were still included in this study.

The pre-imaginal stages used in the taxonomic studies were obtained from fertile females collected from the field and were maintained under laboratory conditions (Temperature: 21-26 °C; Relative Humidity: 60-80 % and Photoperiod: 16L: 8D). In some cases, larvae were collected directly from the field.

Specimens of all instars were killed in KAAD solution and then preserved in 70 % ethyl alcohol. To examine the specimens in detail, they were cleared in hot lactic acid and then mounted on slides in glycerin.

The chaetae on the head have been named using the system of Rousset (1966) (fig. 4b). Thoracic and abdominal setae were named using the system described by Tsukaguchi (1978). For convenience, other morphological characters which are useful in distinguishing the larvae of European Chrysopidae, are named as shown in fig. 3, 5a, b. The segments are divided into 5 regions, namely anterior-, lateral-, laterodorsal-, submedial- and spiracle-region. In each region the setae or the tubercles are named assigning the appropiate aforementioned prefix (fig. 5a, b). The generic classification of Chrysopidae follows Brooks & Barnard (1990).

Recognition of three instars

First instar larvae (L-1) are distinguished easily by their small size and pale body. The setation consists of a small number of primary setae (fig. 5a, b). The lateral tubercles bear, at most, 2 setae on the prothorax and abdominal segments II-VII; and 3 setae on the meso- and metathorax. Each seta arises from a small conical tubercle (fig. 6-17). Third instar larvae (L-3) are invariably coloured and bear large numbers of secondary setae. The lateral tubercles of the thorax and abdomen also usually bear numerous setae (fig. 18-29). Second instar (L-2) have characteristics that are intermediate between the earlier (L-1) and later (L-3) instars (Tsukaguchi, 1978).

IDENTIFICATION KEYS

Key to genera of European Chrysopid first-instar larvae (L-1)

(1) Distal segment of antenna about 10 times shorter than medial segment, with a group of small apical setae (fig. 1b) ..... **SUBFAMILY NOTHOCHRYSINAE (12)**

– Distal segment of antenna about 3 to 6 times shorter than medial segment, with a long apical setae (fig. 1a, c) ..... **SUBFAMILY CHRYSOPINAE (2)**

(2) Mouthparts shorter than cephalic capsule. Thoracic lateral-tubercles bearing 8-10 serrated setae (fig. 3a). Meso- and metathorax with numerous dorsal rows of hooked setae (fig. 3b-11). Antenna with distal segment as in fig. 1c ..... **TRIBE BELONOPTERYGINI** (*Italochrysa* Principi, 1946)

– Mouthparts as long as, or longer than cephalic capsule. Thoracic lateral-tubercles bearing, at most, 2-3 setae (fig. 5), never serrated. Meso- and metathorax without dorsal rows of hooked setae. Antenna with distal segment as in fig. 1a ..... **TRIBE CHRYSOPINI (3)**

(3) Body humped, with dorsal setae long and hooked (fig. 5a). Thoracic and abdominal lateral-setae long, pointed and spoonbilled (fig. 3c and 3e). Larva coats itself with debris (fig. 6-10) ..... **(4)**

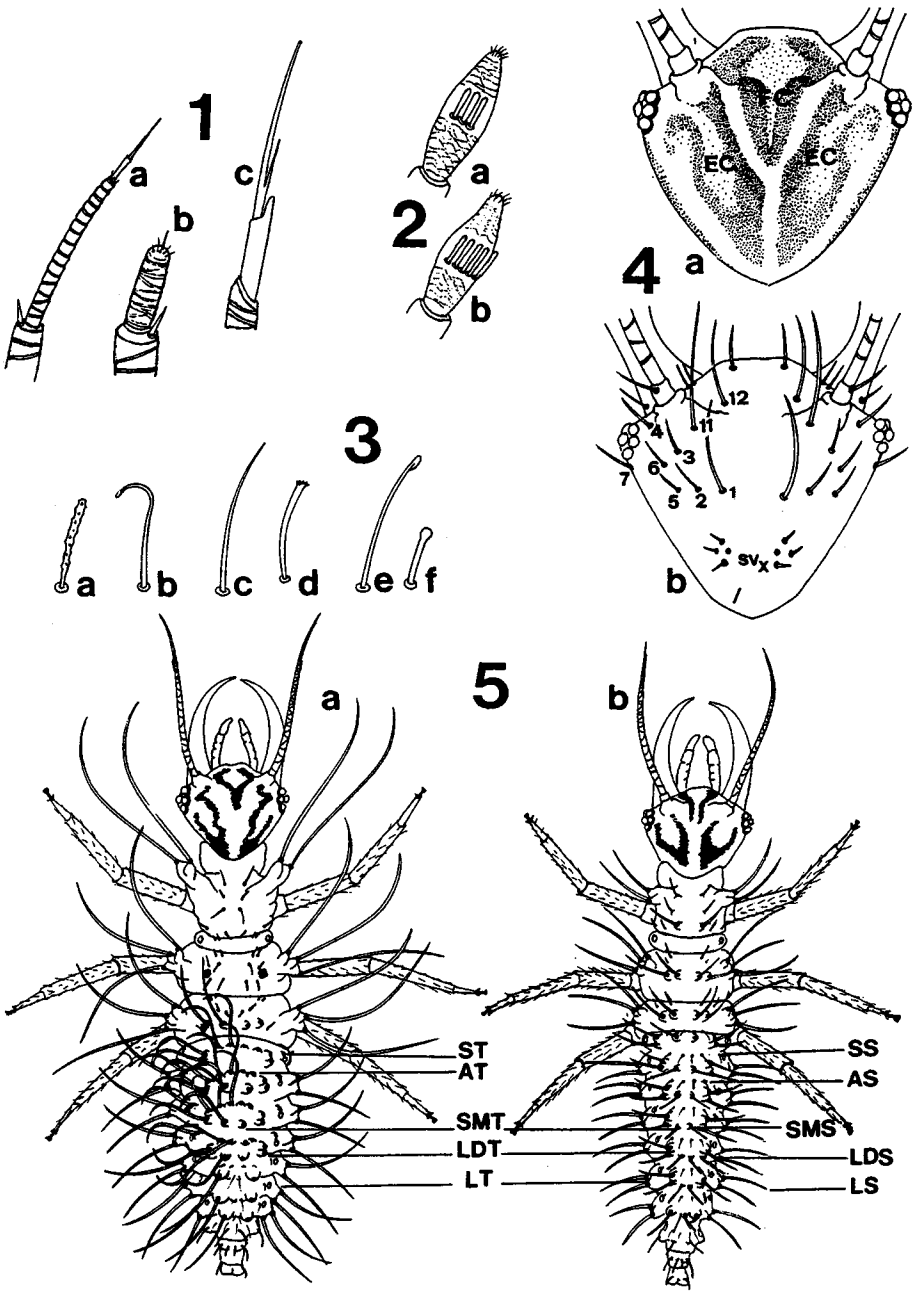

Fig. 1-5. 1.- Distal segment of antennae. 2.- Sensilla on distal segment of labial palps. 3.- Setae, a: serrated, b: hooked, c: pointed, d: multi-pointed, e: spoonbilled, f: knobbed. 4.- Cephalic capsule (dorsal view), a: cephalic markings, FC: Frontoclypeal, EC: Epicranial, b: cephalic chaetotaxy. 5.- First instar larvae, a: larva that coasts itself with debris, b: larva naked, (see text).

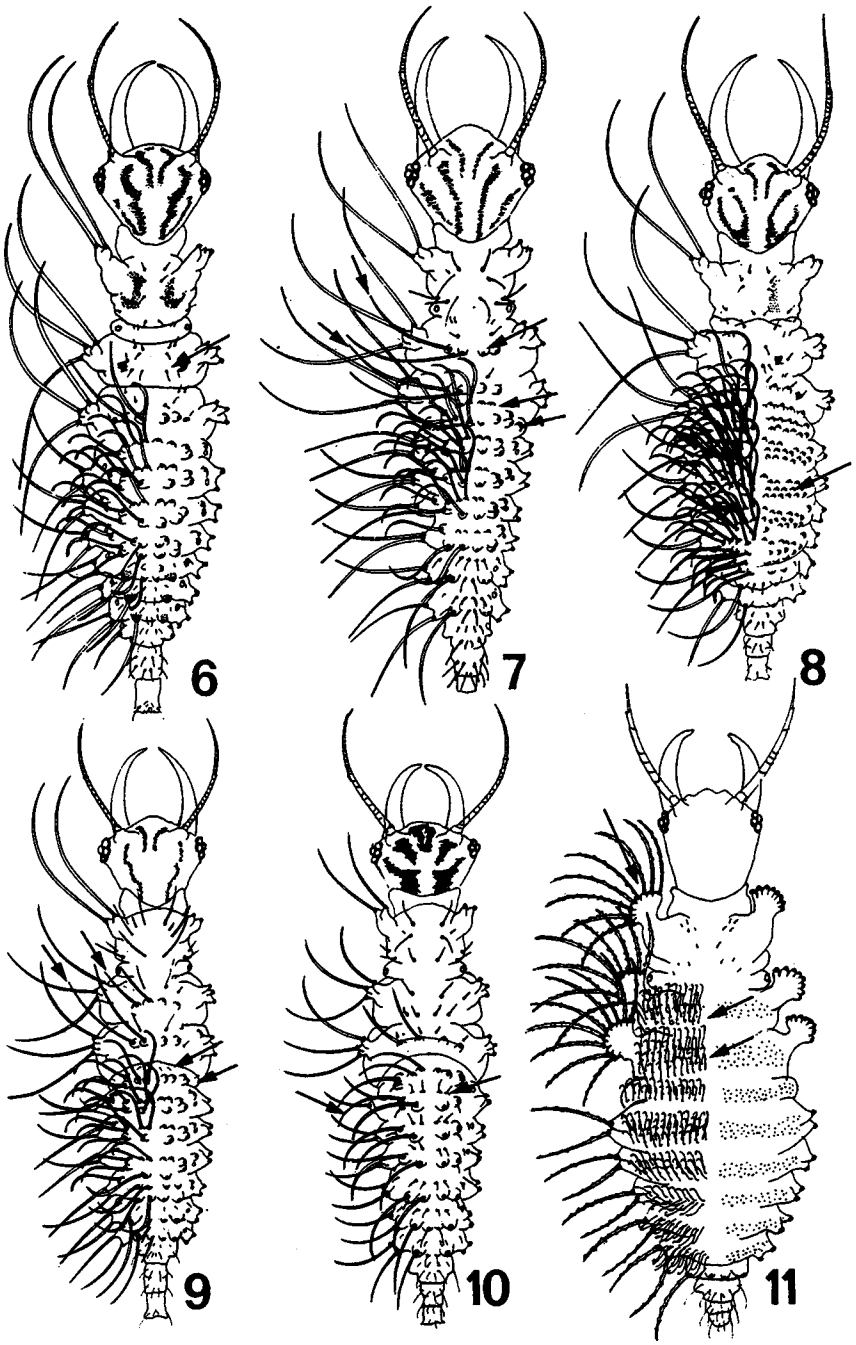

Fig. 6-11. First instar (l-1) of larvae that coat themselves with debris. 6.- *Mallada (M. venosus).* 7.- *Cunctochrysa (C. baetica).* 8.- *Suarius (S. walsinghami).* 9.- *Chrysopidia (C. ciliata).* 10.- *Rexa (R. lordina).* 11.- *Italochrysa (I. stigmatica).*

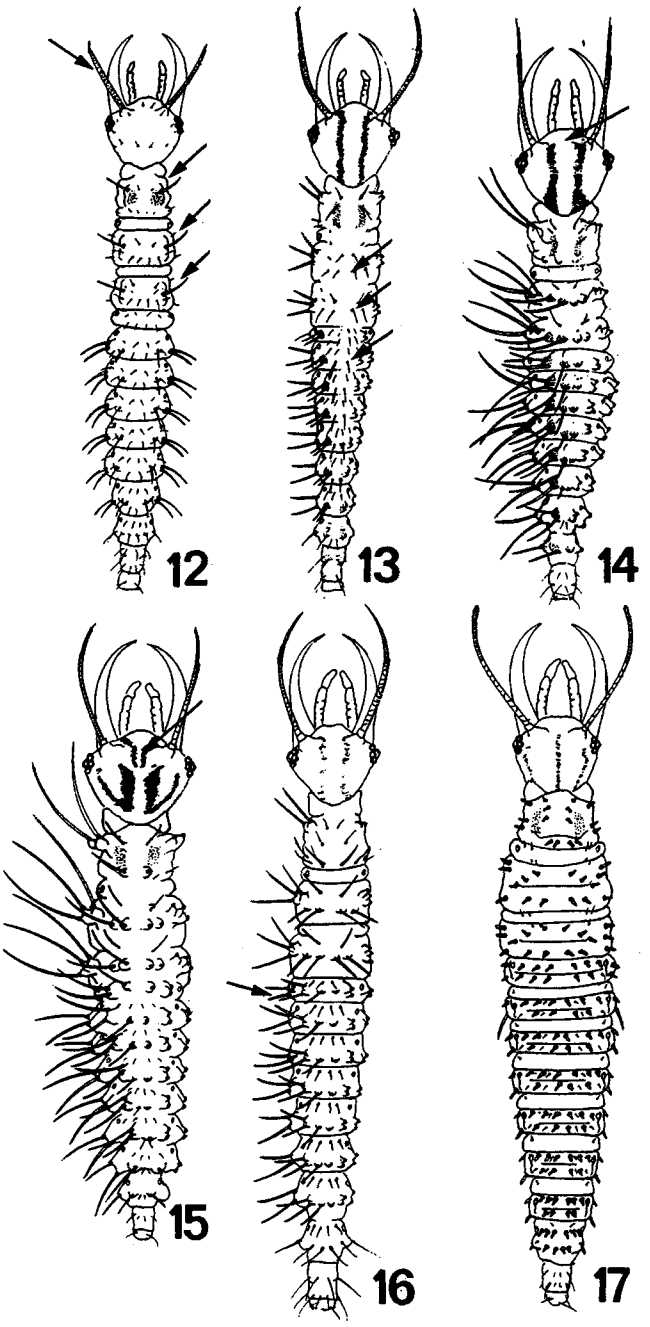

Fig. 12-17. First instar (L-1) of naked larvae. 12.- *Brinckochrysa (B. nachoi).* 13.- *Peyerimhoffina (P. gracilis).* 14.- *Chrysoperla (C. mediterranea).* 15.- *Chrysopa (C. regalis).* 16.- *Nineta (N. guadarramensis).* 17.- *Hypochrysa (H. elegans).*

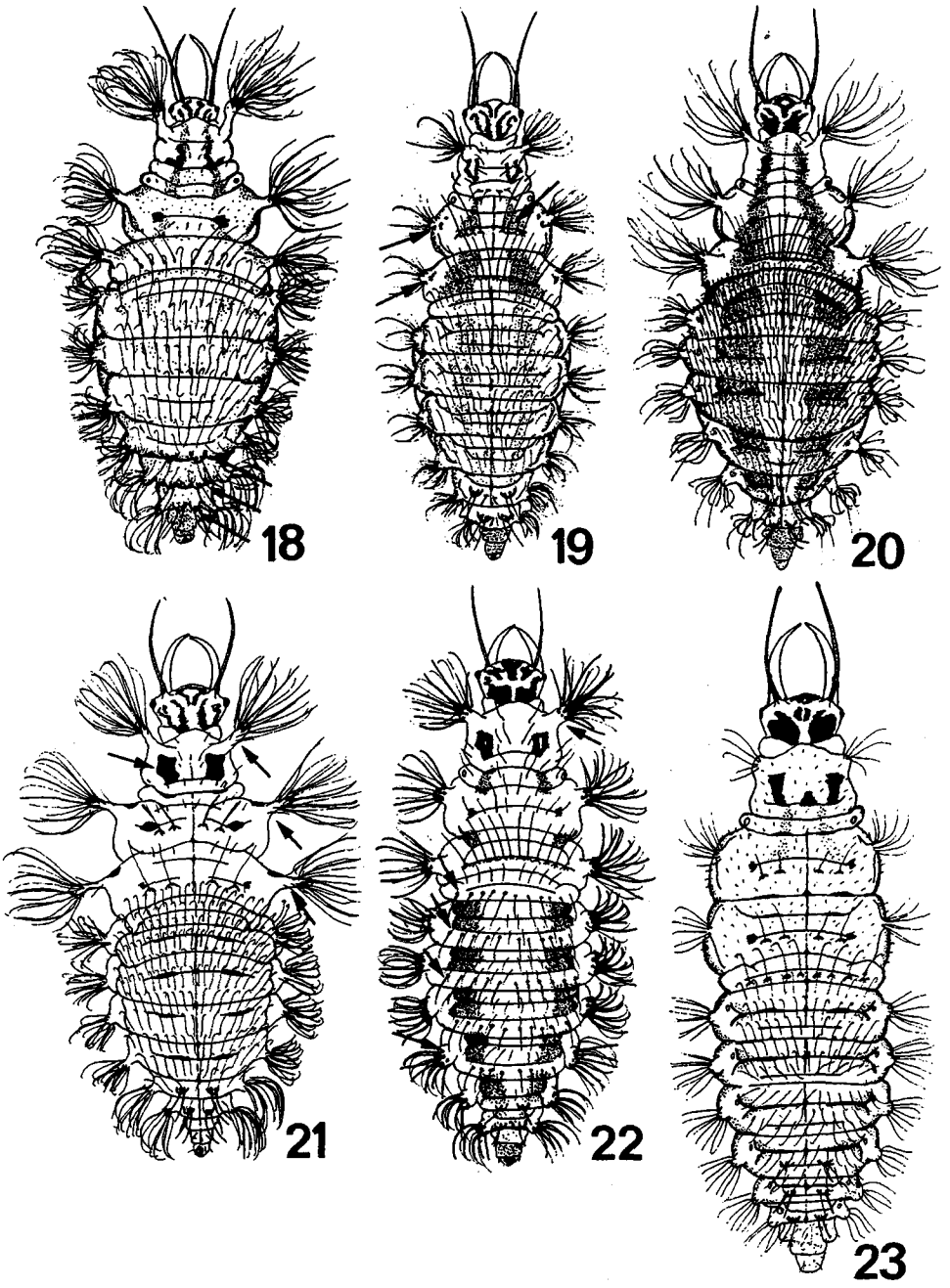

Fig. 18-23. Third instar (L-3) of larvae that coat themselves with debris. 18.- *Mallada (M. venosus).* 19.- *Cunctochrysa (C. baetica).* 20.- *Suarius (S. walsinghami).* 21.- *Chrysopidia (C. ciliata).* 22.- *Rexa (R. lordina).*23.- *Nothochrysa (N. fulviceps).*

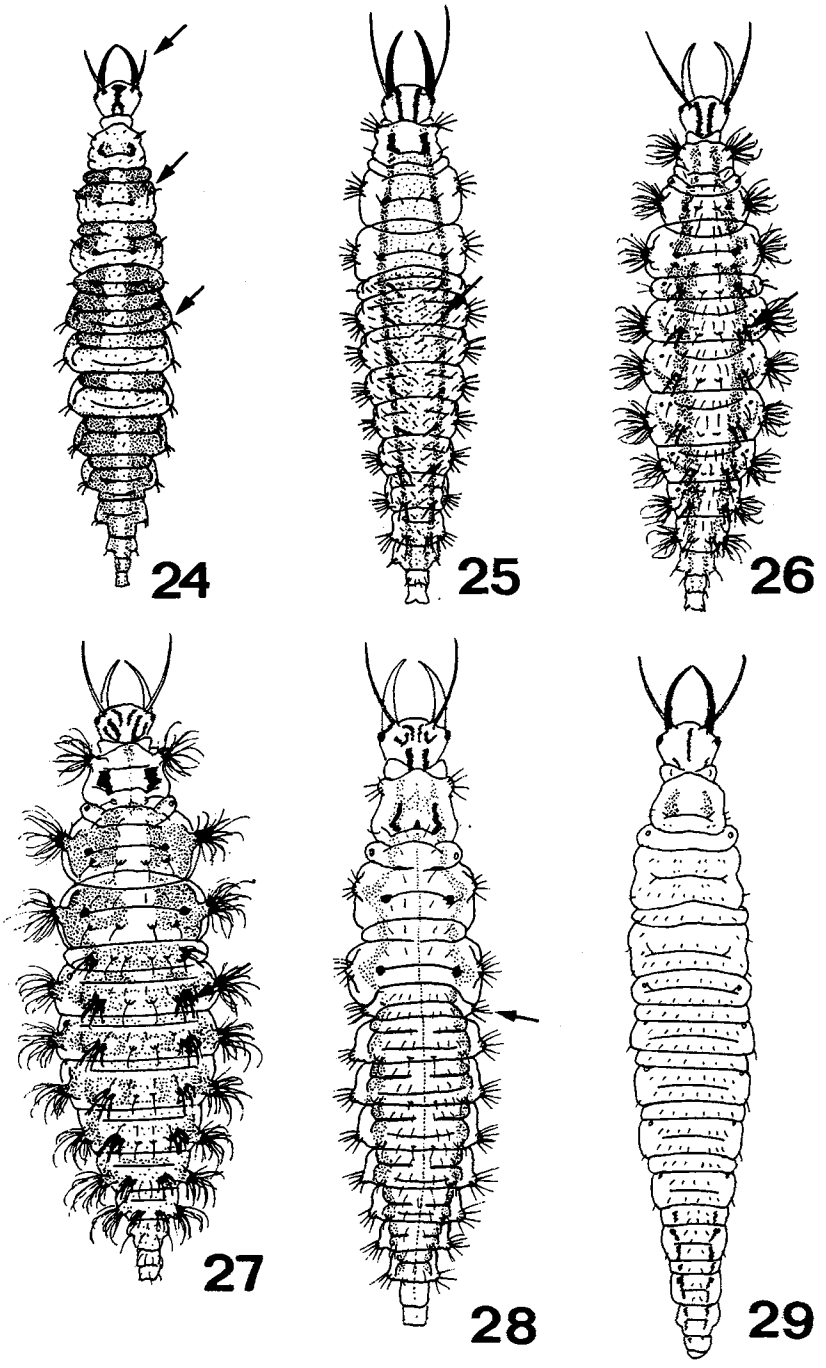

Fig. 24-29. Third instar (L-3) of naked larvae. 24.- *Brinckochrysa (B. nachoi).* 25.- *Peyerimhoffina (P. gracilis).* 26.- *Chrysoperla (C. mediterranea).* 27.- *Chrysopa (C. regalis).* 28. *Nineta (N. guadarramensis).* 29.- *Hypochrysa (H. elegans).*

– Body fusiform and flattened, with dorsal setae short and pointed (fig. 5b). Thoracic and abdominal lateral-setae short and pointed. Larvae naked (fig. 12-16) ..... **(8)**

(4) Abdominal segment with primary anterior-, spiracle-, submedial-, laterodorsal- and lateral-setae as in fig. 5a ..... **(5)**

– Abdominal segment with more setae than the aforementioned (fig. 8) ..... *Suarius* Navas, 1911

(5) Abdominal segment (at least I-IV) with anterior-setae long and hooked, on a small tubercle (anterior-tubercle). Laterodorsal-tubercles with 2 long setae (fig. 6, 7, 9) ..... **(6)**

– Abdominal segment (at least I-IV) with anterior-setae short and pointed. Anterior-tubercles absent. Laterodorsal-tubercles with 1 long seta (fig. 10) ..... *Rexa* Navas, 1920

(6) Mesothorax with laterodorsal- and submedial-setae long (fig. 7, 9) ..... **(7)**

– Mesothorax with laterodorsal- and submedial-setae very short or microscopic (fig. 6) ..... *Mallada* Navas, 1925

(7) Mesothoracic laterodorsal- and submedial-setae as long as, or longer than metathoracic laterodorsal- and submedial-setae (fig. 7). Abdominal segment I with anterior- and spiracle-setae long and hooked, on small tubercles (anterior- and spiracle-tubercles) (fig. 7) ..... *Cuntochrysa* Hölzel, 1970

– Mesothoracic laterodorsal- and submedial-setae shorter than metathoracic laterodorsal- and submedial-setae (fig. 9). Abdominal segment I with anterior- and spiracle-setae very short and not hooked, without anterior- and spiracle-tubercle (fig. 9) ..... *Chrysopidia* Navas, 1910

(8) Antennae shorter than mouthparts (fig. 12). Thoracic lateral-tubercles absent or only sligthly developed, bearing 1 short seta (fig. 12). Thoracic and abdominal setae multi-pointed apically (fig. 3d) ..... *Brinckochrysa* Tjeder, 1966

– Antennae longer than mouthparts. Thoracic lateral-tubercles well developed, bearing 2 setae on the prothorax and 3 on the meso- and metathorax (fig. 13-16). Thoracic and abdominal setae pointed apically ..... **(9)**

(9) Thorax and abdomen with lateral- and laterodorsal-setae shorter than femur ..... **(10)**

– Thorax and abdomen with lateral- and laterodorsal-setae as long as, or longer than femur ..... **(11)**

(10) Body (including mouthparts) longer than 3 mm. Thorax and abdomen with lateral- and laterodorsal-setae longer than setae on legs ..... *Nineta* Navas, 1912

– Body (including mouthparts) shorter than 3 mm. Thorax and abdomen with lateral- and laterodorsal-setae about as long as setae on legs .. *Peyerimhoffina* Lacroix, 1920

(11) Cephalic seta S-12 (fig. 4b) present. Frontoclypeal marking (fig. 4a) absent or only slightly developed (fig. 14) ..... *Chrysoperla* Steinmann, 1964

– Cephalic seta S-12 (fig. 4b) absent (except *Chrysopa viridana*). Frontoclypeal marking (fig. 4a) present (fig. 15) ..... *Chrysopa* Leach, 1815

(12) Dorsal setae hooked and long ..... *Nothochrysa* McLachlan, 1868

– Dorsal setae knobbed apically (fig. 3f) and very short (fig. 17) ..... *Hypochrysa* Hagen, 1866

KEY TO GENERA OF EUROPEAN CHRYSOPID THIRD-INSTAR LARVAE (L-3)

(1) Distal segment of antenna about 10 times shorter than medial segment, with a group

of small apical setae (fig. 1b). Distal segment of labial palp with 4 or more sensilla on outer edge (fig. 2b) ..... **SUBFAMILY NOTHOCHRYSINAE (12)**

– Distal segment of antenna about 3 to 6 times shorter than medial segment, with a long apical seta (fig. 1a and 1c). Distal segment of labial palp with, at most, 3 sensilla (fig. 2a) ..... **SUBFAMILY CHRYSOPINAE (2)**

(2) Mouthparts distinctly shorter than cephalic capsule. Distal segment of antenna as in fig. 1c. Cephalic setae and thoracic and abdominal lateral-setae serrated (fig. 3a). Thoracic and abdominal tergites with numerous rows of hooked setae. Larvae associated with ants ..... **TRIBE BELONONPTERYGINI** (*Italochrysa* Principi, 1946)

– Mouthparts as long as or longer than cephalic capsule. Distal segment of antenna as in fig. 1a. Cephalic setae never serrated. Thoracic and abdominal lateral-setae never serrated. Thoracic tergites without numerous rows of hooked setae. Usually predators on soft-bodied arthropods ..... **TRIBE CHRYSOPINI (3)**

(3) Body humped. Thoracic lateral-tubercles elongated, bearing long setae. Abdomen with spherical lateral-tubercles bearing long setae. Abdominal tergites with several rows of hooked setae. Larva coats itself with debris (fig. 18-23) ..... **(4)**

– Body fusiform, flattened dorsoventrally. Thoracic lateral-tubercles spheroidal, not elongated, bearing comparatively short setae (fig. 24-28). Abdomen without several rows of hooked setae, with laterodorsal-tubercles and submedial-tubercles developed, bearing pointed setae. Larva naked (fig. 24-28) ..... **(8)**

(4) Mouthparts about as long as cephalic capsule length. Thoracic lateral-tubercles robust, with thick stalk. All thoracic and abdominal lateral-setae with black base (fig. 22). Abdominal tergites each with 3-4 rows of setae, of which the posterior row is the more conspicuous, with setae arising from black small protuberances (fig. 22) ..... *Rexa* Navas, 1920

– Mouthparts longer than cephalic capsule. Thoracic lateral-tubercles with thin stalk. Not all thoracic and abdominal lateral-setae with black base. Abdominal tergites with similar rows of setae (fig. 18-21) ..... **(5)**

(5) Cephalic seta S-12 (fig. 4b) microscopic or absent. Abdominal tergites V, VI and VII each with laterodorsal-tubercles bearing 2 long setae (fig. 18) .*Mallada* Navas, 1925

– Cephalic seta S-12 (fig. 4b) present. Laterodorsal-tubercles absent on abdominal tergite V (fig. 19-21) ..... **(6)**

(6) Lateral-tubercle very long and thin on the 3 thoracic segments, not or slightly enlarged apically. Larvae enterely white, with conspicuous dark pronotal laterodorsal sclerites (fig. 21) ..... *Chrysopidia* Navas, 1910

– Thoracic lateral-tubercle enlarged apically, longer on prothorax than on meso- and metathorax. Larvae white with brown or reddish marking on thoracic and abdominal tergites. Pronotum with laterodorsal sclerites less conspicuous ..... **(7)**

(7) Mesothorax with a dorsal row of long setae (fig. 19). Abdomen slightly humped. Thoracic lateral-tubercles slightly elongated, nearly spheroidal on meso- and metathorax. Thorax white coloured with a pair of oblique brown or reddish markings on meso- and metanotum (fig. 19). Larva naked or with little debris ..... *Cunctochrysa* Hölzel, 1970

– Mesothorax without a dorsal row of long setae (fig. 20). Abdomen strongly humped. Thoracic lateral-tubercles well developed. Thorax white coloured with a pair of laterodorsal brown stripes (fig. 20). Larva completely covered with large amounts of debris ..... *Suarius* Navas, 1914

(8) Antennae shorter than mouthparts (fig. 24). Thoracic and abdominal setae multipointed apically (fig. 3d). Thoracic and abdominal lateral-tubercles not developed. Thoracic segments with 1 lateral-seta and abdominal segments with 2 lateral-setae (fig. 24). Coloration quite conspicuous and disruptive (black or reddish with white stripes) (fig. 24) ..... *Brinckochrysa* Tjeder, 1966

– Antennae longer than mouthparts. Thoracic and abdominal setae pointed apically. Thoracic and abdominal lateral-tubercles developed, bearing numerous setae ..... **(9)**

(9) Thoracic and abdominal lateral-tubercles slightly-developed. Abdomen without submedial- and laterodorsal-tubercles. Abdominal tergites with numerous secondary setae spoonbilled apically (fig. 3e) and oriented to dorsomedian line (fig. 25) .... *Peyerimhoffina* Lacroix, 1920

– Thoracic and abdominal lateral-tubercles well developed. Thorax and abdomen with submedial- and laterodorsal-tubercles (fig. 26-27). Secondary setae pointed apically ..... **(10)**

(10) Larval length (including mouthparts) about 12 mm. Body long and thin. Mouthparts about 2-3 times longer than cephalic capsule. Abdominal segment I with lateral-tubercles bearing several setae (fig. 28) ..... *Nineta* Navas, 1912

– Larval length (including mouthparts) less than 10 mm. Body fusiform. Mouthparts about 1.5 times longer than cephalic capsule. Abdominal segment I without lateral-tubercles (except *Chrysopa viridana* and *Chrysopa pallens*) ..... **(11)**

(11) Cephalic seta S-12 (fig. 4b) present. Frontoclypeal marking (fig. 4a) absent or only slightly developed. Abdominal laterodorsal-tubercles bearing, at most, 2 setae (fig. 26) ..... *Chrysoperla* Steinmann, 1964

– Cephalic seta S-12 (fig. 4b) absent (except *Chrysopa viridana*). Frontoclypeal marking (fig. 4a) well-developed. Abdominal laterodorsal-tubercles bearing about 5 setae (fig. 27) ..... *Chrysopa* Leach, 1815

(12) Larva covered with debris (fig. 23). Body dark-brown or coloured yellow. Cephalic marking well-developed (fig. 23). Thoracic and abdominal tubercles slightly developed, bearing long hooked setae ..... *Nothochrysa* McLachlan, 1868

– Larva naked (fig. 29). Body green coloured with cephalic capsule yellow coloured and a longitudinal dark stripe (fig. 29). Thoracic and abdominal tubercles not developed (fig. 29). Setae very short and knobbed apically (fig. 3f) ... *Hypochrysa* Hagen, 1866

Behaviour of larvae and egg-deposition

Table I summarizes additional data concerning the behaviour of larvae and egg-deposition, which can help in distinguishing the genera of European Chrysopidae.

On the behaviour of larvae, within Chrysopidae there are two basic forms of larvae: "naked larvae" and "trash-carrying or debris-carrying larvae". The latter cover their dorsal surface with exogenous materials, including vegetable matter, skin remains of their prey and general debris.

With regard to the mode of egg-deposition, all European species of Chrysopidae lay stalked eggs. The eggs are deposited singly, in batches or in clusters (Duelli, 1984). The word single is used to describe when eggs are deposited singly or in small groups of 2 to 6 eggs.

The eggs are placed either on the underside of leaves and twigs (fig. 30) or at the tips of leaves and twigs (fig. 31). A batch is used to described those eggs that are laid in groups

TABLE 1

Data on the behaviour of larvae and pattern of eggs deposition

Species	Naked or debris-c larvae	Eggs		Species	Naked or debris-c larvae	Eggs	
		Colour	Depostion			Colour	Deposition
Brinckochrysa nachoi	naked	green	single	*Mallada genei*	debris-carrying	white	single
Chrysopa formosa	naked	green	batches	*Mallada granadensis*	debris-carrying	white	cluster
Chrysopa pallens	naked	green	batches	*Mallada ibericus*	debris-carrying	green	single
Chrysopa perla	naked	green	single	*Mallada picteti*	debris-carrying	white	cluster
Chrysopa regalis	naked	green	single	*Mallada prasinus*	debris-carrying	white/ green	single/cluster
Chrysopa viridana	naked	green	single	*Mallada subcubitalis*	debris-carrying	white	single
Chrysoperla ankylopteryformis	naked	green	single	*Mallada venosus*	debris-carrying	white	single
Chrysoperla carnea	naked	green	single	*Mallada ventralis*	debris-carrying	green	single
Chrysoperla mediterranea	naked	green	single	*Nineta flava*	naked	green	cluster (fig. 35)
Chrysotropia ciliata	debris-carrying	green	single	*Nineta guadarramensis*	naked	green	cluster (fig.-35)
Cunctochrysa albolineata	debris-carrying	green	single (fig. 31)	*Rexa lordina*	debris-carrying	green	single
Cunctochrysa baetica	debris-carrying	green	single (fig. 31)	*Suarius iberiensis*	debris-carrying	white	single (fig. 31)
Mallada clathratus	debris-carrying	green	single	*Suarius tigridis*	debris-carrying	white	single (fig. 31)
Mallada flavifrons	debris-carrying	white	cluster (fig. 35)	*Suarius walsinghami*	debris-carrying	white	single (fig. 31)

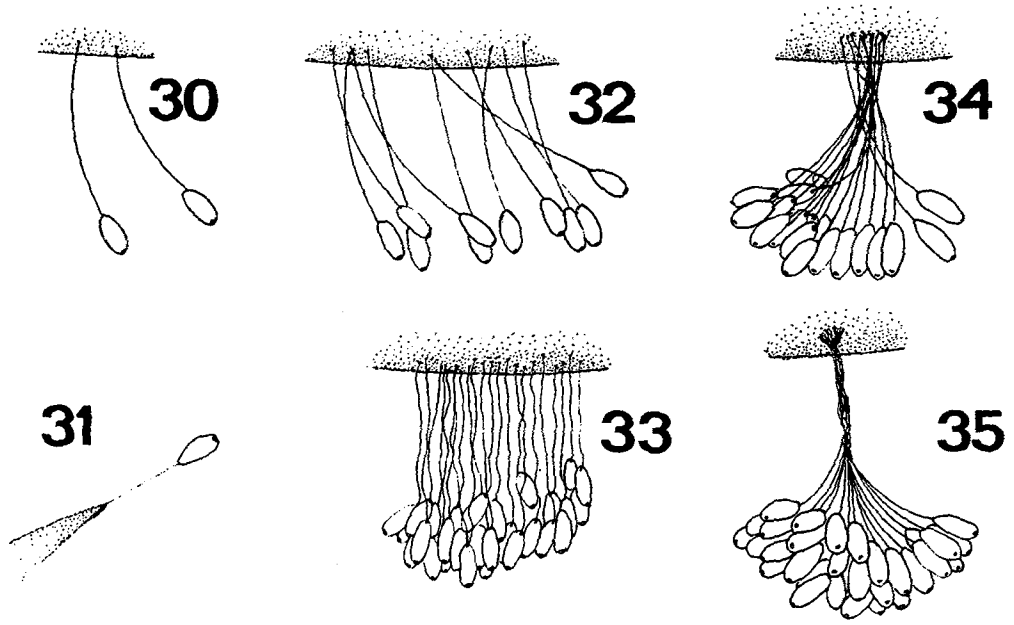

Fig. 30-35. Pattern of egg deposition. 30-31.- Single. 32-33.- Batches. 34-35.- Clusters.

of 20 to 40 (fig. 32, 33). Finally, egg clusters are used to describe those situations where the females lay their eggs in bundles and the eggs stalks then become tightly (fig. 35) or loosely intertwined (fig. 34).

Irrespective of their mode of desposition, the eggs may be coloured white or green. The general colour and pattern of egg deposition is characteristic for most species (table 1).

RÉSUMÉ

Clé pour la détermination des stades larvaires des genres de Chrysopes de l'Europe (Insecta, Neuroptera : Chrysopidae)

Dans ce travail nous présentons les caractères morphologiques des larves de Chrysopes qui sont utilisés dans la détermination des 13 genres qui habitent en Europe, ainsi que des clés pour l'identification des premiers et troisièmes stades larvaires (L-1 et L-3). Les stades L-1 et L-3 de tous les genres étudiés sont illustrés par des figures.

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