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LARVAL MORPHOLOGY AND BIONOMY OF *AMARA (LEIRIDES) ALPESTRIS*
VILLA (COLEOPTERA, CARABIDAE)

MORFOLOGIA LARVALE E CICLO BIOLOGICO DI *AMARA (LEIRIDES) ALPESTRIS*
VILLA (COLEOPTERA, CARABIDAE)

Abstract - The larval instars of *Amara (Leirides) alpestris* are described: this species is endemic of Italian Eastern Alps and develops through only two larval stages, probably an adaptation to the short favourable season of the high altitudes, where *A. alpestris* is very common. It reveals to be an autumn breeder, with overwintering larvae, and reproduction probably delayed to the second life year. Moreover, the main activity peak of the population is found to be early in the season. The diagnostic characters are inserted in the keys to subgenera and species of *Amara*, previously known from literature.

Key words: Carabidae, Larval morphology, Reproduction cycles and rhythms.

Riassunto breve - Vengono descritti gli stadi larvali di *Amara (Leirides) alpestris*, specie endemica italiana delle Alpi Orientali. Lo sviluppo larvale è accorciato a soli due stadi, probabilmente come adattamento alla stagione riproduttiva molto breve che si ritrova alle notevoli altitudini dove *A. alpestris* è molto comune. La specie è un riproduttore autunnale a larve svernanti, con però la riproduzione probabilmente differita al secondo anno di vita. Il picco di attività massima della popolazione risulta inoltre anticipato ai mesi estivi. I caratteri diagnostici sono inseriti nelle chiavi di identificazione già note in letteratura per il genere *Amara*.

Parole chiave: Carabidae, Morfologia larvale, Ritmi riproduttivi.

Introduction

A complete survey of literature on *Amara* larvae was published by BILY (1975), who reported also bionomic notes for several species of the subgenus *Celia* and one species of the subgenus *Amara* s. str. (BILY, 1972). Recent contributions to the larval knowledge of *Amara* are in HURKA & DUCHAC (1980), DESENDER et al. (1986), DESENDER (1988). Identification keys for the species were published by LARSSON (1941, 1968), SHAROVA (1958) and recently by ARNDT in KLAUSNITZER (1991). About thirty species (more or less the half for this genus) result described.

The described species belong to six subgenera, i.e. *Percosia*, *Curtonotus*, *Zezea*, *Bradytus*, *Amara s. str.*, *Acrodon* and *Celia*. BILY (1975) proposed an identification key for all these taxa. Nothing is reported in literature about the other subgenera, particularly *Leirides*, to which *Amara alpestris* belongs. JEANNEL (1942) ranked this taxon as a subgenus of a separate genus *Cyrtotus* Stephens (syn. *Curtonotus* Stephens).

Amara alpestris is an Italian endemite of the Southeastern Alps, the distribution area ranges from the Prealps near Bergamo (Orobian Alps) to the Carnic Prealps (M.te Cavallo) (MAGISTRETTI, 1965).

BRANDMAYR & ZETTO BRANDMAYR (1988) give for this species the following autoecological profile: "Guide species characteristic of the alpine prairie on carbonatic bedrock and screes, xerophilous, partly phytophagous, spermophagous. The abundance peak is reached in well drained *Seslerietum* vegetation, in the *Carex firma* pioneer cushions the beetle is less dense. The ecological optimum is found in the rainy Prealps, where this *Amara* is more eurytopic than in sites inside the alpine chain. In the "Busa delle Vette" (near Belluno, the site from which the most adult and larval specimens have been collected), this species is the dominant ground beetle everywhere the herb-layer covers at least 40% of the soil. The (adult) phenology shows a very clear peak in July, a minimum in September and a less pronounced autumn peak. Teneral appear in September, larval stages drop into the pit-fall traps in all the summer months, until October. Reproduction rhythm of the "autumn" type, with overwintering larvae and ripening of adults delayed to the following spring or summer. Brachypterous, petrophilous, endemic of the refugium massifs."

In this work the larval stages of *Amara alpestris* are described for a better knowledge on the systematics of the genus. The study of adult and larval phenology in the "Busa delle Vette" and the observations on adult ripening done by dissection allowed a careful reconstruction of propagation rhythm and of the biological cycle of this alpine ground beetle.

Materials, methods and habitat

The larvae of *A. alpestris* (518 I instars and 343 II instars) are conserved in alcohol 70% in the larval collection Zetto-Brandmayr, Dipartimento di Ecologia, Università della Calabria. All the specimens were collected by pitfall traps in the Eastern Alps, namely on the Vette di Feltre (BI).

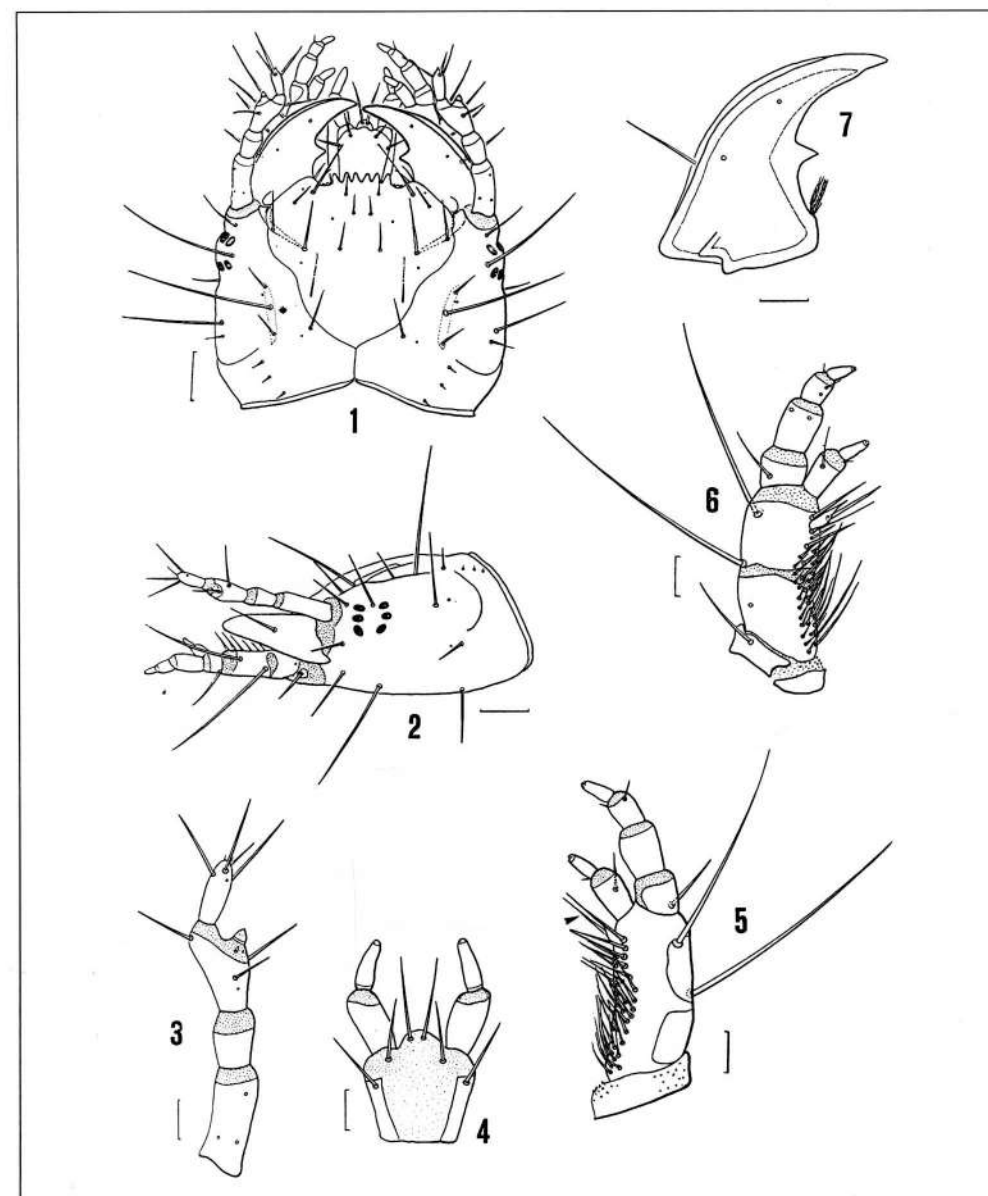


Plate I - *Amara alpestris*, first instar larva. 1: head, *: setae PA 5,7,8; 2: head (lateral); 3: right antenna (dorsal); 4: labium (dorsal); 5: right maxilla (dorsal), arrow: seta MX6; 6: right maxilla (ventral); 7: left mandible (dorsal). Scale 1 and 2: 0.25 mm; 3,4,5,6,7: 0.1 mm.

- *Amara alpestris*, larva al I stadio. 1: capo, *: setole PA 5,7,8; 2: capo (visione laterale); 3: antenna destra; 4: labbro inferiore; 5: mascella destra, freccia: setola MX6; 6: mascella destra (visione ventrale); 7: mandibola sinistra. Scala 1 e 2: 0.25 mm; 3,4,5,6,7: 0.1 mm.

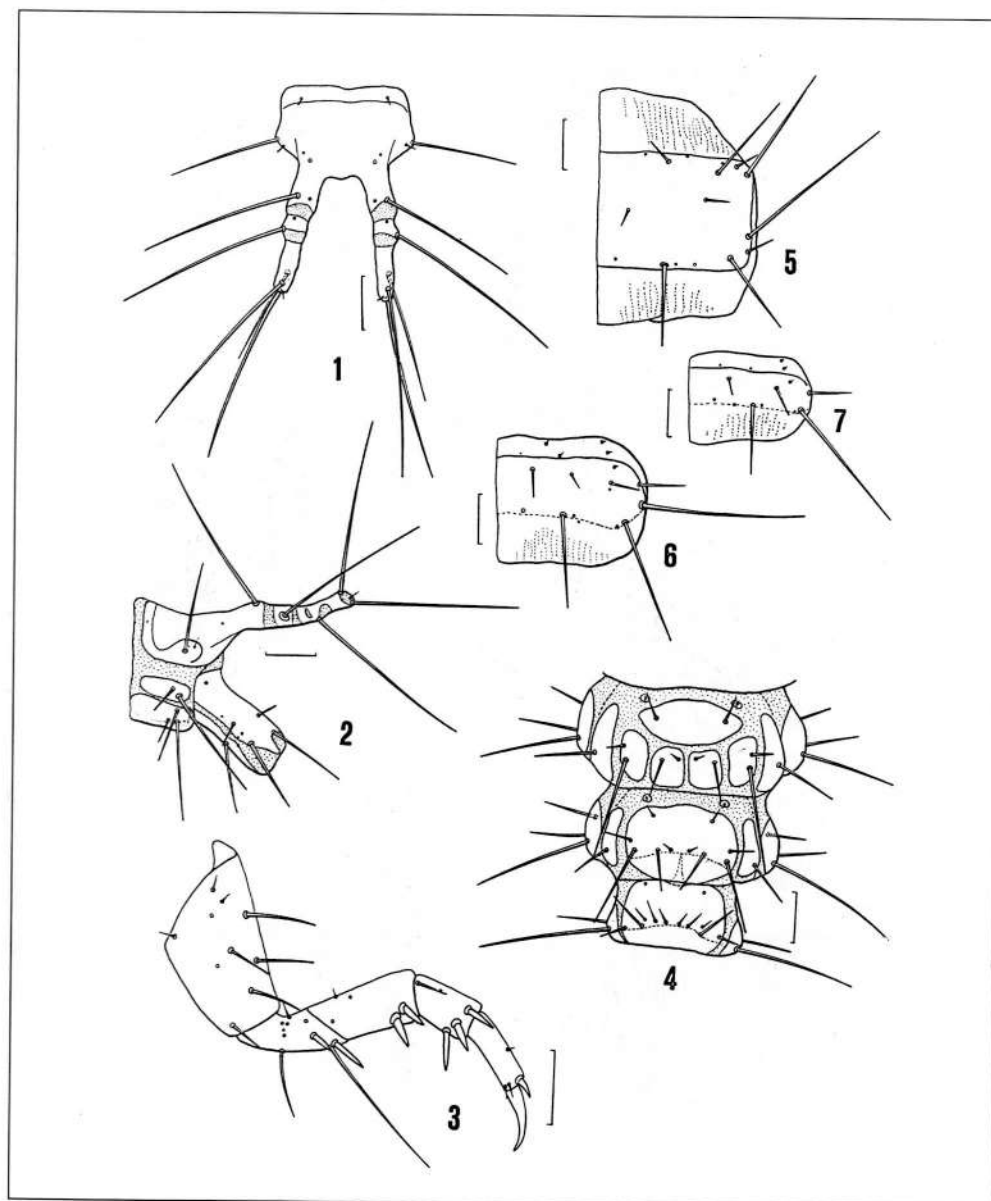


Plate II - *Amara alpestris*, first instar larva. 1: abdominal tergum IX with cerci; 2: abdominal tergum IX and X (lateral); 3: right fore leg (dorsal); 4: abdominal sternum VII, VIII and IX (ventral); 5: pronotum; 6: metanotum; 7: abdominal tergum I. Scale 0.25 mm.

- *Amara alpestris*, larva al I stadio. 1: tergite IX addominale con cerci; 2: tergiti IX e X addominali; 3: zampa anteriore destra; 4: sterniti addominali VII, VIII e IX; 5: pronoto; 6: metanoto; 7: tergite I addominale. Scala 0.25 mm.

The habitat investigated is an alpine prairie, *Seslerio-Caricetum sempervirentis*, at 2100 m a.s.l., on "Biancone" limestone. This sampling site was investigated by one of the authors, Pizzolotto, in the years 1983-84 (for more details see BRANDMAYR & PIZZOLOTTO, 1987).

The material was observed in non-permanent preparates under WildM5 and ZeissRS stereomicroscopes with drawing apparatus and measured with a calibrated ocular.

The location of pores and setae is according to that used by BOUSQUET & GOULET (1984) and BOUSQUET (1985).

The phenology of the adults is based on the samples collected by pitfall traps containing an attractive/preserving mixture of wine vinegar with 5% formalin added, active from early June to last November 1983. For the reconstruction of the biological cycle, both the males and the females were dissected to investigate the gonad development.

Larval diagnosis of subgen. *Leirides* Putzeys

Head larger than longer, nasale with 6 conspicuous subequal teeth. Frontale in L1 with egg busters shaped as a pronounced keel. Epicranial suture long at least as IV article of the antenna. Cervical keel present. First article of the antenna slender, longer than III article. Retinaculum distinct, penicillum present. Outer side of mandible with 3 setae in II instar. IX sternite without a pair of long setae in its central part.

Description of the larva

First instar larva (Plates I and II)

Body size. Head width: 1.3-1.5 mm; head length: 1-1.2 mm; total length: 8-12 mm.

Colouration. Head yellow-brown, tergites a little lighter.

Head. Cephalic capsule subquadrate, nasale with 6 pronounced teeth, separated from each other by regular distances. Subnasale distinctly indented; ruptor ovi shaped as a linear keel, as long as I antennal article. Postocular and postantennal grooves absent. Cervical groove evident, lightly sinuate, not extending to ventral side. Parietale with an elongated, lightly pronounced keel external to setae PA 5,7,8. Epicranial suture scarcely longer than IV antennal article. Ligula dome-shaped, as large at the base as the base of palpi, with 2 non contiguous setae. Setae with pronounced, strongly sclerotized, insertion points. First article of labial palpus distinctly longer and three times larger than II. Length of maxillary stipes little more than twice the width, with a longitudinal, comblike row of 5 long setae in the apical part, inwardly directed; membranous transverse area present on ventral surface.

Lacinia well developed, with lateral seta and a spine long about the half of the seta MX6. First article of galea about twice the II. Antennal articles 1 and 2 glabrous. Hyaline vesicle dome-shaped, well developed. Mandible without additional teeth between retinaculum and apex. Retinaculum rather small, scarcely longer than a tooth of nasale, widely inserted. Only one seta is present on external side, that is strongly flattened. Penicillum present.

T h o r a x a n d a b d o m e n. Pronotum with well distinct pre- and postscutum. Seta PR13 absent. Thoracic tergites anteriorly marginate, only with a trace of lateral margin. Abdominal tergites only with anterior margin. Sternites of VIII and IX segment fused, only one row of posterior setae present on IX. Urogomphi short, about as long as anal tube, with 5 setae and very pronounced setiferous nodes. Two less coloured circular areas are distinguishable.

L e g s: tarsus 1.3 times longer than tibia, distinctly thinner.

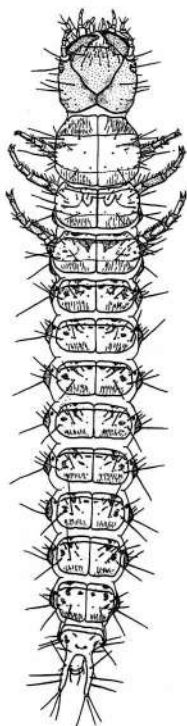


Plate III - *Amara alpestris*: larval habit of the second instar. Scale 1 mm.
- *Amara alpestris*: *habitus larvale del II stadio*. Scala 1 mm.

Second instar larva (Plates III, IV and V)

B o d y s i z e. Head width: 1.7-2 mm; head length: 1.5-1.6 mm; total length: 12-16 mm.

C o l o u r a t i o n. Head yellow-brown, tergites a little pale.

H e a d. Roundly quadrangular, nasale as at I instar. Postocular groove only feebly distinguishable, frontale with two longitudinal depressed areas starting from the basis of tentorium to the posterior border of the pars aboralis frontalis. Parietal keel (see I instar) and cervical keel present, but less pronounced than in the first instar. Epicranial suture as long as III antennal article. There are no secondary setae on frontale, near FR3. First antennal article glabrous, with pores, II with one bristle on its inner side. Mandible with 3 setae on the outer side. Maxillary stipes with 4 setae on the external border and 4-5 strong bristles on its internal apical side. First article of galea about twice as long as the II. Labium laterally sinuate, owing to the strong setiferous points. Numerous secondary setae present. First article of palpus distinctly longer and stouter than II.

T h o r a x a n d a b d o m e n. Tergites anteriorly margined, scarcely at sides. Epipleurites with 4 setae. Cerci with 8 long setae, longer than X segment, about twice longer than the IX. UR2 very long.

The described characters are very similar to those typical for the subgenus *Curtonotus* (BILY, 1975). Nevertheless, the subgen. *Leirides* seems to present a less evident increase of number of secondary setae. Focusing its main morphological features, the previously published identification keys could be modified as follows.

Key to larvae of the known subgenera of the genus *Amara* BONELLI (BILY, 1975)

- 1 (2) sternite IX with one or more pairs of short setae in mid-portion; cervical grooves and epicranial suture absent; clypeus with 6 spines; egg-busters of larva I spinous *Bradytus* STEPH.
- 2 (1) sternite IX without setae in its mid-portion
- 3 (4) clypeus with 4 teeth; cervical grooves absent; epicranial suture absent or very short *Percosia* ZIMM(+ *A. quenseli*)
- 4 (3) clypeus with 6 teeth
- 5 (6) retinaculum considerably closer to mandible base than apex; cerci 2.5 times longer than their width at the base *Acrodon* ZIMM.
- 6 (5) retinaculum approximately in the middle of inner mandible margin

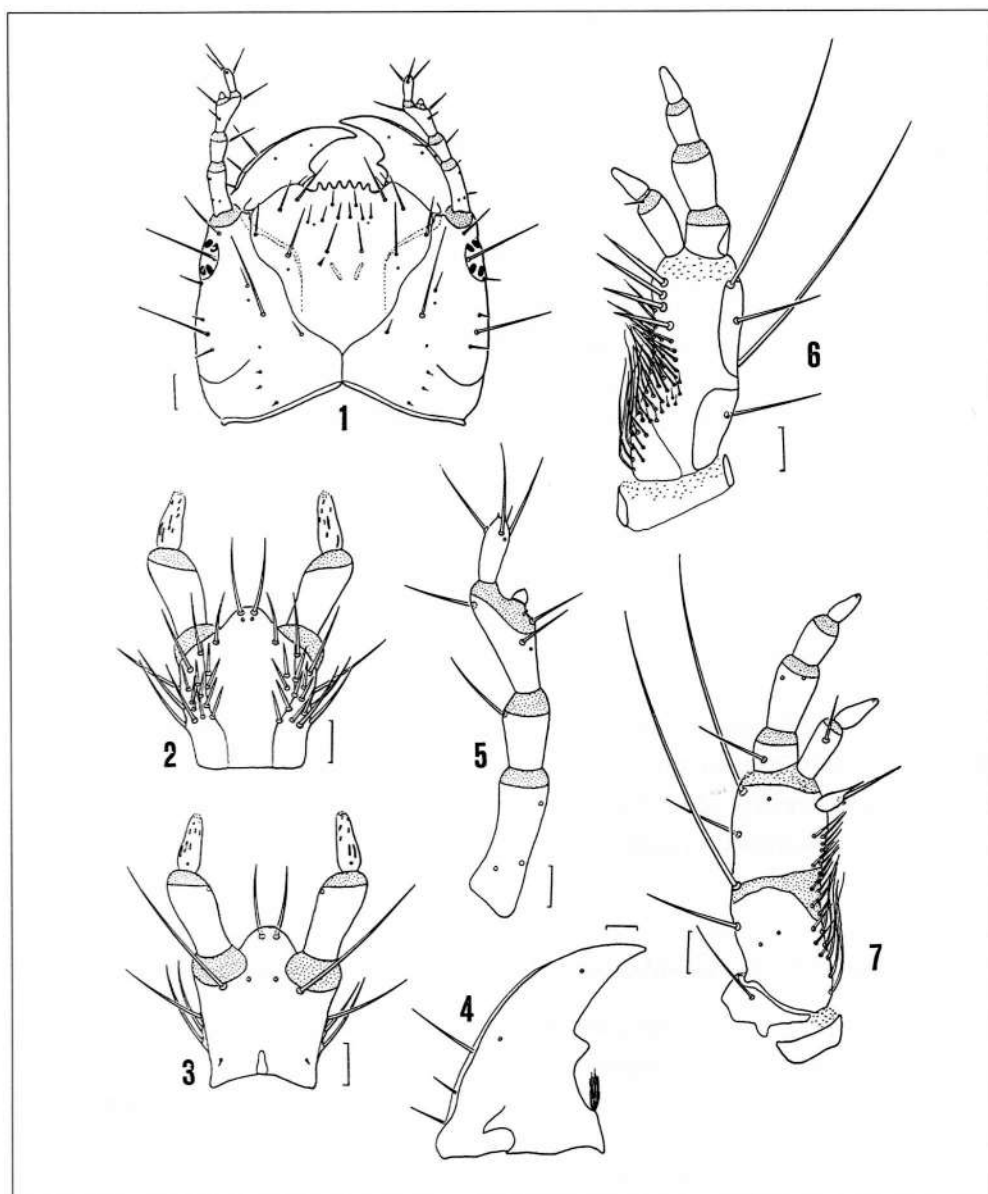


Plate IV - *Amara alpestris*, second instar larva. 1: head, arrow: seta FR3; 2: labium (dorsal); 3: labium (ventral); 4: left mandible (dorsal); 5: right antenna (dorsal); 6: right maxilla (dorsal); 7: right maxilla (ventral). Scale 1: 0.25 mm; 2,3,4,5,6,7: 0.1 mm.

- *Amara alpestris*, larva al II stadio. 1: capo, freccia: setola FR3; 2: labbro inferiore; 3: labbro inferiore (visione ventrale); 4: mandibola sinistra; 5: antenna destra; 6: mascella destra; 7: mascella destra (visione ventrale). Scala 1: 0.25 mm; 2,3,4,5,6,7: 0.1 mm.

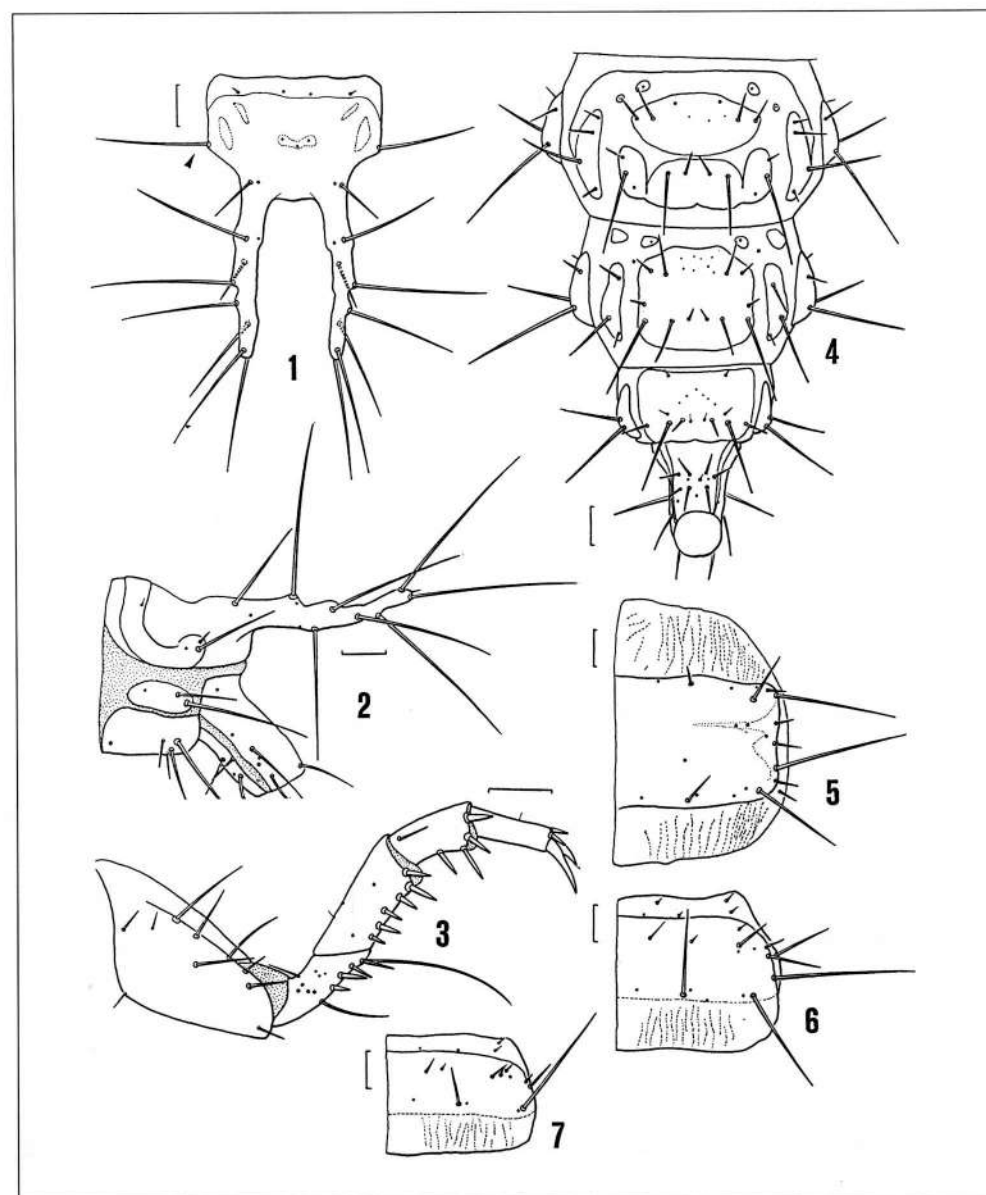


Plate V - *Amara alpestris*, second instar larva. 1: abdominal tergum IX with cerci, arrow: seta UR2; 2: abdominal terga IX and X (lateral); 3: right fore leg (dorsal); 4: abdominal sternum VII, VIII, IX and X (ventral); 5: pronotum; 6: metanotum; 7: abdominal tergum I. Scale 0.25 mm.

- *Amara alpestris*, larva al II stadio. 1: tergite IX addominale con cerci, freccia: setola UR2; 2: tergiti IX e X addominali; 3: zampa anteriore destra; 4: sterniti addominali VII, VIII, IX e X; 5: pronoto; 6: metanoto; 7: tergite I addominale. Scala 0.25 mm.

- 7 (12) epicranial suture well-developed, its length similar to that of antennal segment IV
 8 (11) cervical grooves developed on dorsal side of head capsule only
 9 (10) more secondary setae on frontale, near seta FR3 *Curtonotus* STEPH.
 10 (9) no secondary setae near seta FR3 *Leirides* PUTZEYS
 11 (8) cervical grooves developed on dorsal and ventral side of head capsule
 *Amara* s. str. (+ *A. erratica*)
 12 (7) epicranial suture very short or absent
 13 (14) epicranial suture short, but distinct; head quadrangular *Celia* ZIMM.
 14 (13) epicranial suture absent; head almost twice as wide as frontale length
 *A. infima* (*Camptocelia* JEANNEL?)

Key of subgenus *Curtonotus* (from HURKA & DUCHAC, 1980) and *Leirides*

L1

- 1 Last segment of maxillary palpus as long as penultimate, head width 0.95-1.04 mm
 *A. (Curtonotus) convexiuscula* (MARSHAM)
 1+ Last segment of maxillary palpus shorter than penultimate, head width at least 1.30 mm
 2 Width ratio of stipes about 2.1: 1, seta PR13 absent *A. (Leirides) alpestris* VILLA
 2+ Width ratio of stipes 2.3-2.7: 1, seta PR13 present
 3 Width ratio of stipes 2.3-2.4: 1, seta PR13 small, head width 1.30-1.55 mm
 *A. (Curtonotus) aulica* (PANZER)
 3+ Width ratio of stipes 2.6-2.7: 1, seta PR13 long, head width 1.54-1.74 mm
 *A. (Curtonotus) helleri* GREDLER

L2 and L3

- 1 cerci with 9 long setae *A. (Curtonotus) convexiuscula* (MARSHAM)
 1+ cerci with less than 9 long setae 2
 2 Frontale without secondary setae near the seta FR3, cerci with 8 long setae
 *A. (Leirides) alpestris* VILLA
 2+ Frontale with one or more pairs of secondary setae near the seta FR3, cerci with 7 long setae 3
 3 Frontale with 2 secondary setae near FR3 *A. (Curtonotus) aulica* (PANZER)
 3+ Frontale with 1 secondary seta near FR3 *A. (Curtonotus) helleri* GREDLER

Life cycle and propagation rhythm

On the basis of the data coming from pitfall traps and dissections, it appears that *A. alpestris*, in the studied biotopes, shows a summer/early autumn activity, with a main peak during July/August and a minor one during last September/early October (fig. 1). At the beginning of the period of activity the males are more abundant in the population, but their activity decreases rapidly. On the contrary the females reveal a more constant activity rhythm during the whole favourable season, from June to October.

By dissection we ascertained (fig. 2) that males were all sexually mature in August (100% of the captured specimens), while during June and July a part of the population showed gonads not yet fully developed (76% and 98% respectively, of the mature males). During the autumn, males with unripe gonads appeared again.

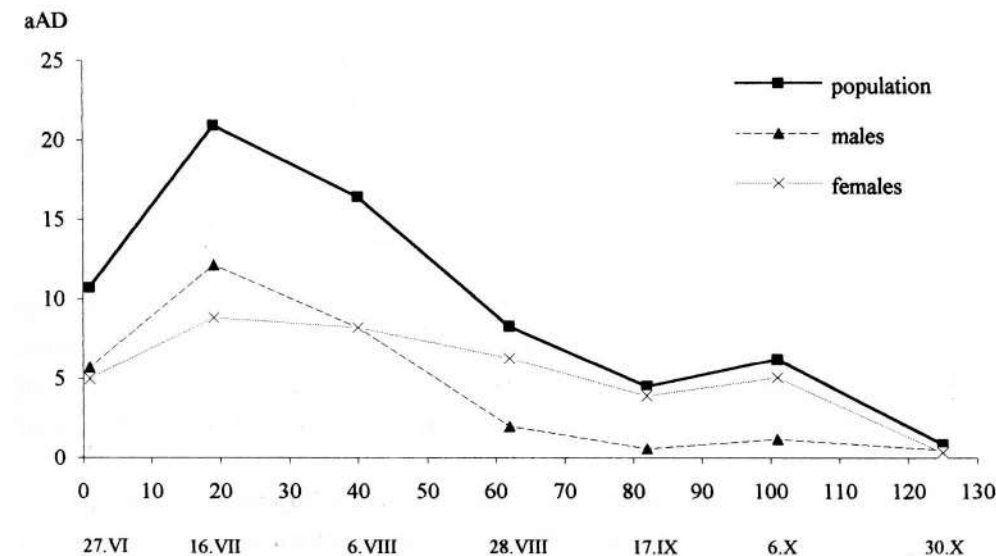


Fig. 1 - Annual Activity Density (aAD) of *Amara alpestris* in an alpine prairie. The aAD is the yearly mean of specimens collected per trap in the standard period of ten days. An activity period of 125 days (abscissa) has been recorded for the sampled population; with a maximum at the beginning of the favourable season. The most part of the males appears during the breeding period, while females are responsible for the second peak of October.

- Densità di Attività annua (aAD) di *Amara alpestris* in un prato alpico. La aAD rappresenta la media annua di individui catturati in una trappola nel periodo standard di dieci giorni. È stato rilevato un periodo di attività di 125 giorni (ascissa); con un massimo all'inizio della stagione favorevole. I maschi sono abbondanti nel periodo riproduttivo, mentre alle femmine è dovuto il secondo picco di ottobre.

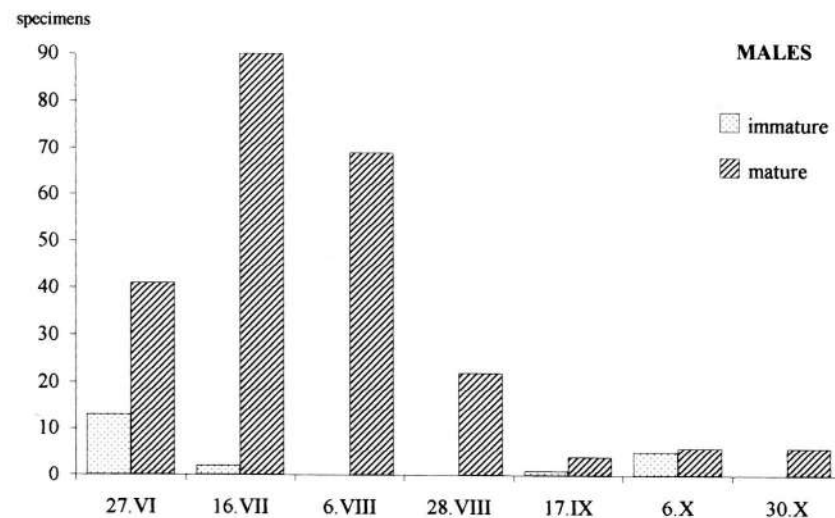


Fig. 2 - Development of the male gonads during the period of activity. The maturation is achieved in August, while the peak of abundance of mature males is reached immediately after the beginning of the favourable season.

- Sviluppo delle gonadi maschili durante il periodo di attività. La maturazione è raggiunta in agosto, mentre la massima abbondanza di maschi maturi si verifica dopo l'inizio della stagione favorevole.

The females (fig. 3) had gonads with ripe eggs in June (36% with 2.5 eggs/female on average), July (100% with 4.5 eggs/female), August (98% with 4.5 eggs/female), September (28% with 2.5 eggs/female), October (2%, only one female with 5 eggs). From August to the end of October we found females with corpora lutea, with a maximum (64%) in September.

The females active in October showed gonads in previtellogenesis conditions (71% the 6th and 75% the 30th respectively). These percentages are calculated with respect to the dissected females whose gonads were still identifiable. A part of the specimens got a bad conservation, therefore it was not possible to ascertain their development stage. The percentage of this individuals was very high in June (more than 50%) and in September (about 36%); we suppose for these females a previtellogenesis condition because non rest of eggs was found.

Larval population: The instar I shows a first peak in July and a second one in October/November. The instar II is active in the population only from June to August. The pupa phase probably occurs during August/September (fig. 4).

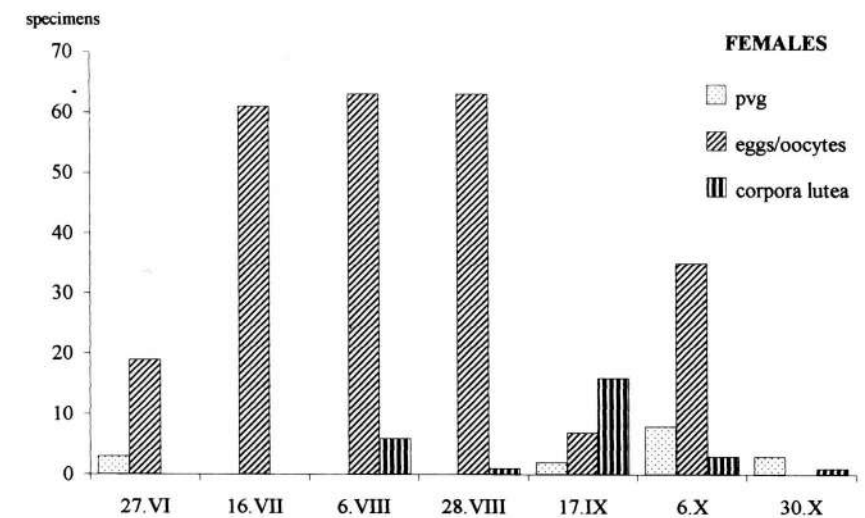


Fig. 3 - Development of female gonads during the period of activity. Mature females are abundant during the summer. They seem to avoid the period of drought for the oviposition.

- Sviluppo delle gonadi femminili durante il periodo di attività. Le femmine mature sono abbondanti durante l'estate. Esse sembrano evitare il periodo di siccità per la ovideposizione.

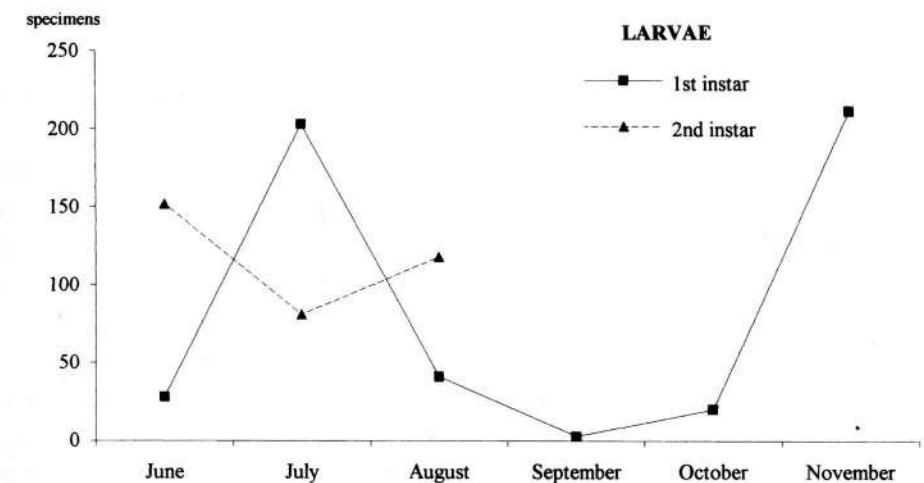


Fig. 4 - Abundance of the preimaginal instars of *A. alpestris*. The data come from all the sampled biotopes (11 sample sites; see BRANDMAYR & PIZZOLOTTO, 1987). Larvae I are active during the entire favourable season, and become larvae II at the beginning of the next season.

- Andamento dell'abbondanza degli stadi preimmaginali di *A. alpestris*. I dati provengono da tutti i biotopi campionati (11 siti di campionamento; vedi BRANDMAYR & PIZZOLOTTO, 1987). Le larve I sono attive durante tutta la stagione favorevole, e mutano in larve II all'inizio della stagione successiva.

Discussion

The collected larvae of *A. alpestris* reveal that in this species the development is achieved only through two larval stages.

A shortening of the larval cycle was already described for some *Amara* species. BILY (1975) observed it in *A. ingenua*, *A. municipalis* and *A. cursitans*. This author reports the same phenomenon as observed by Hurka in *Harpalus autumnalis*. PAARMANN (1966) found a two-stages larval cycle in three species of *Pterostichus*, i.e. *P. oblongopunctatus*, *P. coerulescens* and *P. nigrita*. But the factors responsible for this phenomenon are not of the same nature as in the cases studied by Bily. For *Amara* Bily was able to state that the shortening occurs regularly, even if the larvae are reared in different conditions of light and temperature. It is therefore a genetically fixed mechanism, that produces normal adults, able to reproduce. For *Pterostichus* species on the contrary, the adults were not able to survive, as a consequence of a hormonal disturbance; Paarmann considered this a case of prothetely. Moreover the third instars of *P. oblongopunctatus*, *P. coerulescens* and *P. nigrita* are commonly collected in the field.

For *A. alpestris* a two-stages larval cycle is surely the normal development, because no third instar was collected in the field. We suppose that the third instar is missing, and not the second, because our specimens show less secondary setae when compared with the second and third instar of *Curtonotus* ssp. larvae, which is the "nearest" subgenus. The morphological larval features are in our opinion different enough to justify two separated taxa.

Analysing the phenological data and the dissection results, we can state that *A. alpestris* is an autumn breeder as reported in BRANDMAYR & ZETTO BRANDMAYR (1988), but with reproduction probably delayed to the second year of life, at least for the most part of the population. The teneral adults occur in September, but there is a real paucity of them in the catches by pitfall traps. We suppose that they rest in the pupal cell up to complete pigmentation and sclerification. During September, early October, depending on seasonal conditions, the secondary activity peak in the population is partly due to this new generation, which shows not developed gonads. These specimens have to overwinter and wait for a temperature increase to achieve gonad maturation. The life cycle of *A. alpestris* suggests that the breeding period, which appears strongly in advance compared with that of a typical autumn breeder, and the period of maximum activity are correlated so to "use" at best the short favourable season.

The larvae develop during the summer without interruption, and the development period is shorter than that of a typical autumn breeder, so to allow *A. alpestris* to emerge before autumn. The first instar hatches before or during the autumn, then overwinters

without changing instar and becomes a larva II only after the springtime. The fact that all larvae II have been found only from June to August, suggests that an increasing in temperature and/or lightening could be the synchronizing factor for the change to the second instar.

The shortening of larval development, and the "rapidity" of the whole life cycle, may be interpreted as an adaptation to the extreme climatic conditions of the biotope where this carabid beetle lives; the snow in the studied biotopes is present from October to June and such a short favourable season probably does not allow a longer larval development.

It is not to be excluded that the July peak of larvae I comes from a delayed oviposition, as it is possible to argue from the relative abundance of mature females in October (fig. 3).

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