

The pupal morphology of the *Carabus* (s.l.) (Coleoptera, Carabidae) in the southwestern Iberian peninsula

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Abstract

The pupal morphology of the Carabus (s.l.) (Coleoptera, Carabidae) of the southwestern Iberian peninsula.— The pupae of *Carabus* (s.l.) of the south–west Iberian peninsula are described. The study was carried out with pupae of *Macrothorax rugosus* (Fabricius, 1792), *Hadrocarabus dufouri* (Dejean, 1831), *H. lusitanicus* (Fabricius, 1801) and *Rhabdotocarabus melancholicus* (Fabricius, 1798) reared in the laboratory from adults caught in the field. By determining and testing various morphological structures, all three genera were identified. These results indicate that the presence or absence of setae on the pronotum, the distribution of hairs on the abdominal tergi and the development of tergal expansions from urotergi are the most significant features for identification.

Key words: Pupal morphology, *Carabus*, Coleoptera, Carabidae.

Resumen

Morfología de la pupa de los Carabus (s.l.) (Coleoptera, Carabidae) del suroeste de la península ibérica.— Se describe la pupa de los *Carabus* (s.l.) del suroeste de la península ibérica en base a la morfología preimaginal de las especies *Macrothorax rugosus* (Fabricius, 1792), *Hadrocarabus dufouri* (Dejean, 1831), *H. lusitanicus* (Fabricius, 1801) y *Rhabdotocarabus melancholicus* (Fabricius, 1798). La descripción se ha realizado sobre ejemplares obtenidos en cultivos realizados con parentales procedentes de su medio natural. Determinando y contrastando las estructuras propias de cada una de las especies mencionadas es factible identificar los tres géneros representados en el suroeste de la península ibérica, estableciendo como caracteres diagnósticos decisivos la presencia o ausencia de sedas en el pronoto, la distribución de la pubescencia en los terguitos abdominales y el grado de desarrollo de las expansiones urotergales.

Palabras clave: Morfología de la pupa, *Carabus*, Coleoptera, Carabidae.

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Mientras este artículo estaba en imprenta ha sido publicada, con desconocimiento por parte de los autores, una versión anterior de este trabajo en el *Butll. Soc. Port. Entom. Supp.*, 6: 427–432 (1999), correspondiente a las **Actas del VIII Congreso Ibérico de Entomología**, donde se había presentado como una comunicación (poster).

Introduction

Literature on the immature forms of Carabidae is scarce, especially regarding Iberian endemisms (ORTUÑO & TORIBIO, 1996). Moreover, although the morphology, biology and ecology of larvae is examined in most cited papers (i.e. HURKA, 1961, 1971; STURANI, 1962; LUFF, 1969; RAYNAUD, 1975–76; ARNDT, 1993, 1998), data related to the pupae are only rarely included (i.e. COSTA et al., 1988).

This lack of information is mainly due to the difficult task of finding the pre-imaginal stage in the field. As the pupae are subterranean and immobile, they go unnoticed. Nevertheless, when pupal morphological features and biological data are available they are of great interest for completing the information on the various life forms and on the life cycle of the species as well as for solving systematic questions.

In order to provide data on this subject, research into the immature stages of Andalusian ground beetles was carried out (CÁRDENAS, 1993; CÁRDENAS et al., 1994; CÁRDENAS & HIDALGO, 1995, 1998). The laboratory rearing cultures provided sufficient pupae to characterize the morphology of *Carabus (sensu lato)* living in the SW Iberian peninsula. In this study the following species were examined: *Macrothorax rugosus* (Fabricius, 1792), *Hadrocarabus dufouri* (Dejean, 1831), *H. lusitanicus* (Fabricius, 1801) and *Rhabdotocarabus melancholicus* (Fabricius, 1798).

Material and methods

Cultures were performed with *Macrothorax rugosus*, *Rhabdotocarabus melancholicus*, *Hadrocarabus dufouri* and *H. lusitanicus* adults collected in their natural environment. To start the laboratory experiments, the previous knowledge of the animal cycle of each species was applied (CÁRDENAS, 1993; CÁRDENAS & BACH, 1992; CÁRDENAS & HIDALGO, 1995; CÁRDENAS & HIDALGO, 1998, 2000).

Rearing cultures were prepared with 40 parental groups each formed by a pair. The reproductive groups were kept in cylindrical plastic containers measuring 10 cm in diameter and 15 cm in height. They contained 5 cm of moistened peat substrate and a plentiful supply of maggots as food. The containers were placed in a shaded area adjacent to the laboratory under outside conditions and checked three times per week. Eggs were removed as they were laid and isolated in Petri-dishes (9 cm diameter) over sterile sand as substrate. The eggs were kept in full-darkness at 18–20°C.

The larvae, which were also isolated in order to avoid cannibalism, were placed individually in cylindrical glass containers (6 cm diameter x 10 cm height) in the same conditions as the parents. Pertinent chronological and biometrical data

were taken, especially during the moulting process. When larvae reached the third stadia, the check was intensified in order to detect the exact moment of pupation, to study the larval/pupa development and to describe the pupal morphology. Some pupae were fixed and kept for study following the methods proposed by STEHR (1983). The rest of the specimens were kept in their respective pupal cells until emergence as adults.

Results

All the pupae of the species in this study were initially whitish and showed morphological features typical for Carabini species. They belonged to the adecticous type of pupa having no functional mandibles and were exarate, with appendages projecting freely from the body. Pterotheca were arranged diagonally on both sides of the body and the abdomen was mobile. The pupae simultaneously showed archaic features proper to the larvae, such as the three pairs of stemmata or the urotergal expansions and adult features, such as podothecal dilatations in males. Typical pupal features were observed, namely the labrum morphology (from trilobulated to unilobulated), pubescence in the tergal plates, the mandible structure (always of the archaic type, known as calosomian), the presence of parastigmas next to the spiracles or the disposition of the meso and meta thoracic pterothecas (CASALE et al., 1982).

Macrothorax rugosus (Fabricius, 1792) (fig. 1)

Description

Head

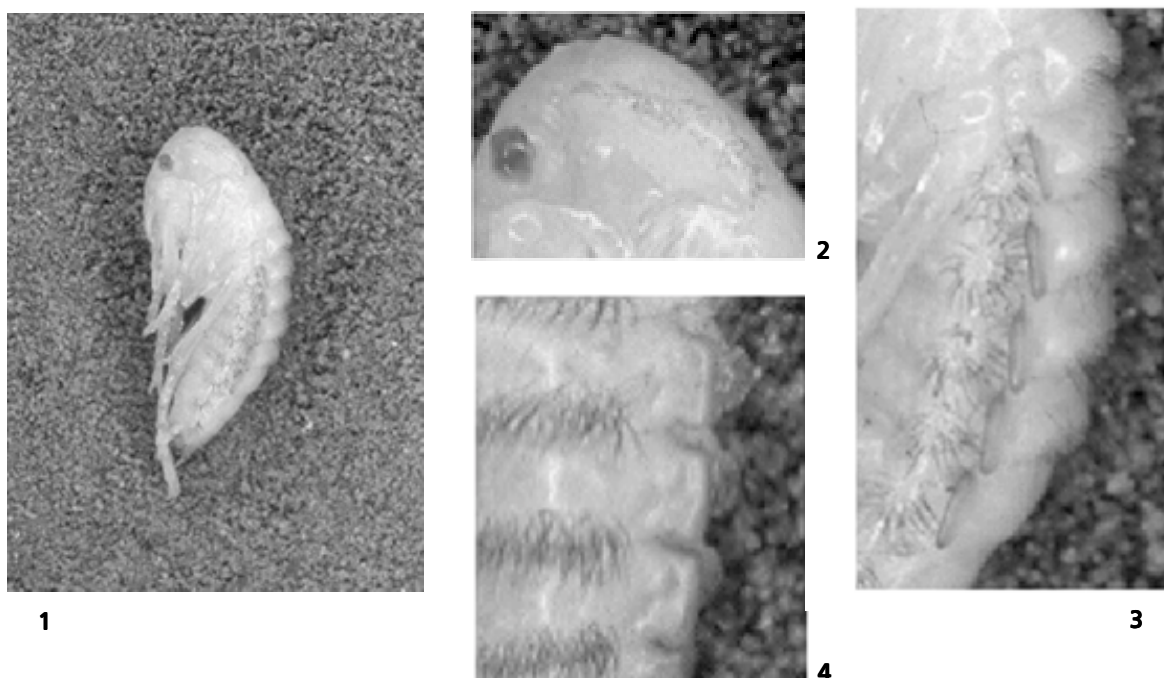
Hairless, clearly rectilinear mandibles on the inner side, subpentagonal and distally trilobate labrum, but with attenuated lobes. Antennae quite long, reaching the middle region of the abdomen.

Thorax

Strong but short and sparse pubescence, black-testaceous in color and arranged to form distinct bands on both sides (fig. 2). Some hairs on the discal plate. The mesothorax and metathorax glabrous with no notable morphological features.

Abdomen

Lateral margins in urotergal plates were slightly bordered and bore lateral expansions, such as two lobes in segments 2, 3, 4, 5 and 6 (fig. 3). These expansions increased in size in the posterior region as a consequence of the progressive differentiation of the posterior lobe (fig. 4). Rows of long, rigid, dark testaceous hairs were observed on each side of the median line of tergal plates of the first five and in the eighth



Figs. 1–4. *Macrothorax rugosus*: 1. Pupa, lateral view; 2. Head and prothorax, lateral view; 3. Urites, lateral view; 4. Abdominal hemi-tergites, dorsal view.

Figs. 1–4. *Macrothorax rugosus*: 1. Pupa, vista lateral; 2. Cabeza y protórax, vista lateral; 3. Uritos, vista lateral; 4. Hemiterguitos abdominales, vista dorsal.

segments. The median line was glabrous. These rows occupied almost the total posterior area of each hemitergite, although in the eighth segment they were more sparse with large lateral margins and a wide central hairless area. Tergites 6 and 7, and the tip of the urogomphi were glabrous. Hairy bands were observed at the base of the urogomphi, which were similar to those in the last segment. Irregular but abundant pubescence was also present over the remaining surface, and a small but long medio-dorsal tubercle was observed. Pleural expansions were present in segments 2 to 8 showing dense pubescence similar to the tergal plates. The spiracles were open in segments 1 to 7. The parastigmas were not noticeable and were reduced to a small, posterior sclerotized plate.

Hadrocarabus dufouri (Dejean, 1831) (fig. 5)

Description

Head

The head glabrous and normally conformed; the mandibles were quite rectilinear on the inner side and curved in the distal extreme; the labrum

was subpentagonal in shape and almost equal in length and width. It was trilobated at the distal end. Antennae were quite long, as in the previous species.

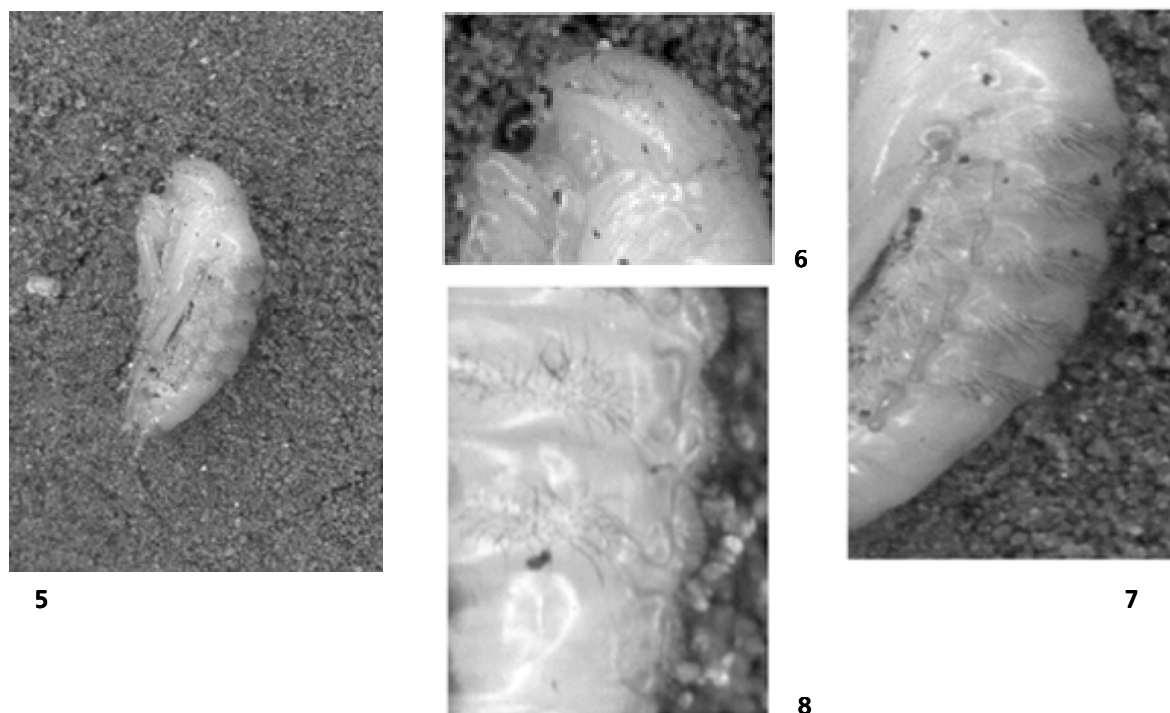
Thorax

The thorax showed short, sparse, light testaceous pubescence with noticeable insertion marks (fig. 6). Only the anterior third of the median line and the centre of the tergal plate were completely hairless.

Pubescence in the lateral margins was closer than in *M. rugosus*, but on each side stripes of hair were not distinguishable. The mesothorax and metathorax were glabrous and had no notable morphological features.

Abdomen

The lateral margins of urotergi on abdomen were slightly bordered in segments 2, 3, 4, 5, and 6, with two lateral lobated expansions each, which increased in size towards the end of the body (fig. 7). The relative size of the lobes belonging to the same segment was also variable having a tendency to be subequal but always differentiated (fig. 8). In the urotergal plates (1–5), there was a band of strong



Figs. 5–8. *Hadrocarabus lusitanicus*: 5. Pupa, lateral view; 6. Head and prothorax, lateral view; 7. Urites, lateral view; 8. Abdominal hemi-tergites, dorsal view.

Figs. 5–8. *Hadrocarabus lusitanicus*: 5. Pupa, vista lateral; 6. Cabeza y protórax, vista lateral; 7. Uritos, vista lateral; 8. Hemiterguitos abdominales, vista dorsal.

testaceous hairs on each side of the median line, which was glabrous. These bands were also present in the posterior middle of each urotergite. The sixth and seventh tergal plates were glabrous. Bands of hairs, which were quite similar to the eighth urite, were present at the base of the urogomphi. The end of the urogomphi was glabrous; nevertheless, on the basal surface and on the sides there was sparse pubescence, and a small basal tubercle was also present. In segments 1 to 8 hairy lateral lobes were present, although in the first and in the last segments these lobes were not very evident. Spiracles were observed in the seven anterior urites. Segments having urotergal expansions also bore parastigmatic structures which started before the anterior lobe of the tergal expansion, just under the lateral tergal border. The parastigmas were extensive in the posterior area surrounding the peritreme, later enlarging to become very noticeable in the posterior area of the pleurite. These structures were quite similar in segments 3, 4, 5 and 6 and reduced to a small, posterior, well-sclerotized plate in urites 1, 2 and 7.

Hadrocarabus lusitanicus (Fabricius, 1801)

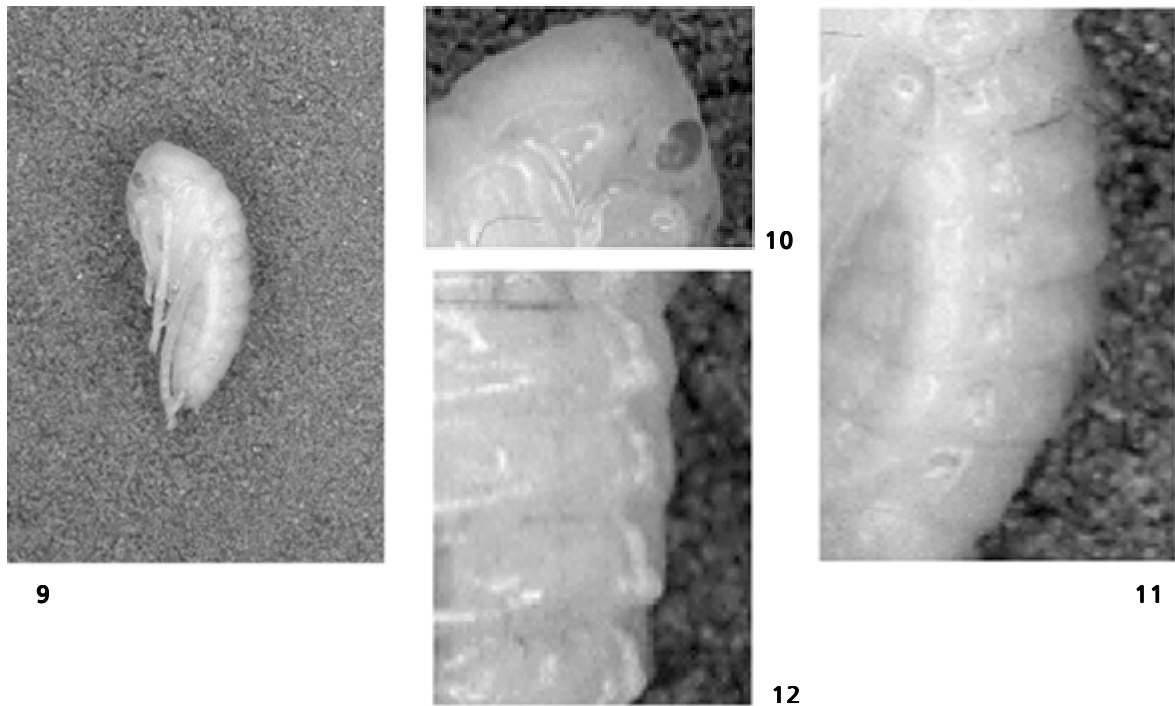
Description

As the result of the morphological and taxonomical proximity of *H. dufouri* and *H. lusitanicus*, the pupa of both species were quite similar, sharing the features previously described.

Nevertheless, some differences in the morphology and the relative size of the lobes of the urotergal expansions in the abdominal segments were observed.

These features were not clear enough to discriminate the two species, but their distribution area in the southwest of the Iberian peninsula allowed the correct assignment.

H. lusitanicus is found north of the Guadalquivir river and from the northern slope of Sierra Nevada and Sierra de Baza to the eastern limits of Andalucía (subspecies *baguenai*, Breuning, 1926), whereas *H. dufouri* is distributed south of the Guadalquivir river, from Cádiz to Almería and in the central and south slopes of Sierra Nevada.



Figs. 9–12. *Rhabdotocarabus melancholicus*: 9. Pupa, lateral view. 10. Head and prothorax, lateral view; 11. Urites, lateral view; 12. Abdominal hemi-tergites, dorsal view.

Fig. 9–12. *Rhabdotocarabus melancholicus*: 9. Pupa, vista lateral; 10. Cabeza y protórax, vista lateral; 11. Uritos, vista lateral; 12. Hemiterguitos abdominales, vista dorsal.

Rhabdotocarabus melancholicus (Fabricius, 1798) (fig. 9)

Description

Head

The head showed several differences respect to the other species considered. The mandibles are somewhat bent on the inner side; the antenna were shorter, only reaching the first abdominal third. The labrum was subpentagonal, equal in length and width, and of the unilobated type.

Thorax

The protergum was absolutely hairless, even in the lateral margins (fig. 10).

Abdomen

The abdomen had urotergal expansions in segments 2 to 6 which were typically bilobulated (fig. 11). The anterior lobe was smaller than the posterior lobe (fig. 12). The posterior lobe was somewhat prominent and well-sclerotized. The lobes became very noticeable at the end of the abdomen. The spiracles were located in the pleural region of urites 1 to 7 under the anterior lobe of each tergal

expansion, except for the first pair (in urite 1 no tergal expansions exist).

The parastigmas showed a variable degree of development depending on the number of urites. Development varied from small posterior sclerites to a chitinous structure dorsally surrounding the spiracle. The chaetotaxy in tergal plates consisted of a series of sparse, long, brun-testacean hairs. Each was inserted into its respective setigerous pore, which was also evident. These series were located on either side of the median line in the posterior half of the 1, 2, 3, 4, 5 and 8 urites. Abdominal segments 6 and 7 were glabrous. The pleural surface of the urites lacked hair and salient lobes. The ninth segment, which was also hairless, bore a pair of short and noticeable urogomphi which had a small tubercle like a spine at the base.

In order to clarify the diagnosis of the pupae included in this paper, the identification key is given.

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Identification key of the pupae of *Carabus* (s.l.) of the southwestern Iberian peninsula.

Clave de identificación de las pupas de Carabus (s.l.) *del suroeste de la península ibérica.*

1	Glabrous prothorax and unequal lobes in urotergal expansions	<i>Rabdotoxocarus melancholicus</i>
	Pubescent prothorax, and subequal lobes in urotergal expansion	2
2	Prothoracical pubescence arranged to form a clear band on both sides. Parastigmas reduced to a small, posterior sclerite. No pleural expansions in the first urite	<i>Macrothorax rugosus</i>
	Lateral pubescent bands of the prothorax are not clearly isolated from the sparse discal pubescence. Well-developed parastigmas surrounding the spiracle. Noticeable pleural expansions even in the first urite	3
3	In the southwestern Iberian peninsula (occidental Andalucía) the species is distributed at the north of the Guadalquivir river	<i>Hadrocarabus lusitanicus</i>
	In the southwestern Iberian peninsula (occidental Andalucía) the species is distributed at the south of the Guadalquivir river	<i>Hadrocarabus dufouri</i>

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