ISSN: 1989-6581

www.aegaweb.com/arquivos_entomoloxicos

Ramos-Abuin (2024)

ARQUIVOS ENTOMOLÓXICOS, **28**: 269-285

ARTIGO / ARTÍCULO / ARTICLE

The preimaginal stages of *Carabus (Archicarabus) steuartii* Deyrolle, 1852 (Coleoptera: Carabidae)

Jorge Ángel Ramos-Abuin [1, 2]

[1] Grupo Naturalista Hábitat.

[2] c/ Tercia, 12, 2ºd. E-13500 Puertollano (Ciudad Real). e-mail: jrabuin007@gmail.com

Abstract: The larval stages of *Carabus (Archicarabus) steuartii* Deyrolle, 1852 (Coleoptera: Carabidae) are described, providing some new data on the biology and distribution of this species.
Key words: Coleoptera, Caraboidea, Carabidae, Carabini, *Carabus*, *Carabus (Archicarabus) steuartii*, preimaginal stages, biology, distribution, Galicia, Iberian Peninsula.

Resumen: Los estadios preimaginales de *Carabus (Archicarabus) steuartii* Deyrolle, 1852 (Coleoptera: Carabidae). Se describen los estadios larvarios de *Carabus (Archicarabus) steuartii* Deyrolle, 1852 (Coleoptera: Carabidae), aportando algunos nuevos datos sobre la biología y distribución de esta especie.
Palabras clave: Coleoptera, Caraboidea, Carabidae, Carabini, *Carabus*, *Carabus (Archicarabus) steuartii*, estados preimaginales, biología, distribución, Galicia, Península Ibérica.

Recibido: *6 de marzo de 2024*
Aceptado: *9 de junio de 2024*
Publicado on-line: *30 de junio de 2024*

Introduction

The species within the genus *Carabus* Linnaeus, 1758 (Coleoptera: Carabidae) of northwestern Spain is well known so far (VALCÁRCEL *et al.*, 1997; CAMPOS & NOVOA, 2006; S.G.H.N., 2014), lacking only a better knowledge of their distribution and biology, which may be important to properly preserve them.

Concerning the study of their preimaginal stages, two periods must be considered. Firstly, the second part of the last century, with the description of most of the Iberian *Carabus* larvae mainly by RAYNAUD (1965, 1975, 1976) and others (ANDRADE MALDE, 1977), and underlining the studies by CÁRDENAS (1993), CÁRDENAS & BACH (1993), CÁRDENAS & HIDALGO (1995, 1998, 2000), and CÁRDENAS *et al.* (1994), that were done to define the life cycles of some Iberian *Carabus*.

Nevertheless, most of the papers about *Carabus* larvae lacks an accurate study of the chetotaxy (see BOUSQUET & GOULET, 1984 and MAKAROV, 1993), necessary to clarify the taxonomy of the family (GOULET, 1979). These studies, as ARDNT (1985) and ARDNT & MAKAROV (2003) mentioned, provide a useful tool to identify the larvae.

Then, there's a second period, covering the last three decades, when this kind of techniques were applied. Some papers about the larvae of Iberian and Mediterranean *Carabus* were then published (BUSATO & GIACHINO, 1993; BUSATO, 2003, 2004; BUSATO & CASALE, 2005; GILGADO & ORTUÑO, 2011, 2012; RAMOS-ABUIN, 2011; or BUSATO *et al.*, 2014, 2023).

Nevertheless, the review of the old descriptions of the preimaginal stages of some European *Carabus* is needed, either because of some mistakes in them, as it happened with the larva of *Carabus (Eucarabus) deyrollei* Gory, 1839 (RAMOS-ABUIN, 2011), because are not clear enough to differentiate some larvae, i.e. belonging to species within subgenera *Oreocarabus* and *Mesocarabus*, or even because some *Carabus* larval stages still remain unknown (ARNDT & MAKAROV, 2003). Of course, the lack of knowledge about larval (or even adult) biology of some *Carabus* species cannot be left aside (TURIN *et al*., 2003).

For the task of breeding, some classical papers by LAPOUGE (1904), RAYNAUD (1968), GOULET (1976) or MALAUSA (1977), were important to consider, as well as the more recent contributions by BURAKOWSKI (1993) or BUSATO (2022).

In this context, as RAYNAUD (1974) and VALCÁRCEL (1995) wrote, and more recently ARDNT & MAKAROV (2003) confirmed, just the larva of only one Iberian *Carabus* species is not yet known. The larva of *Carabus (Archicarabus) steuartii*[1] Deyrolle, 1852 remains undescribed to date and that is the blank we are trying to fill with this paper.

Material and methods

Field research

After thirteen years of field research in some localities of Portugal and the northwest of Spain, some imagoes of *C. steuartii* were collected, and some larvae were born from them. To get this goal, old and new data about the distribution of this species were considered (VALCÁRCEL, 1995), including recent captures made by Daniel Prunier in the north of Portugal in 2011 (com. pers.), and the classic datum by RAYNAUD (1974), confirming that this species breeds in Mars and lay the eggs in April. Moreover, some unidentified *Carabus* larvae collected by Javier Pérez Valcárcel were studied, three of them resulting of the same type than those young larvae later obtained.

Small groups of pitfall traps made with pierced plastic cups and baited with drops of vinegar were settled in different places of Portugal and northwest Spain, firstly during the spring, and then, mainly in autumn. After a week, some living individuals were collected and kept alive in captivity during some months[2], adding new details about its life cycle and reproductive habits, the temperature and humidity they required, the daily activity and the type of prey that they prefer, at least in captivity.

In the spring 2022, some were caught but, unfortunately, any of them bred, and only two infertile eggs were obtained. In November 2022, a small group of seven beetles (six females and one male) of *C. steuartii* from a pine forest of *Pynus sylvestris* L. near Campobecerros (Ourense) were collected and, after the winter diapause, in March 2023, they started laying some eggs. Finally, some information was added thanks to the recent mating (April 2024) of one couple collected in the same locality.

Laboratory tasks

As told before, some unidentified larvae captured in April (22-04-1984) in Monforte de Lemos (south of the province of Lugo, Galicia) were given by Javier Pérez Valcárcel. They were accurately observed, photographed and studied, resulting that belong to the serrilabre type of *Carabus* larvae (*sensu* LAPOUGE, 1904, 1905), which includes the known larvae of *Carabus (Archicarabus) nemoralis* O.F. Müller, 1764 and others). The presence of *C. steuartii* in Monforte, Lugo, was already reported (VALCÁRCEL, 1995, 2021).

[1] DEYROLLE (1852) described this species as *Carabus steuartii* and according to the current version of the International Code of Zoological Nomenclature (I.C.Z.N., 1999) and the Catalogue of the Palaeartic Coleoptera (LÖBL & LÖBL, 2017) this has to be the right spelling.

[2] Finally released in the same places as stated in the permission by the Xunta de Galicia.

All these larvae were studied and photographed through a Labomed microscope and a Seben stereoscopic microscope, fitted with an AMS Scopecamera, attached to them. In addition, some images of living larvae were taken with a Xiaomi MI pro mobile phone (Fig. 2) in order to give accurate measurements, different from the dead larvae.

As a result, two of these larvae collected in Monforte turned out to be of first stage, other two of second stage and, finally, one of third stage, according to the larvae obtained from the eggs and the literature. Of all these larvae, three were cleared (Fig. 19) (one L I, one of L II and the L III larva), using hydrogen peroxide and put in a glycerin solution, according to the method by BOUSQUET & GOULET (1984), a bit modified lately by RAMOS-ABUIN (2011), another L I was dissected and put with DMHF between two acetate layers, as mentioned by GILGADO & ORTUÑO (2011). The other LII larva was kept and preserved in dry conditions in order to compare with the other preserved in liquid.

The breeding

Meanwhile, from the field, as commented before, seven individuals were captured in November 2022. All of them were collected in a pine forest near Campobecerros (Ourense), at an altitude of about 1000 m.

This area is a *Pinus sylvestris* L. forest with an undergrowth of heath (*Erica* spp., *Daboecia cantabrica* (Huds) K. Koch) and *Pteruspartum tridentantum* (L.) Willk. This type of habitat, shrub land, is very similar to other habitats where this species was found (VALCÁRCEL *et al*., 1997; PRUNIER, 2011; pers. comm.; and personal observations). It is related with the degradation of the soil (by podzolitation and accumulation of organic matter, giving an acidic feature, caused by the ancient and common use of fires by man to spread pastures) and is linked with a Mediterranean-Iberoatlantic (not Eurosiberian) flora (RIVAS–MARTÍNEZ, 1987).

These beetles were kept alive in a four litres plastic container (29 cm x 18.5 cm x 13 cm), with a covering that was pierced to permit the release of water vapour, and a layer of soil of 5 cm, soil collected from the site where the adults were caught with some pieces of moss and a piece of a slate stone. The soil and moss weren't sterilized in order to give the insects some natural conditions.

The container was put into a refrigerator whose temperature could be set between 0°C and 10°C, controlled with the help of a timer to turn it off for some lapses of time to get higher temperatures, but always below 30°C. The refrigerator had a window, so the sunlight could reach the container during the natural photoperiod that exists in the south-center of Spain where the breeding took place, with a small difference compared to the light span in Campobecerros (Ourense). MALAUSA (1977) referred the importance to have natural daylight in order to keep the photoperiod, one of the important factors that control the life cycle of *Carabus*, along with the average temperature.

About this parameter, one digital thermometer was settle inside the container, to measure the maximum and the minimum temperature recorded daily, and compared with the ones obtained from the AEMET's meteorological station in Erosa (Ourense), 10 km far from Campobecerros, whose daily data were reviewed. In this way, the temperature parameters are set to be as natural as possible, kept between the minimum and maximum detected in the field.

Concerning the humidity, the water losses through evaporation were considered weighing the container from time to time, and spraying drops of water. The containers were observed daily, the adults and larvae were fed with pieces of chicken liver, banana and waxworms (these caterpillars usually made a good meal for *Carabus* beetles and larvae, as it was observed in previous breeding experiences) and the cages were constantly cleaned to have good conditions avoiding the growth of moulds and the presence of dirty (see LAPOUGE, 1904). Daily, when the imagoes restart the activity, in February, the bottom of the cage was reviewed to see the eggs, and the presence of these and the activity of the adults were registered taking notes in every occasion. So, in March 2023 some eggs were laid in the bottom of the breeding cage (most of them not so deep) and they weren't perturbed. On March 18th, a young black and small L I (Fig. 2), similar to those larvae given by Javier Pérez Valcárcel from Monforte, was caught.

In the next days, a total of 15 larvae were born, from which 13 were collected: 11 were preserved in a solution of 70% of alcohol and two of them were cleared, as described before, and then put in glycerin.

Two of the larvae were lost, but the head of the first larva born was recovered. This larva has been the living model (Fig. 2) whose habitus is shown in Fig. 3.

Two of the other larvae were sacrificed, but the others were kept in small plastic cages to go on with the study, but finally died and any of them get the LII stage. These larvae were preserved.

Finally, four more larvae were obtained from one couple this year, being all of them preserved the same way (Figs. 21 and 22).

According to the key to *Carabus* larvae by ARNDT & MAKAROV (2003), the features of these larvae match with those of the known *Carabus (Archicarabus)* Seidlitz, 1887 larvae, as it is shown in the description of them.

Results and discussion

For the description of larval features, the useful terms mentioned by HŮRKA (1971) were widely applied, taking into account the last papers about *Carabus* larvae by BUSATO *et al.* (2023), the recently printed monograph about *Carabus* by DEUVE (2021) and the embryologic studies by KOBAYASHI *et al.* (2013).

Description of the preimaginal stages

- **The egg**

  The egg of *Carabus steuartii* larvae (Fig. 1) is 4 mm in length and has a width of 2 mm in one end (corresponding to the head of the larva) and 1,6 mm in the other. The eggs were laid not too deep in the soil, around 20 or 30 mm under the surface, irregularly settled, so most of them are not visible on the bottom of the box. The total number of eggs by female was 15, as we could confirm the last spring. In them, some movement of the larvae is detected four days before the hatching of the larvae, movement that was recorded and appears to be similar to that mentioned by DELKESKAMP (1930) about the larvae of *C. nemoralis*.

- **First instars' description (*ex ovo* and *ex societate imagines*)**

– **First larval instar**

  Average morphometric data in mm: 12.75 mm. Head length: 1.75 mm. Head width: 1 mm.

  L I Carabus *steuartii* larvae (Figs. 2, 3, and 11), after one day, are well sclerotized and black as mentioned by DELKESKAMP (1930) about the larvae of *C. nemoralis*. In the Figs. 21 and 22 two newborn white larvae are shown, before the complete darkening.

  They are a bit elongated, with a length of 12.75 mm (from the clypeus (*nasal*) to the apex of the pygidium). Their maximum width is 2 mm, which corresponds to those of mesonotum and metanotum. Their chetotaxy is described according to BOUSQUET & GOULET (1984) and MAKAROV (1993), but only the setae that can be unequivocally identified and regularly present in the studied larva were registered and are mentioned in this work, helping to differentiate this larvae from others. It is known that some *Carabus* larvae setae can lack or even appear in variable number (DELKESKAMP, 1930) so a right identification sometimes is very difficult (GILGADO & ORTUÑO, 2011). About this, under the microscope, an irregularly spread lot of pores is observed, making very complex to establish their relevance.

  - **Head**

    LI larvae has a cephalic capsule (Figs. 4 and 6) clearly wider than long, having a width of 1.75 mm and a length of 1 mm, showing a very small epicranial suture. The frontal (Fig. 20) (frontoclypeolabro *sensu* BUSATO *et al.*, 2023) is 1.03 mm in width and 0.83 mm in length.

The frontal has a trapezoidal shape (ratio length/width=0.78), showing three lobes in the anterior border. In the middle, the central lobe or clypeus (*sensu* HŮRKA, 1971; nasal *sensu* ENDEM, 1942, and others) (Figs. 4, 6, and 7) has two bit pointed endings with a concave border between them and with a small bulge in their lateral edge in the same way that *C. nemoralis* larvae shown (DELKESKAMP, 1930; HŮRKA, 1971; ARNDT, 1985; and others). The clypeus (Fig. 7) is almost six times wider than long. Between these clypeal endings, in the underside, one hypodon (Fig. 7) downwards directed is seen. On the sides of the frontal, two anguli frontalis (labro external lobi, *sensu* LAPOUGE, 1905) are identified, protruding the same as the medium lobe. The clypeus is a bit wider (0.31 mm) than the external lobi (0.29 each one). Near the frontal base (pars aboralis frontalis *sensu* BENGTSSON, 1927 and HŮRKA, 1971), two pointed, directed forward and linear egg busters are present (Fig. 21). At each side of the sagital plane, a total of six setae are found. According to MAKAROV (1993) regarding the known *Carabus (Archicarabus)* larvae, the pairs FR3 and FR4 are distant between them. The FR3 is only visible by this base, FR5, FR8, FR9 are also seen, as FR7 and FR2 which are very long, while FR10 and FR11 are not present. About the pores, FRb is clearly detected.

In the parietal, there are six stemmata (Figs. 4, 5, and 6), three in an anterior line, and three posterior. In this area four setae are found: PA7, very long, and PA9, PA3, PA2 and PA1 and, in the same way, the pore PAd is also defined.

Mandible (Fig. 6, 8, and 13) robust and curved has a clearly serrated edge in the apical half part. It bears a well-developed and curved smooth retinaculum but without accessory tooth, as described in MAKAROV (1993) for *Carabus* (*Archicarabus)* larvae. This tooth of the retinaculum is present, nevertheless, in other *Carabus* larvae. 0.98 mm long. The small setae MN2 and MN1 are appreciated with difficulty.

About this MN1 seta, it is mentioned that it lacks usually in this larvae according DEUVE (2021). According HŮRKA (1971), it is not present in *C. nemoralis* and *Carabus montivagus* Palliardi, 1825 larvae designs. STURANI (1962) writing about the *Carabus (Archicarabus)* larvae, tells that this seta easily break and fall, so it is only observed in young larvae and not in older or exuviae, lacking completely in *Carabus alyssidotus* Illiger, 1798. In CASALE *et al*. (1982), it is written that this seta could be present or not in the *Carabus* larvae and this is not shown in the drawings of the mandible of *C. alyssidotus* and *Carabus rossi* Dejean, 1826. Nevertheless, Busato (com. pers.) observed this seta in *C. nemoralis* and *Carabus monticola* Dejean, 1826 larvae and not in *C. rossi*. No other setae are visible in the mandibles.

About the labium (Figs. 4, 5, and 12), labial palpus have two palpomeres. The apical with a blunt end. In them, the seta LA6 is long. LA1 y LA2 are also present. According to the pores, in the *labium* the LAa and Lac are detected.

Maxillae (Figs. 5, 9, and 10) are, with the stipes, longer than the mandibles. Cardo is much reduced. Four palpomeres in the palpus, decreasing in size from the base to the apex. In them, MX10, MX7, MX2 and MX3 and the small MX II can be seen.

Galea (Fig. 9) is shorter than the half of the labial palpus. Lacinia has a long seta MX6 that does not reach the joint between the two galeomeres.

Antennae (Figs. 4, 5, and 15) have four subcylindrical antennomeres. It is longer than the mandible (ratio Antenna/mandible=0.88). The first, in its base, is short and wide; the second is longer and a bit thinner; the third is almost equal in length but slimmer; and the fourth is a bit smaller and it is the thinnest of all. In the antennae, the second antennomere has any setae (as mentioned about *Archicarabus* larvae by ARNDT & MAKAROV, 2003), but the setae AN2, AN3, AN4, AN5 y AN7 stand out in its end.

- **Thorax** (Fig. 3)

  In all the thoracic tergites, a medial suture that coincides with the sagital plane is present. In each of them three different areas are possible to distinguish from the front to the back: a slightly sclerotized pretergum, a very sclerotized tergum and a less sclerotized postergum.

Prothorax is the first and the longest part of thorax, a bit wider than longer, reaching a maximum width of 1.9 mm and a maximum length of 1.8 mm. Dorsally, pronotum bears the setae PR6, PR9, PR11, and PR12. Prosternum has one seta on each side that belongs to the group that GILGADO & ORTUÑO (2011) call gPS. Each side of the prosternum also has the PS1 at the end and shows another seta from the group gES1.

Mesothorax, 2 mm, is a bit wider than pronotum, 1.9 mm but it is shorter than it, with a length of 1.15 mm.

Metathorax is equal in width and length than mesothorax.

Legs (Figs. 11 and 14) are less sclerotized than the terguites. In the tarsus, as it happens with others first instar larvae, it lacks the gTA spines. On the other hand, the setae TA2, TA3, TA4, TA5, TA6 y TA7 are present.

About metathoracic legs, they have the next ratios: trocanter/coxa=0.55, femur/coxa=0.58, tibia/coxa=0.51, tarsus/coxa=0.51.

- **Abdomen** (Fig. 3)

  Approximate length of 7.3 mm. The average length of the abdominal segments is 0.81 mm and the maximum width of them is 2.08 mm.

  In the first abdominal terguite it is possible to detect TE3 and TE4. The rest of the abdominal terguites shows TE2, TE7, TE8, TE10 and TE11. TE8 is mentioned in MAKAROV (1993) about *Archicarabus* larvae, but TE9 lacks, as LUFF (1993) has pointed out about the larva of *C. nemoralis.* It bears the pleural organ, easy to distinguish (Fig. 16).

  Urogomphi (Figs. 9, 11,and 12) are clearly unmistakable and unique, and they are similar to that of *C. montivagus*, a mainly east European species, and very different of that *C. nemoralis*, both figured in HŮRKA (1971), ARNDT (1985), and ARNDT & MAKAROV (2003). They are smooth (Figs. 4 and 17). In them, the setae UR4, UR5, UR6, UR7, and UR8 are long and clearly visible. The fact that the urogomphi clearly end in a round top, relate *C. steuartii* to *C. montivagus*, probably indicating that the former is its vicariant species in the east. This fits with the idea of a Mediterranean origin of *C. steuartii* suggested by the distribution of its habitat of shrub.

  The pygidium has a length of 0.36 mm. It is possible to detect four chetae on each side, dorsally the PY2, PY4, in the medium, PY7 and one more ventral chetae with a somewhat problematic assignation.

– **Second and third instars**

Only two larvae of the second instar and one larva of the third one were studied (*ex societate imagines*). These larvae were collected in Monforte, in the south of the province of Lugo. They show similar characteristics of the described L I with some small differences, becoming less acute and more rounded in their shape, for example, in the frontoclypeolabrum (Fig. 20), as it happens with other *Carabus* larvae. The shape of the clypeus and the urogomphi are similar too, and appeared clearly different from the *C. nemoralis* larvae according to the literature and from one *C. nemoralis* larva from Asturias. Thus, at the clypeus, the hypodon is less visible and the urogomphi become robust but with a round apex that present the L I too. The L II is 16.5 mm long and has a maximum width of 2.96 mm and the L III has a length of 23 mm and is 3.14 mm wide, as a maximum.

- **Second larval instar**

  Average morphometric data in mm: 16.5 mm. Head length: 1.6 mm. Head width: 1.8 mm.

  Frontal (Fig. 20) is a bit wider than long (ratio length/width=0.88). Clypeus is five times wider than long, showing a clear hypodon. Clypeus is a bit wider than each one of the lobi or anguli frontalis. Third antennal segment a slightly longer than the fourth. Last segment of maxilar palpi 1.5 times longer that the basal segment. Last segment of the labial palpi approximately 1.2 times longer than the first segment. Width of the head of two larvae of 1.61 mm and 1.77 mm.

- **Third larval instar**

  Average morphometric data in mm: 23 mm. Head length: 1.86 mm. Head width: 2.38 mm.

  Frontal (Fig. 20) slightly wider than long (ratio length/width=0.78). Pars aboralis frontalis twice time wider than long. Clypeus 3.5 times wider than long. As the other instars, the narrow hypodon is clearly detected in the middle of the clypeus. Anguli frontalis as wide as the clypeus. Its anterior border almost right, forming one right angle with respect to the clypeus. Anterior borders of the clypeus protruding a few more than the border of the anguli frontalis. Antennae clearly longer than mandibles. The ratio between the antennomeres is I:II:III=1:1,5:1,3; I:IV=1,3:1. Retinaculum without accessory tooth. Stipes 1.5 times longer than wide. Maxillary palpi about 1.87 times longer than the stipes. Urogomphi clearly granulated (Fig. 18).

– **Biology update of *Carabus (Archicarabus) steuartii***

According to ARNDT (1985), the *Archeocarabus* group species (*Carabus serrilabros sensu* LAPOUGE, 1929, including *C. nemoralis* and *C. steuartii*) are species adapted to hard soils and capable to dig in the ground. This group has larvae that inhabit open fields and meadows, and feed on insects of these habitats.

Moreover, according to STURANI (1962), *C. nemoralis*, *C. monticola* and *C. montivagus* live in forests and meadows, *C. nemoralis* from 900 to 2000 masl, *C. monticola* from 400 to 2000 masl and *C. montivagus* from the plains to 1800 masl. However, in the northwest of Spain, *C. nemoralis* is found from the sea level, as it happens with other *Carabus* species (*C. deyrollei* Gory, 1839, *C. lineatus* Dejean, 1826, *C. melancholicus* Fabricius, 1798, *C. rugosus* Fabricius, 1792, *C. lusitanicus* Fabricius, 1801, and *C. luetgensi* Beuthin, 1886 according to personal observations and data). It is clear that this fact is related to climatic factors.

It seems interesting to mention that this species is associated with heaths and shrub lands with *Pteroscarpum tridentatum* (L.) Will., *Erica* spp. and *Ulex* spp. both in the north of Portugal or in the northwest of Spain. According to LASSALLE (1983) and VALCÁRCEL (1995), where *C. nemoralis* and *C. steuartii* coexist, in the south of Lugo, the first inhabits the forests and the second the meadows. This fits with the mentioned observations, including the man-made pine plantations (usually with *Pynus sylvestris* (L.) Will. over shrublands, as occurred in Serra do Marão in Portugal and Campobecerros in Spain. Probably, *C. steuartii* finds these soft soils in these pine forests more suitable to dig and overcome the hard winter and summer, with temperatures between -4,3°C and 38,2°C. In Campobecerros, in July, at a depth of 15 cm, temperatures 20°C lower than the surface were recorded.

Other recent data from well-known localities of the north of the provinces of A Coruña and Lugo (REY MUÑIZ, 2014), must be considered carefully and with doubts. The lack of preserved specimens of *C. steuartii* of these sites (X.L. Rey Muñiz and P. Torrella, com. pers.) made no possible to confirm the right identification. On the other hand, the confusion between *Oreocarabus* and *Archicarabus* imagoes is very common (LASSALLE, 1983), not considering the shape of thorax, penis and, above all, the elytral sculpture: heptaploid in *Oreocarabus* and pentaploid in *Archicarabus*. To differentiate *C. luetgensi* from *C. steuartii*, which coexist in the same pine forest in Campobecerros, a detailed snapshot of the elytra was a great help in the field. Probably, the same type of mistake could have been made before, since *C. luetgensi* is widespread in the north of A Coruña and Lugo (VALCÁRCEL *et al.*, 1997; CAMPOS & NOVOA, 2006; and own data).

Indoors, the beetles show an activity between 10°C and 20°C, stopping it below 10°C or above 20°C. The beetles started to hibernate between the last week of October or the second of December and keep on resting until February, as we could see in the field and was registered by the literature (LASALLE, 1983; VALCÁRCEL, 1995; VALCÁRCEL *et al.*, 1997).

They usually show a summer diapause too, but not always. It appears that tend to lack near the top of the mountains (DARGE, 1985). Considering temperature data, in Erosa, near Campobecerros, the maximum temperatures drop below 15°C in December and do not recover these values again until the second half of February (Erosa station, data published by AEMET and used with permission). In this month, indoors, they started to move and in a few days the reproductive activity was easily detected. Prunier (com. pers.) recorded this spring activity by the number of collected imagoes using pitfalls in Serra do Marão, in the north of Portugal, in 2011.

Carabus steuartii was found in pine forests with an undergrowth of heath or heath shrubs, and this landscape, consisting in shrubland, was found in Arga de São João (Viana do Castelo, Portugal), Serra do Marão (Vila Real, Portugal), Sabrosa (Vila Real, Portugal), Cabeza de Meda, Campobecerros (Ourense, Spain), Candán (Pontevedra, Spain), Porto (Zamora, Spain), or A Pobra do Caramiñal (A Coruña, Spain), where this species was registered (VALCÁRCEL, 1995).

In summary, considering the literature (LASALLE, 1983; DARGE, 1985; VALCÁRCEL, 1995; VALCÁRCEL *et al.*, 1997) and our own data, this *Carabus* is active from February until November (Campobecerros, Ourense, for example, in both cases) at different altitudes and places, showing a winter and summer diapauses, reducing or lacking the last of them in some high places (Porto, Zamora, in August, between 1500 m and 1800 m of altitude, near a stream, DARGE, 1985; and in Campobecerros, own data). After the winter pause, required for egg maturation (CARABAJAL, 1995; LEQUET, 2023), they start the reproduction. Without these low temperatures in winter, the quantity and fertility of the eggs was poor, according to the results of the breeding in 2022. In the terrarium, during this pauses, the beetles lay them not too deep in the soil (around 3 cm deep). As mentioned, they show activity indoors mainly between 10ºC to 20ºC and only few individuals were seen below or above this temperature, no matter if it is daytime or nighttime. It was easy to see some beetles active during the day, mainly in the morning or in the last part of the day. After the mating, that sometimes was detected under the surface, the female lays the eggs a few days later. One female laying the eggs with only the thorax and head above the soil was observed, showing the reason why the eggs are not detected very deep.

By now, as it is shown by recent observations, each female lay a number of eggs that varies from 15 to 17, which is not a very high number. According to CARABAJAL (1995), the number of eggs laid by one female varies from 12 in *Carabus (Chaetocarabus) intricatus* Linnaeus, 1761 to 75 in *Carabus (Macrothorax) morbillosus* Fabricius, 1792. According ASSMANN (2003), this number varies between 9 in *Carabus (Limnocarabus) clathratus* Linnaeus, 1761 and 56 in *Carabus (Tachypus) auratus* Linnaeus, 1761. BUSATO (2022) registers 132 eggs in *C. clathratus*, and 28 eggs in *Carabus (Macrothorax) planatus* Chaudoir, 1843. The record was registered by BUSATO *et al.* (2014): 511 eggs laid by one female of the Moroccan *Carabus (Cathoplius) asperatus* (Dejean, 1826). CÁRDENAS & HIDALGO (2000) registered from 2 to 67 eggs by female in *Carabus (Mesocarabus) dufouri* Dejean, 1829.

About the oviposition, STURANI (1962) describes that a female of *C. monticola,* which belongs to the same group of *Carabus* larvae (the serrilabro type) laid 6 eggs in 20 hours, letting a corridor with six small cells below it. This was not observed in *C. stuartii*.

As time goes by, they started the summer diapause at April or May, but the moment does not appeared directly related to high temperatures, as it happens about the winter diapause, not related to low temperatures. The moment in the year when it is finished is yet ignored, but in August some individuals were collected near Campobecerros, increasing in numbers in October and November. Moreover, DARGE (1985) detected this summer activity in cool places and at high altitudes of Zamora so, supposedly, is the time for the new tenerals to probably emerge from the pupae.

The beetles can stand the summer high temperatures buried in the soil, at least until certain limit, surviving when the temperature reaches 40ºC in a sunny place in summer, conveniently registered with a maximum/minimum thermometer inside the box. Of course, in the underground, coolest temperatures were detected, where the beetles rest. This datum could explain the presence of this species in warm places according to their capacity to stand hard climatic conditions buried in the ground (and probably resist a scarce of food during some periods, considering the small quantity of food consumed in the terrarium).

Thus, the observations lead to understand its distribution in this area, avoiding the competence between *C. nemoralis* and *C. steuartii*, as LASSALLE (1983) told, and would confirm the resilience of this last species about climatic conditions and habitat present in the Mediterranean climatic area it inhabits (VALCÁRCEL, 1995). One could even infer the difficulty for the survival of *C. nemoralis* in this area, a typical inhabitant of the riverside and deciduous forests of the north of Spain, as it occurs in Asturias.

Acknowledgements

First, I want to express my deepest gratitude to Nacho Cabellos and Cosme Damián Romay Cousido, enthusiast naturalists, who have encouraged me to do this work. I also want to express my gratitude to Martin Luff and, especially, to Erik Arndt, for providing some important articles about *Carabus* larvae. María Polo and Phil Park were very kind with the first review of the English text. I am also especially grateful to Dr Enrico Busato, from the University of Torino, and Dr Ana Cárdenas, from the University of Córdoba, for reviewing the article and helping me to improve it, and my old friend and colleague Javier Pérez Valcárcel, that unintentionally, caused this work to be started. I also want to thank the friends who shared the excursions to Amarante, Monforte and Campobecerros: Modes, Antonio, Juana, Fernando, and Lupe, on different occasions. And, at last but not least, I would like to thank Goretti for her constant closeness and support, and especially for the long, numerous and sometimes unsuccessful journeys we shared searching for these rare beetles.

Literature

Andrade Malde, J. 1977. In memoriam Paul Raynaud. *Ctenocarabus galicianus*, Gory (Coléoptère Carabidae). Estados larvarios (Ex societate imaginis). *Nouvelle Revue d'Entomologie,* **7**(3): 257-260.

Arndt, E. 1985. Larvenbestimmungsschlüssel der *Carabus*-Arten Europas (Col., Carabidae). *Entomologische Nachrichten und Berichte*, **29**(2): 49-62.

Arndt, E. & Makarov, K. 2003. *Key to the larvae* , pp. 125-149. In: Turin, H., Penev, L. & Casale, A. (eds.). *The Genus* Carabus *in Europe - a Synthesis*. Fauna Europaea Evertebrata No 2. Pensoft Publishers & European Invertebrate Survey, Leiden, xvi + 512 pp., 24 col. pls, 217 maps.

Assmann, T. 2003. *Biology and ecology*, pp. 287–305. In: Turin, H., Penev, L. & Casale, A. (eds.). *The Genus Carabus in Europe - a Synthesis*. Fauna Europaea Evertebrata No 2. Pensoft Publishers & European Invertebrate Survey, Leiden, xvi + 512 pp., 24 col. pls, 217 maps.

Bengtsson, S. 1927. Die Larven der nordlischen Arten von *Carabus* L. Eine morphologische Studie. *Lunds Universitets Års-skrift*, N. F., Avd. 2, **24**: 1-89.

Bousquet, Y. & Goulet, H. 1984. Notation of primary setae and pores on larvae of Carabidae (*Coleoptera: Adephaga*). *Canadian Journal of Zoology*, **62**: 573–588.

Burakowski, B. 1993. *Laboratory methods for rearing soil beetles (Coleoptera)*. Memorabilia Zoologica, 46. Polska Akademia Nauk, Muzeum I Instytut Zoologii. Warszawa, 67 pp.

Busato, E. & Giachino, P.M. 1994. Contributo alla conoscenza della morfologia larvale del genere *Carabus*. La larva di *Carabus (Orinocarabus) latreilleanus* Csiki, 1927 (Coleoptera, Carabidae). *Rivista Piemontese di Storia naturale*, **14** (1993): 185-193.

Busato, E. 2003. Morfologia larvale di *Carabus (Orinocarabus) baudii* (*Coleoptera, Carabidae*). *Bolletino de la Società Entomologica Italiana,* **135**(1): 25-38.

Busato, E. 2004. Morfologia larvale di *Carabus (Orinocarabus) adamellicola* Ganglbauer, 1904 e di *Carabus (Orinocarabus) castanopterus* Villa, 1833 (Coleoptera, Carabidae). *Bolletino del Museo regionale di Scienze Naturali, Torino*, **21**(1): 73-88.

Busato, E. 2022. *Carabus clatratus* (*Coleoptera: Carabidae*): study case of mass rearing and release of a threatened species with new details on its life history. *Journal of Insect Conservation*, **26**: 29–41.

Busato, E. & Casale, A. 2005. Note sul ciclo biologico e sulla morfologia pre-immaginale di *Carabus (Macrothorax) planatus* Chaudoir, 1843, specie endemica dell'Appennino siculo (Coleoptera, Carabidae). *Studi Trentini di Scienze Naturali, Acta Biologica*, **81** (2004): 177-187.

Busato, E., Gallizia, S. & Ferracini, Ch. 2023. Contributo alla conoscenza della morfologia larvale del Genere *Carabus* Linnaeus, 1758. La larva di *Carabus (Orinocarabus) lepontinus* Born, 1908 (Coleoptera, Carabidae). *Rivista piamontese di Storia naturale*, **44**: : 153-162.

Busato, E., Ghittino, C. & Casale, A. 2014. *Carabus* of Subgenus *Cathoplius C.G.* Thomson, 1875, with description of their life-way, life–cycle and pre-imaginal morphology (Coleoptera, Carabidae). *Zootaxa*, **3866**(4): 451-478.

Campos, A.M. & Novoa F. 2006. Los *Carabidae* (*Orden Coleoptera*) de Galicia (N.O. de España). Catálogo, Distribución y Ecología. *Nova Acta Científica Compostelana. Serie Bioloxía. Monografías,* **2**: 1-358.

Carabajal, E. 1995. *Cría de* *Carabus* en cautividad. *Boletín de la Sociedad Entomológica Aragonesa*, **9**: 17-20.

Cárdenas, A.M. 1993. Inmature stages of *Macrothorax rugosus baeticus* (Col. Carabidae). *Elytron*, **7**: 123-131.

Cárdenas, A.M. & Bach, C. 1993. Primeros datos sobre la biología de reproducción y desarrollo larvario de *Macrothorax rugosus* Fabricius, 1792 (Coleoptera, Carabidae). *Zoologica Baetica*, **3**: 139-146.

Cárdenas, A.M. & Hidalgo, J.M. 1995. Datos sobre la biología de reproducción y desarrollo larvario de *Carabus (Hadrocarabus) lusitanicus* (Fabricius, 1801) (Coleoptera: Carabidae). *Elytron*, **9**: 139-145.

Cárdenas, A.M. & Hidalgo, J.M. 1998. Immature stages of *Rhabdotocarabus melancholicus* ssp. *dehesicola* (García-París & París, 1995) (Coleoptera, Carabidae). *Miscel·lània Zoològica*, **21**(2): 95-104.

Cárdenas, A.M. & Hidalgo, J.M. 2000. Seasonal activity and reproductive biology of the ground beetle *Carabus dufouri* (Coleoptera: Carabidae). *European Journal of Entomology*, **97**(3): 329-338.

Cárdenas, A.M., Molina, M.D. & De Las Heras, A.M. 1994. Morfología larvaria de *Hadrocarabus lusitanicus* Fabricius, 1802 (*Col. Carabidae*). *Graellsia*, **50**: 95-99.

Casale, A., Sturani, M. & Vigna Taglianti, A. 1982. *Fauna d'Italia. Coleoptera, Carabidae I. Introduzione, Paussinae, Carabinae*. Ed. Calderini. Bologna, 499 pp.

Darge, P. 1985. Carabes de Galice. *Sciences Nat*, **46**: 23-24.

Deyrolle, A. 1852. Note pour servir a l'Histoire des Carabes d'Espagne et du Portugal, et remarques sur quelques espèces du Nord de L´Afrique. *Annales de la Société Entomologique de France*, (2)**10**: 237-252.

Delkeskamp, K. 1930. *Biologische Studien über Carabus nemoralis* Müll. *Zeitschrift für Morphologie und Ökologie der Tiere* , **19**(1): 1-58.

Deuve, T. 2021. *Carabus of the World*. Ed. Magellanes. Conflans-Sainte-Honorine, 652 pp., 114 pls.

Emden, F.I. van. 1942. A key to the genera of larval Carabidae (Col.). *Transactions of the Royal Entomological Society of London*, **92**(1): 1-99.

Gilgado, J.D. & Ortuño, V.M. 2011. Biological notes and description of egg and first instar larva of *Carabus (Oreocarabus) ghilianii* La Ferté-Sénectère 1847 (Coleoptera: Carabidae). *Annales de la Societé entomologique de France* (*nouvelle série*), **47**(3–4): 444-456.

Gilgado, J.D. & Ortuño, V.M. 2012. *Carabus (Oreocarabus) guadarramus* La Ferté–Sénectère, 1847 (Coleoptera, Carabidae): first instar larva and reflections on its biology and chorology. *Animal Biodiversity and Conservation*, **35**: 13-21.

Goulet H. 1976. A method for rearing ground beetles (Coleoptera: Carabidae). *Coleopterists Bulletin*, **30**(1): 33–36.

Goulet, H. 1979. *Contributions of characters of larvae to systematics of Carabidae*, pp. 205-208. In: Erwin, T.L., Ball, G.E. & Whitehead, D.R. (eds.). *Carabid beetles: their evolution, Natural History and classification.* Dr. Junk bv Publ. New York, 646 pp.

Hůrka, K. 1971. Die larven der mitteleuropaischen *Carabus*- und *Procerus*-Arten. Morphologisch-taxonomische studie. *Rozpravy Československé Akademie Věd. Řada matematických a přirodních věd*, **81**(8): 1-136.

I.C.Z.N. (International Commission on Zoological Nomenclature). 1999. *International Code of Zoological Nomenclature. Fourth edition.* International Trust for Zoological Nomenclature. London, U.K. Available online at https://www.iczn.org/the-code/the-code-online/.

Kobayashi Y., Niikura K., Oosawa, Y. & Takami, Y. 2013 Embryonic development of *Carabus insulicola* (Insecta, Coleoptera, Carabidae) with special reference to external morphology and tangible evidence for the subcoxal theory. *Journal of Morphology*, **274**: 1323–1352.

Lapouge, G.V. de. 1904. Méthodes d'élevage des larves de Carabes. *Bulletin de la Société des sciences naturelles de l'Ouest de la France*, **4**: 1–15.

Lapouge, G.V. de. 1905. Tableaux de détermination des larves de Carabes et de Calosomes. *L'Échange. Revue Linnéenne*, **21**(248): 159-160; (249): 164-165; (250): 171-173.

Lapouge, G.V. de. 1929. *Synopsis morphologique des larves des Carabinae*, pp. 44-60. In: *Coleoptera Adephaga. Fam. Carabidae: subfam. Carabinae. Premiére partie*. Genera insectorum (P. Wytsman), **192**[1929-1932]: 1-747.

Lassalle, B. 1983. Description d'une nouvelle sous-espèce de *Carabus (Archicarabus) steuarti* [*Col. Carabidae*]. *L'Entomologiste*, **39**(1): 21-23.

Lecquet, A. 2023. Les Carabes.....de A à Z! (Coléoptères Carabidae). Available online at: http://insectes-net.fr/carabes/car1.html [last accessed: 2023]

Löbl, I. & Löbl, D. (eds.). 2017. *Catalogue of Palaearctic Coleoptera. Archostemata, Myxophaga, Adephaga.* Revised and updated edition. Vol. 1. Brill. Leiden/Boston, xxxiv + 1.443 pp.

Luff, M. 1993. *The Carabidae (Coleoptera) larvae of Fennoscandia and Denmark.* Fauna entomologica Scandinavica, 27. Brill. Leiden, 185 pp.

Makarov, K.V. 1993. Larvae of ground beetles of the genus *Carabus* L. (Coleoptera, Carabidae) of the fauna of Russia and neighboring countries. *Entomological Review*, **72**(4): 92-117. [originally published in *Entomologicheskoye obozreniye*, **71**(4) [1992]: 752-774.].

Malausa, J.C. 1977. L'élevage de coléoptères Carabidae: dans la perspective d'une multiplication de masse. *Annales de Zoologie. Ecologie Animale*, **9**: 497-505.

Ramos-Abuin, J.Á. 2011. The larva of *Eucarabus deyrollei* Gory 1839 (Coleoptera, Carabidae): description of the instar III *(ex ovo),* breeding methods and notes on its biology. *Boletín de la Asociación española de Entomología*, **35**(3-4): 369-382.

Raynaud, P. 1965. *Xystrocarabus deyrollei* Gory (Coléoptère Carabidae). Elevage et stades larvaires. *Bulletin mensuel de la Societé Linneenne de Lyon*, **34**(9): 384-388.

Raynaud, P. 1968. Elevage de *Carabus* (Coléoptères Carabidae). *L'Entomologiste*, **24**(3): 61-65.

Raynaud, P. 1974. Carabidae de la Péninsule Ibérique (article 2). *Entomops*, **35**: 70-73.

Raynaud, P. 1975. Synopsis morphologique des larves de *Carabus* Lin. (Coléoptères Carabidae) connues à ce jour. *Bulletin de la Société linnéenne de Lyon*, **44**(7): 211-229; **44**(8): 257-272; **44**(9): 297-328; **44**(10): 349-372.

Raynaud, P. 1976. Synopsis morphologique des larves de *Carabus* Lin. (Coléoptères Carabidae) connues à ce jour. *Bulletin de la Société linnéenne de Lyon*, **45**(2): 61-84; **45**(3): 107-126.

Rey Muñiz, X.L. 2014. *Carabus steuarti* Deyrolle, 1852, pp. 50-55. In: S.G.H.N. (Sociedade Galega de Historia Natural). *Atlas e libro vermello de Carabini, Cychrini e Lucanidae (Insecta, Coleoptera) de Galicia*. Sociedade Galega de Historia Natural. Vilagarcía de Arousa, 162 pp.

Rivas-Martínez, S. 1987. *Memoria del mapa de series de vegetación de España 1: 400.000.* ICONA. Ministerio de Agricultura. Madrid, 268 pp.

S.G.H.N. (Sociedade Galega de Historia Natural). 2014. *Atlas e libro vermello de Carabini, Cychrini e Lucanidae (Insecta, Coleoptera) de Galicia*. Sociedade Galega de Historia Natural. Vilagarcía de Arousa, 162 pp.

Sturani, M. 1962. Osservazioni e ricerche biologiche sul genere *Carabus* L. (s.l.). (Coleoptera, Carabidae). *Memorie della Società Entomologica Italiana*, **43**: 63-79.

Turin, H., Penev, L., Casale, A. & Arndt, E. 2003. *Carabus evaluations*, pp. 439–446. In: Turin, H., Penev, L. & Casale, A. (eds.). *The Genus Carabus in Europe - a Synthesis*. Fauna Europaea Evertebrata No 2. Pensoft Publishers & European Invertebrate Survey, Leiden, xvi + 512 pp., 24 col. pls, 217 maps.

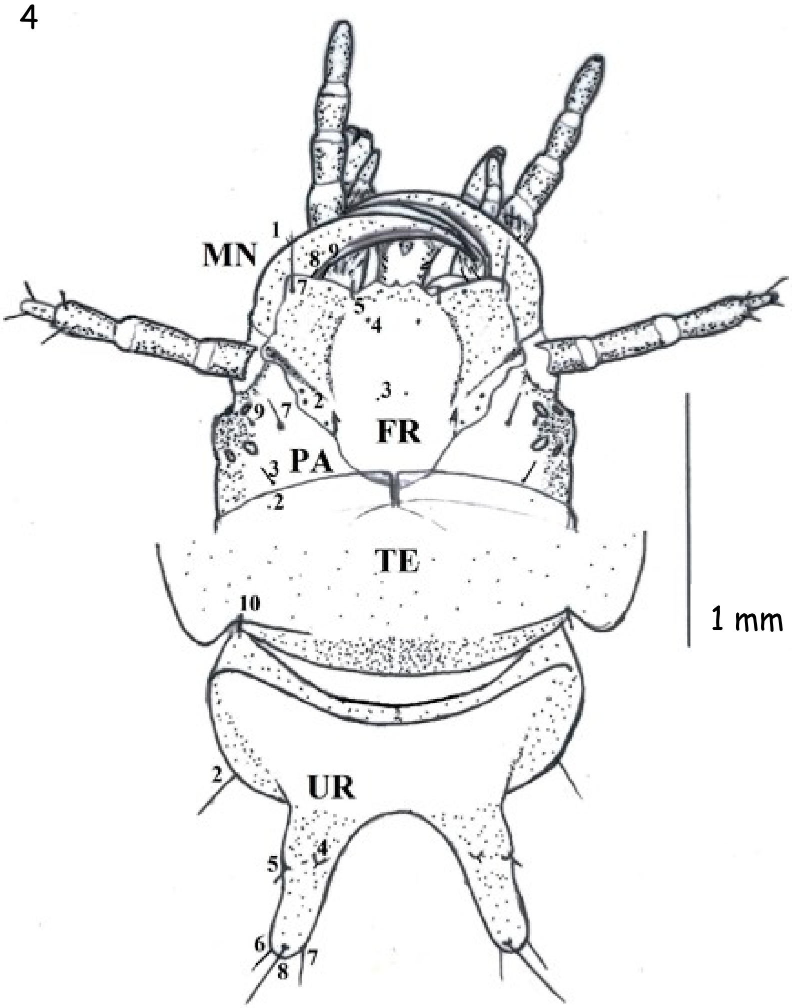
Valcárcel, J.P. 1995. Las especies del género *Archicarabus* (Col. Carabidae) en Galicia (N.O. de la Península Ibérica). *Boletín de la Sociedad Entomológica Aragonesa*, **10**: 3-6.

Valcárcel, J.P., Prieto Piloña, F., Mejuto Rial, C. & Devesa Regueiro, S. 1997. Aportaciones al inventario de los Caraboidea de Galicia (NO de la Península Ibérica). Familias: Carabidae, Nebriidae, Notiophilidae, Omophronidae, Elaphridae y Loroceridae. *Boletín de la Sociedad Entomológica Aragonesa*, **17**: 15-26.

Valcárcel, J.P., López-Díez B. & Prieto Piloña, F. 2021. Los Carabidae Latreille, 1802 (Coleoptera) del valle de Lemos, Lugo (N.O. de la Península Ibérica). I.- Descripción del área de estudio y subfamilias Cicindelinae, Carabinae, Nebriinae y Scaritinae. *Arquivos Entomolóxicos,* **24:** 277-292.

1


2


4


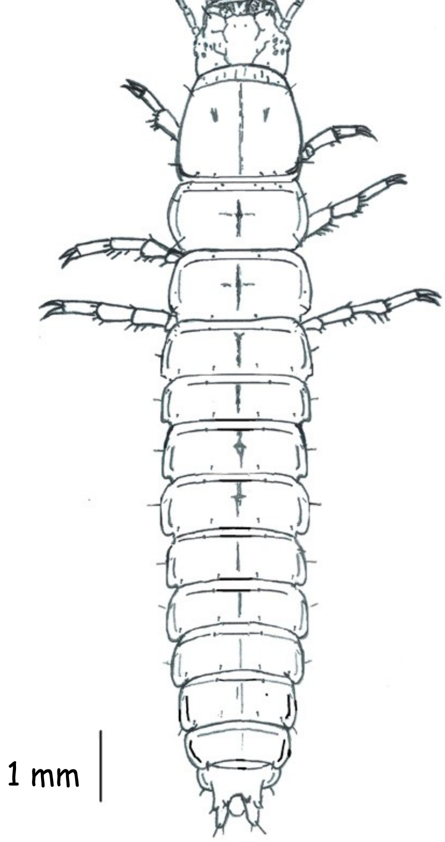
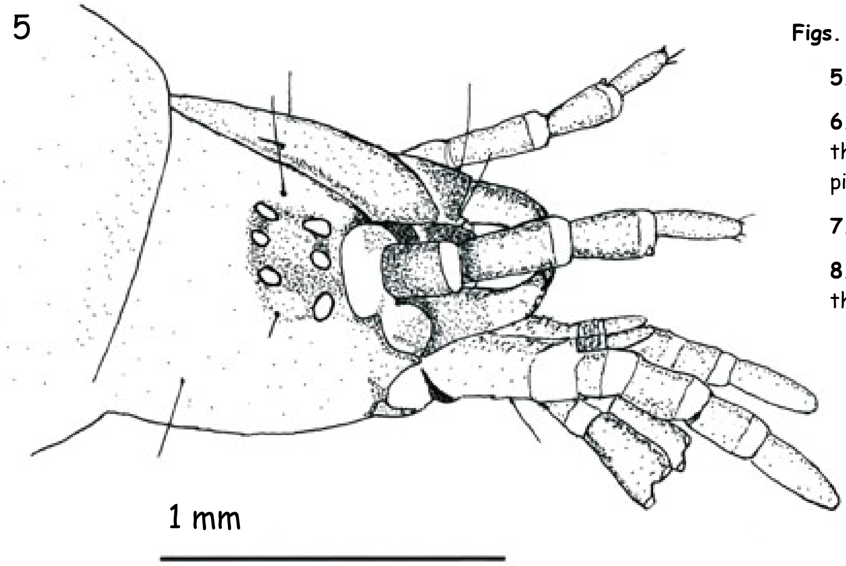
3


Fig. 1.- Egg of *C. steuarti*.

Fig. 2.- First discovered living L I of *C. steuarti*.

Fig. 3.- Habitus of a living L I of *C.steuarti*.

Fig. 4.- Head and urogomphi of the L I of *C. steuarti*. Preserved and cleared L I.



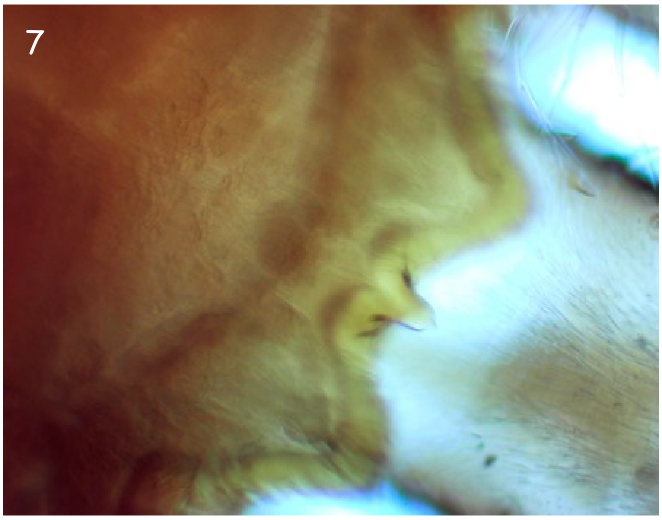
Figs. 5-8.- L I of *C. steuarti.*

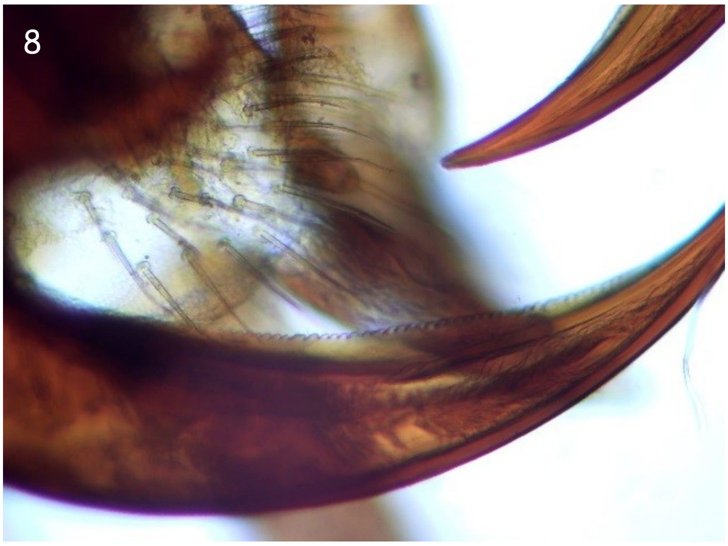
5.- Head in lateral view.

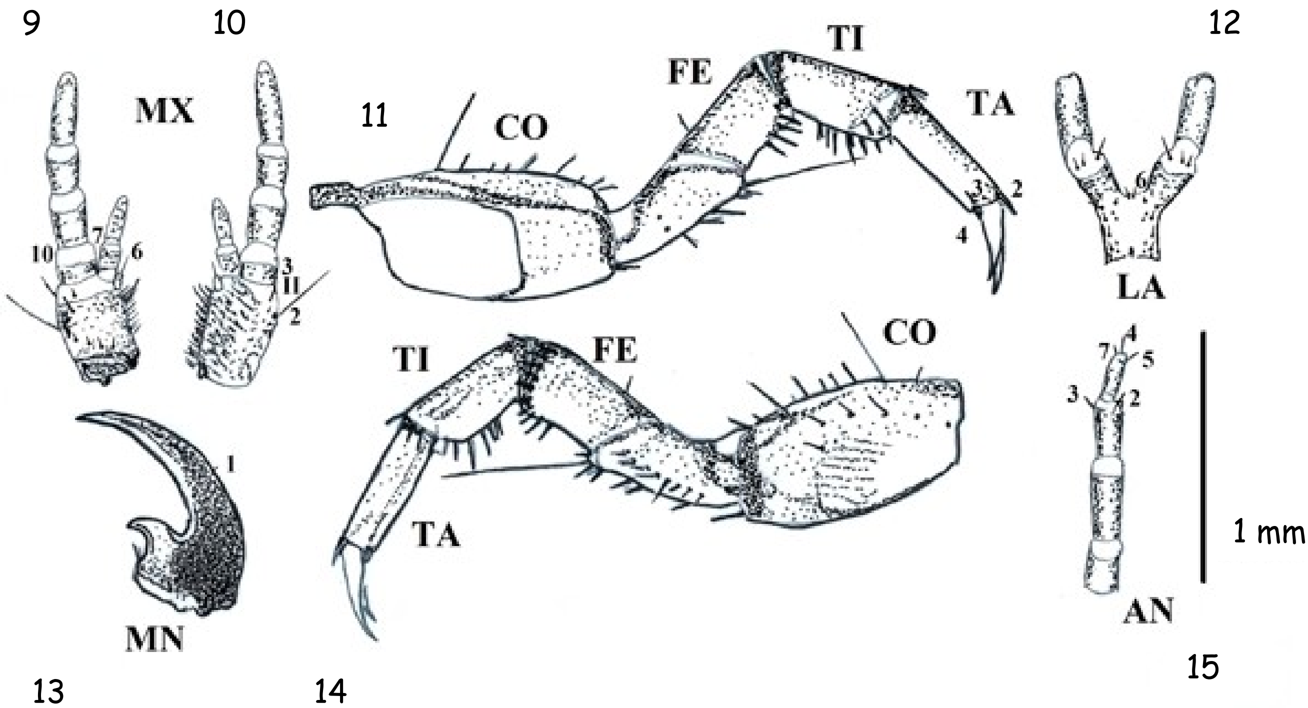
6.- Head, showing with detail the hypodon, the clypeus, the egg busters and the frontal piece.

7.- Detail of the hypodon.

8.- Detail of the right mandible, showing the serrulated inner border.







Figs. 9-15.- L I of *C. steuarti*. The small numbers and letters represent the diferent chetae and pores, according to the text.

9.- Right maxilla in ventral view.

10.- Right maxilla in dorsal view.

11.- Metathoracic right leg in dorsal view.

12.- Labium.

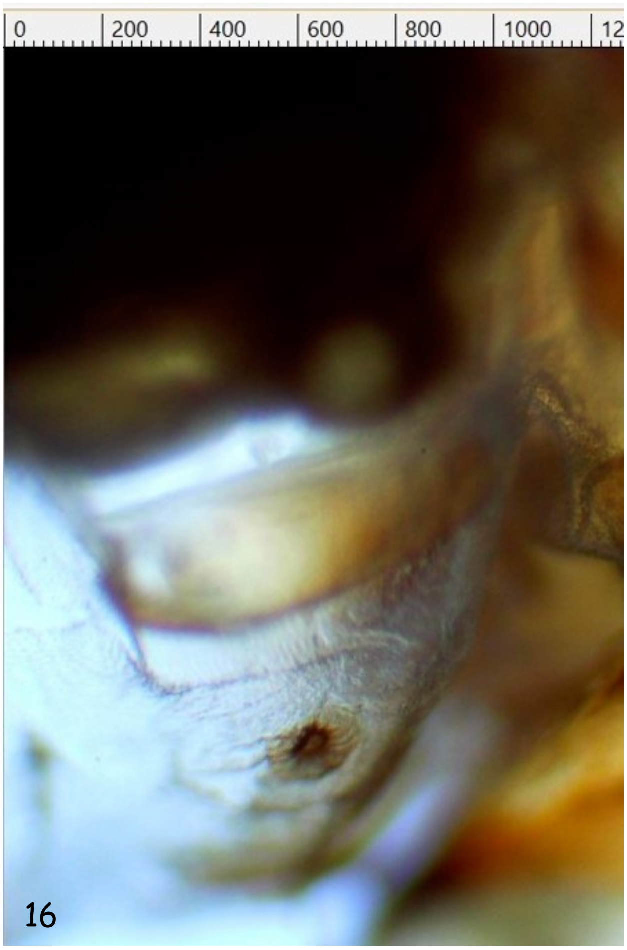
13.- Right mandible.

14.- Metathoracic right leg in ventral view.

15.- Right antenna in dorsal view.

16.- Pleural organ in detail.

17.- Urogomphi of a cleared L I.



18

Fig. 18.- Urogomphi of a L III of *C. steuarti*. The granulated surface is clearly observed.

Fig. 19.- One cleared L I of *C. steuarti*, showing the chetotaxy and the shape of the abdominal lobes.

Fig. 20.- Frontoclypeolabro of L I, L II, and L III.

19

20

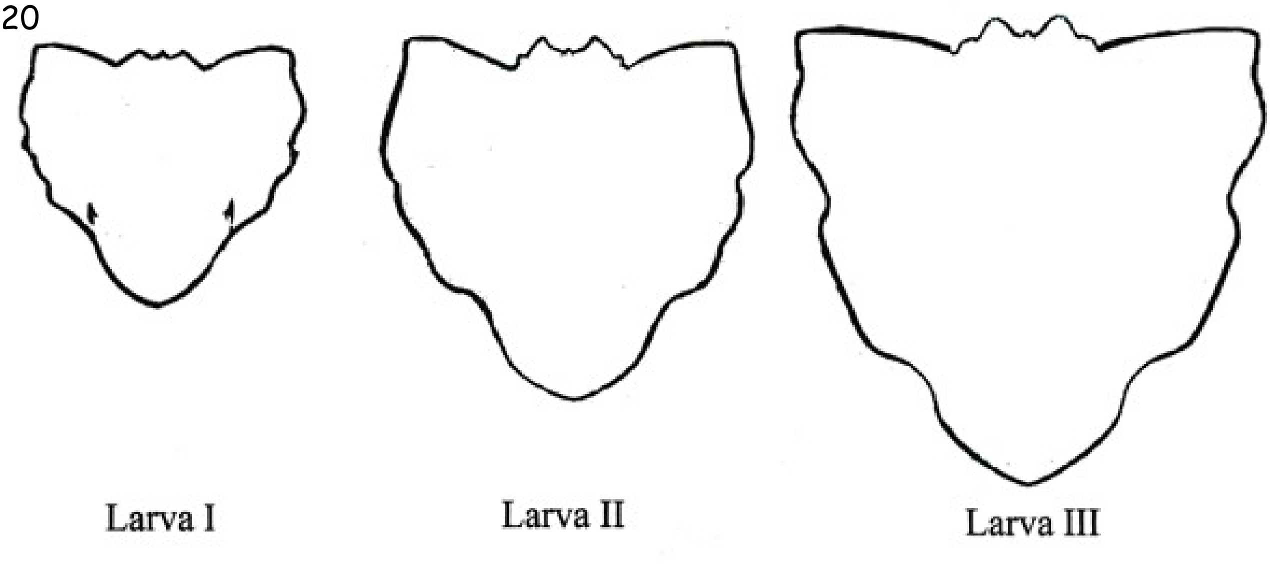


Fig. 21.- Head of a L I, only a few hours after hatching. The sclerotized dark egg busters are clearly visible. In the same day, the entire larva will become black-coloured.

Fig. 22.- Habitus of a newborn L I.