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The morphology of the preimaginal stages of *Choreutis muhabbet* Koçak, 2008 (Choreutidae, Lepidoptera)

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Abstract

This work presents the first description of the last instar larval and pupal morphology of the metalmark moth species *Choreutis muhabbet* Koçak, 2008. All diagnostic morphological features are described in detail, and illustrated with photographs and line drawings.

Diagnostic features for the genus *Choreutis* (Hübner) based on the described last instar larvae and pupae, are proposed and discussed. We compare the description of larval and pupal morphology of *C. muhabbet* to known morphological features of the preimaginal stages of other *Choreutis* species, especially with *Choreutis pariana* (Clerck).

Key words: Lepidoptera, metalmark moths, larvae, pupal exuviae, chaetotaxy, *Ficus*, taxonomy

Introduction

The family Choreutidae (metalmark moths) is one of the small-sized moths, comprising 413 species of 18 genera worldwide (Rota *et al*. 2014). It was placed in the superfamily Yponomeutoidea previously and superfamily Sesioidea (Heppner & Duckworth 1981). However, it was treated as a family of the superfamily Choreutoidea recently (Minet 1991). Adults have attracted the attention of many microlepidopterists due to their colorful wing patterns, but their early developmental stages are largely unknown.

Choreutid larvae are distinguished by unusually long, slender prolegs and long primary setae. The larvae have a curious habit of very rapid movement, generally backwards, when disturbed, as do many tortricid and pyralid larvae.

The morphology of the larvae of the genus *Choreutis* (Hübner) is known for only a few species, such as *Choreutis pariana* (Clerck) (MacKay 1972, Heppner 1987, Park & Heppner 2021), *Choreutis vinosa discolor* (Diakonoff & Arita, 1979), and partly *C. hyligenes* (Butler, 1879), *C. ophiosema* (Lower, 1896), *C. yakushimensis* (Marumo, 1923), *C. atrosignata* (Christoph, 1888), *C. achyrodes* (Meyrick, 1912), *C. japonica* (Zeller, 1877) (Diakonoff & Arita, 1979) and *C. aegyptiaca* (Zeller, 1867) (Gielis & Bippus 2016). The detailed morphology of the pupae of this genus is known only for *Choreutis pariana* (Clerck) (Patočka 1999).

This article deals with one choreutid species, *Choreutis muhabbet* Koçak, 2008, for which the detailed descriptions of the immature stages were previously unknown. Detailed descriptions, photographs, illustrations, and scanning electron micrographs of last instars and pupae are provided, and the life history of the species is briefly characterized.

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Material and methods

Material examined: 5 last instar larvae, Turkey, Prov. Van, Çatak N., 1720 m (type locality) 14.06.2012 leg. A.Ö.Koçak & M. Kemal

One pupa, Turkey, Prov. Van, Çatak N., 1720 m (type locality), 13.06.2022, leg M. Kemal & H. Uçak, one pupa Turkey, Prov. Van, Çatak N., 1720 m, 23.06.2022 leg M. Kemal & K. Insel, CESA collection (Ankara).

One pupal exuvium, Turkey, Prov. Hakkari, Çucurca, Narli N., Zap Valley, 810 m, 8.06.2022, leg M. Kemal & H. Uçak

The collected larvae and pupae of *C. muhabbet* were preserved in 80% ethanol. Prior to the study of the chaetotaxy, larvae were macerated in 10% warm KOH for 2–3 hours; soaked for a few minutes in Chlorazol Black in order to make some membranous parts more visible, and then they were transferred to glass slides with a drop of glycerine. Decapitated larvae were cut in a ventral region along more or less ventral lines and along the border between abdominal segments A4 and A5 on two fragments. After spreading of the cuticle, they were fixed on the slide in a dorsolateral view. Isolated head capsules were prepared as whole or split into individual elements.

Due to technical reasons the chaetotaxy of the larval trunk drawings lack scale bars (Fig. 1F).

In the course of the studies and in the description of morphology and chaetotaxy of the caterpillars the authors used the following papers: MacKay (1972), Rota (2008), Stehr (1987), Bąkowski (2013).

Pupal morphology description is based on the studies of Patočka (1999) and Patočka & Turčani (2005). The morphology of the larva and pupa of *C. muhabbet* was compared (mainly) with the descriptions of the preimaginal stages of *C. pariana* (MacKay 1972; Heppner 1987; Patočka 1999).

The preimaginal stages were examined with a Nikon SMZ 1000 stereoscope microscope. The larval photographs were taken with a digital camera AxioCam MRc5 attached to a Lumar V12 stereoscopic microscope, connected to a computer with Axio Vision 4.8 software. Stereoscopic microscope images were taken in the Laboratory of Electron and Confocal Microscopy (Faculty of Biology, Adam Mickiewicz University, Poznań). All studied material is deposited in the senior author`s collection in the Department of Systematic Zoology (AMU), Poznań (Poland).

Results

Last instar larva (Fig. 1A–F, 2A–F): 11−12 mm in length. Pale green, with amber or yellow head capsule, pinacula distinctly marked, brown–black, well developed.

Head (Figs. 1A, B; 2A,B). Semiprognathous. Five stemmata arranged in L shape, with stemma II slightly diverged, stemmata III−V nearly in a line. Stemmata I–V more or less oval, similar in size, with gaps between stemmata I–II, stemma VI not visible. S1 between stemmata I and III. Adfrontals area clearly indicated, usually narrow. Frontoclypeus triangular in shape. AF2 distinct and situated at about level of frons apex, seta C2 distinctly posterior to anterior margin of postclypeus, F1 longer than AF2. Setae MD1, MD2 and MD3 very small, arranged in a straight line. Seta P2 long, situated dorsally to P1. P1 at about level of frons apex, distinctly longer than P2. A2 more dorsal than line joining A3 and A1; seta A2 slightly closer to A3 than A1, L1 posteroventral to A3. Setae C1 and C2 distinctly smaller than F1. S1 is between stemma I and III. Seta SS1 below stemma V. Seta SS1 anteroventral to SS2, SS3 posteroventral to SS2.

Labrum (Fig. 1C). Lateral margins rounded, in the middle part a distinct incision. Five setae are visible, two in the middle part, and three in the lateral side. Epipharyngeal surface armed with three strong sensory “teeth”.

Mandibulae (Fig. 1D). Teeth II–IV large and well developed, rounded or blunted. Teeth I and V oval, distinctly smaller than rest. The furrows on the mesal side present. Dorsal side with setae M1 and M2; M2 distinctly shorter than M1.

Thorax (Fig. 1F). **T1**: Setae D1 and XD1 occurring at the similar level. Seta D2 posterior to and slightly dorsal to XD2; SD1 ventral to and slightly posterior to XD2, SD2 ventral to D2. Setae SD1 and XD1 equally long, D2 distinctly longer. SD1 and SD2 occurring at the similar level. L1 ventral to middle of L2 and L3 arranged in a straight horizontal line, L2 and L3 long setae, L3 distinctly shorter. Spiracle small and posterior to L3. Setae L1–3 located in the middle of segment I, on common oval shaped pinaculum. SV-group bisetose. Setae SV1 and SV2 as long as L2 and L1; setae SV1 and SV2 located on common elongated pinaculum, both setae more or less equal in length, SV1 posterior to SV2, V1 close to ventral meson, slightly ventral and posterior to thoracic leg.

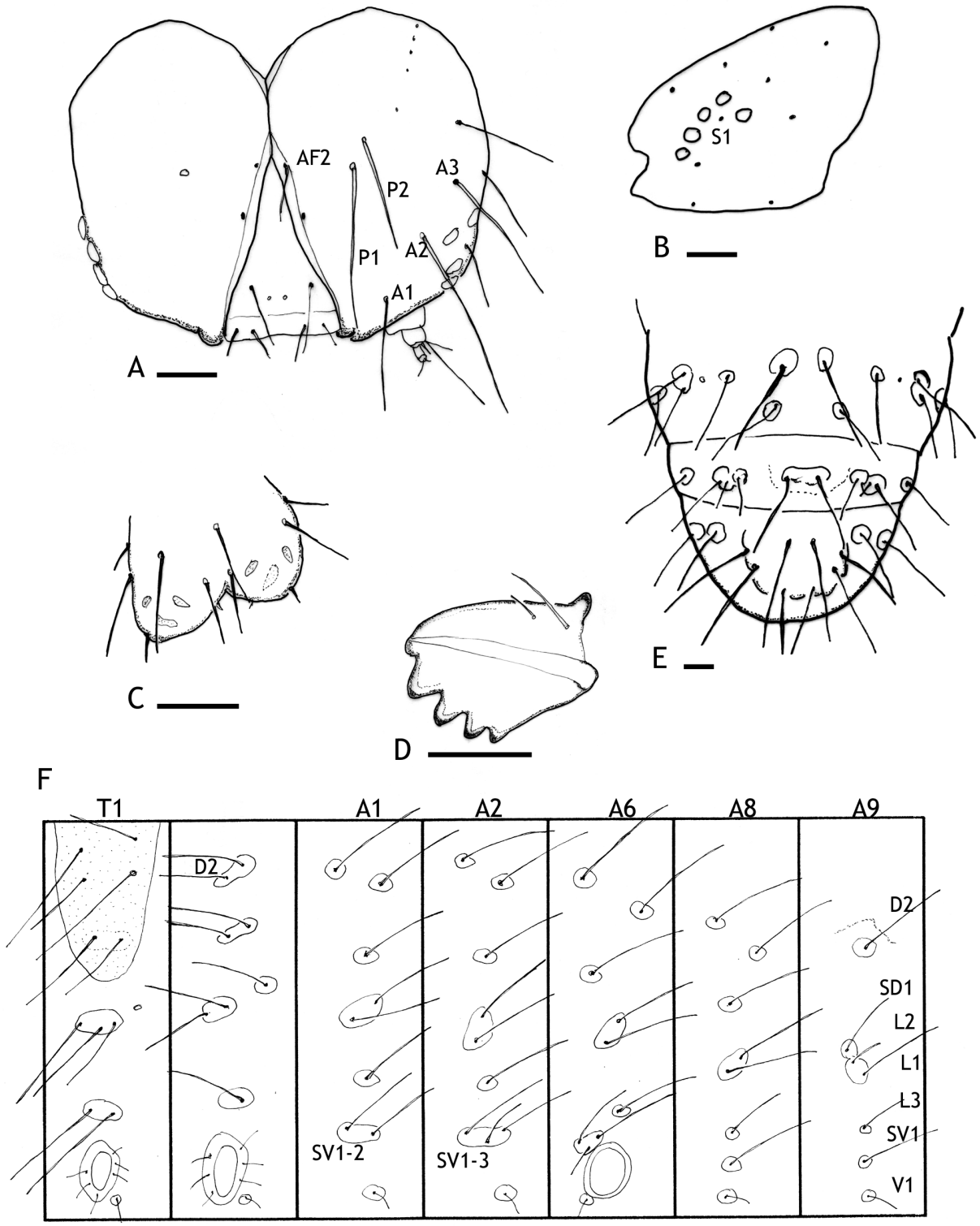


FIGURE 1. Larva of *Choreutis muhabbet*. A. Head capsule—Frontal view, B. Head capsule—Lateral view, C. Labium, D. Mandible, E. Dorsal view of eight to tenth abdominal segments F. Setal map of thorax (T1–3) and abdomen (A1–A9) segments. Scale bar: 0.2 mm.

T2–T3 segments. TII and TIII with D1 and D2 on common elongated pinaculum on mesothorax and metathorax. D2 and D1 more or less equal in length; L3 posterodorsal to L2. SD2 and SD1 on common elongated pinaculum on meso- and metathorax. Setae D1, D2 and SD1, SD2 more or less equal in length. Setae L1 and L2 on common pinaculum. SV-group unisetose, SV1 more or less equal in length to L2, proprioceptors MV1–3 not visible.

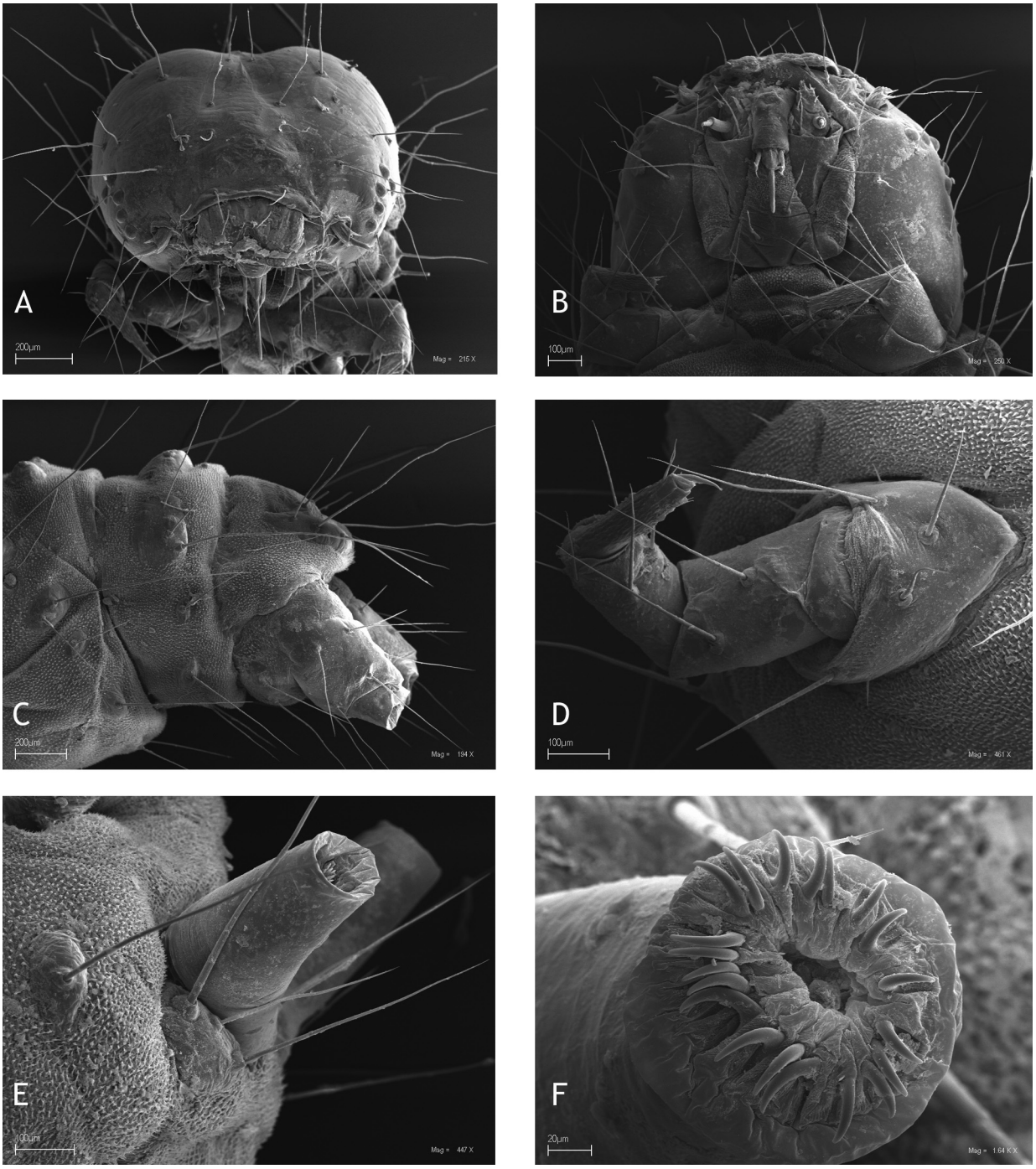


FIGURE 2. Scanning electron micrographs of larva of *Choreutis muhabbet*: A. Head—dorsal view, B. Head—ventral view, C. Last abdominal segments, D. Prothoracic leg, E. Abdominal leg, F. Crochets on an larval proleg.

Abdomen: A1–2 segments. D2 ventral and posteriori to D1, D1 more or less equal in length to D2. SD1 on a separated pinaculum, SD2 reduced. L1 posterior to L2 and sharing pinaculum with L2, L1 above L2, L2 similar in length to L1; A1 with SV-group sharing pinaculum, having two setae; on A2−6, SV trisetose.

A3–6 segments. Arrangement of D group and SD1, L1 and L2 the same as on A1–2 segments. SV3, SV1 and SV2 sharing pinaculum. **A7:** Arrangement of setae D group, SD and L group similar to that of previous segment. **A8:** D2 located ventrally and posteriorly to D1; SD1 present. L2 and L1 sharing pinaculum. Spiracle invisible. L3 located ventrally to L2; from SV group only seta SV1 is present. L3 shorter than SV1.

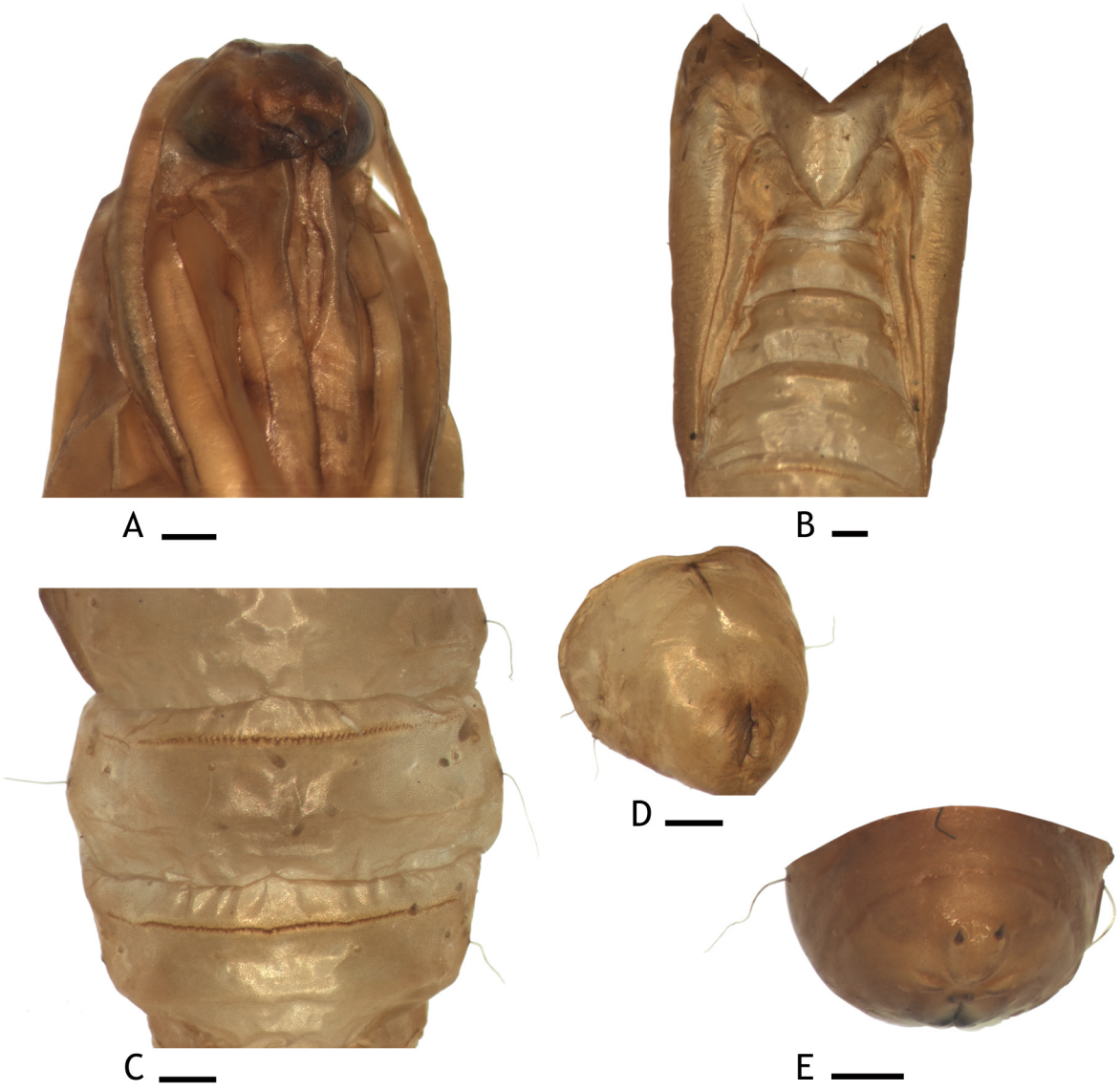


FIGURE 3. Pupa of *Choreutis muhabbet*. A. Labium and vicinity; B. Meso and metathorax; C. Spines on abdominal segments dorsally; D. Abdominal end ventrally. E. Abdominal end dorsally. Scale bar: 0.2 mm.

A9: Setae D2, SD1, L2, L1, L3, SV1 and V1 arranged in a vertical line. D2 on separate pinacula, D1 not present, SD1 on a partly separated pinaculum, below them L1 and L2 sharing pinaculum. L1 slightly longer than SD1. Seta L2 located slightly closer to SD1 than to L1, L2 more or less equal in length to SV1.

A10 (Fig. 1E)**:** Anal shield rounded, more sclerotized, posteriorly with D1, D2, SD1 and SD2 setae.

Crochets of prolegs (Figs. 2E, F). The abdominal prolegs are slender, bear uniserial and uniordinal crochets arranged in a mesal pennelipse. The number of crochets on one ventral proleg is from 15 to 20. The number per one row on anal prolegs is from 18 to 20 in the last instar larva.

Pupae (Figs. 3, 4) 5−6 mm in length. Semiliberae. Frons and postclypeus do not bear projections. One pair of the frontal and conspicuously long setae. Frontal setae situated slightly frontad of level of lateral frons angles. Frons with indistinct elongated depressions (Fig. 4B). Proboscis long, overlaps mesothoracic legs, almost reaches ends of metathoracic legs. Metathoracic legs visible only apically, beyond mesothoracic legs and maxilla. Prothorax femora visible (Figs. 3A, 4A). Antennae curved to medial body region, longer than mesothoracic legs. Maxillary palpi visible and are adjacent to the maxillae. Mandibulae elevated, strongly sclerotized. Labium and labial palpi long and slender. Labrum truncate for a greater distance and with straight or slightly concave sides. Distance between clypeal setae $C1_2$ approximately 2 times greater than distance between $C1_2$ and Cl_1. Seta Cl_2 1.5 times longer than

Cl_1. (Figs. 3A, 4A, 4C). Metanotum deeply excised (Figs. 3B, 4D). Spines on the 1th and 2nd abdominal segment absent in dorsal view. Prothorax on each side bearing one pair of prothoracic lateral setae and one pair of dorsal setae. Mesothorax on each side with two mesothoracic dorsal setae. Metathorax bearing one metathoracic dorsal seta. Ventral abdominal setae visible. (Fig. 4D). Middle abdominal segments without pits, only with transverse row of small spines dorsally (Figs. 3B, 4D). Cremaster on A10 with one pair of short hooked dorsal spines. Cremaster short, roundly conic, smooth (Fig. 3D–E).

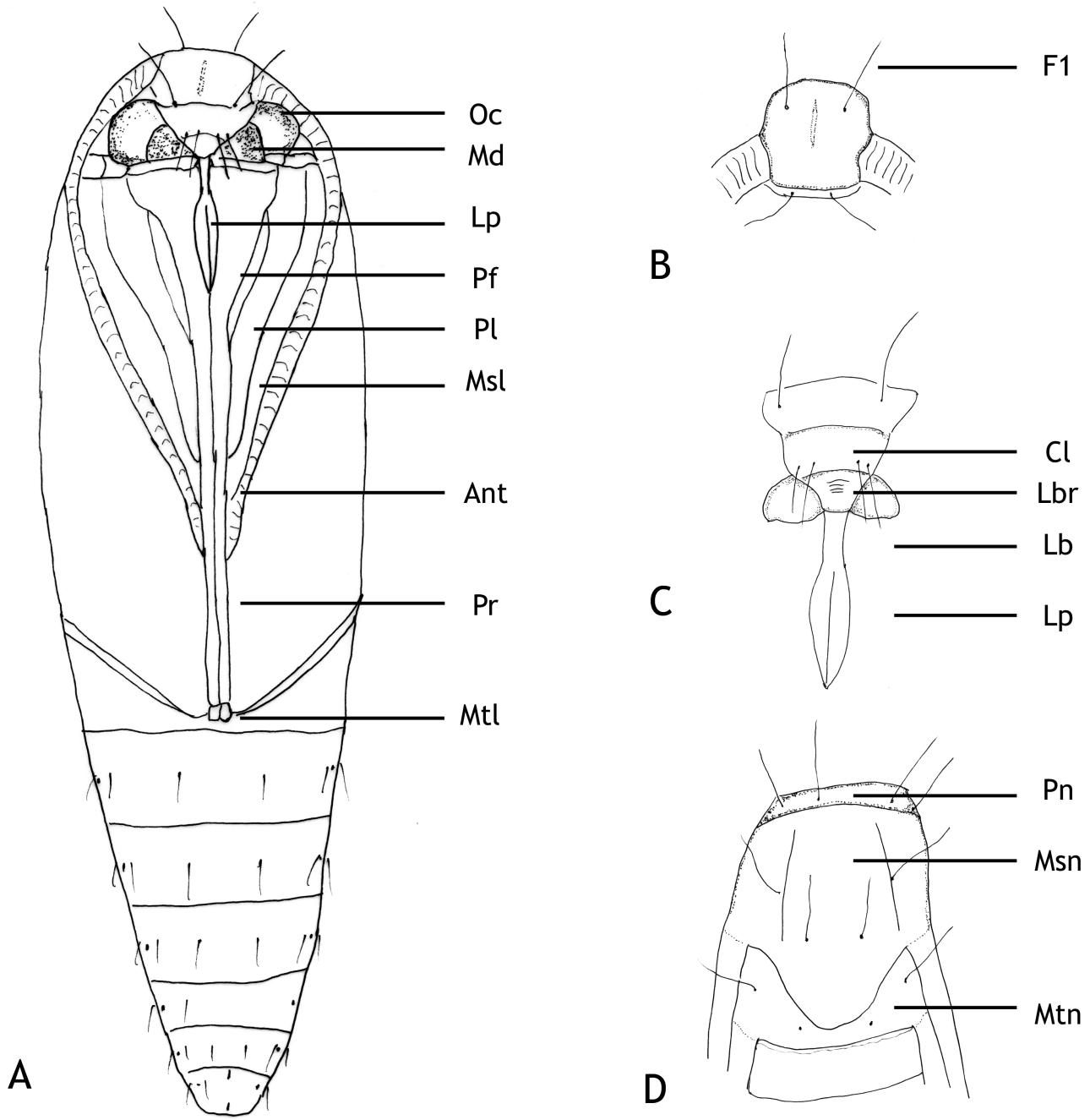


FIGURE 4. Morphology of pupa of *Choreutis muhabbet*. A. Ventral view, B. Frons dorsally, C. Labrum and vicinity, D. Pro, meso and metathorax in dorsal viev. Abbreviations: Ant—antennae, Cl—clypeus, F1—frontal setae, Lb—labium, Lp—labial palpi, Lbr—labrum, Pl— prothoracic legs, Pf—prothoracic femora, Pr—proboscis, Msl—mesothoracic legs, Mtl—metathoracic legs, Oc—oculi, Pn—pronotum, Md—mandibulae, Msn—mesonotum, Mtn—metanotum.

Discussion

Choreutis muhabbet Koçak, 2008 was described on the basis of the specimens reared from *Ficus carica* in Catak Valley, Province Van, Turkey in 2008. According to Koçak (2008a) the species is univoltine and flies from June to July. The larvae make a spinning on the upperside of a *Ficus* leaf and pupate inside a white tough cocoon within a leaf-edge fold (Koçak 2008b, Kemal & Akin 2011, Heppner & Kemal 2023). It should be emphasized that *Ficus carica* is also a host plant of *C. nemorana* (Hübner, [1799]). The plants in the genus *Ficus* are host plants of numerous *Choreutis* species. For instance *Ficus erecta* is a host plant of *C. japonica.*

According to MacKay (1972) the possible Choreutidae larvae characters are: three L setae on prothorax, the position of seta SD2 on abdominal segments, the absence of D1 on segment 9, stemma VI appears less well developed than other stemmata, reduced sometimes. The spiracles on segments 1–7 are about the size of a setal base. The slender polegs, crotchets are uniordinal. Rota (2005) indicated that D1 on A9 is present in at least some choreutid genera, e.g. *Rhobonda* Walker.

C. muhabbet larvae can be distinguished from those of *C. pariana* by following diagnostic characters. *C. muhabbet* have setae SV1–2 on A1 located on common pinaculum, seta SD1 on a partly separated pinaculum on A9, VI stemma reduced, SD2 reduced and invisible. *C. pariana* setae SV1–2 on A1 located on separated pinaculum, seta SD1 on a common pinaculum on A9, VI stemma present, SD2 reduced but visible.

Diakonoff & Arita (1979) studied the morphology of the larvae of *Choreutis vinosa discolor* and partly *C. hyligenes*, *C. ophiosema*, *C. yakushimensis*, *C. atrosignata, C. achyrodes*, and *C. japonica*. Diakonoff & Arita (1979) indicated that differences from the compared species can be found in stemmatal region**,** labrum and the form of mandible. It seems, however, that these larval features are not clear and not significant.

According to Patočka & Turčani (2005) the pupae of Choreutidae are semiliberae. Maxillary palpi and prothoracic femora are present. Antennae do not reach apices of forewings. Metanotum is deeply excised. Middle abdominal segments bear only one (*Choreutis* Hübner), rarely two (*Milliera* Ragonot) transverse rows of spines. However according to the recent studies genus *Milliera* was transferred to the Millieriidae (Rota 2011; Rota & Kristensen 2011). Middle abdominal segments bear also row of pits (*Anthophila* Haworth, *Prochoreutis* Djakonoff & Heppner, *Tebenna* Billberg). These pits are present in *Rhobonda* Walker as well. (Rota 2005).

The compared species *C. muhabbet* and *C. pariana* differ in the shape of the labrum, which is more triangular and rounded on caudal end in *C. pariana*. Labrum is truncated for a greater distance in *C. muhabbet*. Patočka (1999) indicated that maxillary palpi are not adjacent to the maxillae in *C. pariana*, however, in our study they are adjacent in *C. muhabbet.* Both species are characterized by one pair of short hooked dorsal spines on A10.

The comparative analysis of the morphology of preimaginal stages confirmed the differences between *C. muhabbet* and *C. pariana.* The genera diagnosis characters are not clear and require further studies of the preimaginal stages**.** Identifying preimaginal stages of *Choreutidae* to species level can be challenging, especially in the case of closely related species inhabiting the same host plant. For this reason, the knowledge of the host plant from which the larvae, pupae or pupal exuviae are collected can be highly informative for species identification. These findings also suggest taxonomists to consider larval and pupal morphology in the future placement of the species described in this paper.

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