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TAXONOMIC REVISION OF CARABODES CORIACEUS C. L. KOCH, 1836 AND C. ARDUINII VALLE, 1955 (ACARI, ORIBATIDA).

BY M. BARATTI and F. BERNINI

ABSTRACT: Carabodes coriaceus Koch, 1836 and C. arduinii Valle, 1955 are fully redescribed from typical and topotypical materials. Scanning electron microscopy is used to determine hitherto unknown morphological details and intra- and interspecific variability. Analysis of many European and north African populations led to exact recognition of the diagnostic character-states of the two species and identification of their biogeographical ranges and ecological requirements.

INTRODUCTION

Carabodes coriaceus C. L. Koch, 1836 is the type-species of Carabodes and was recently redescribed (MAHUNKA, 1986), however few or no details are given on certain character-states. The intraspecific variations of this taxon and its relationship to closely related species are also unknown. Among the latter, Carabodes hungaricus Balogh, 1943 was recently redescribed (BERNINI, 1981) and Carabodes arduinii Valle, 1955, an entity rarely reported since its discovery, will be redescribed in this paper. In the framework of a programme of redescriptions of the classical Carabodes species (BERNINI, 1976, 1981; BERNINI & BARATTI, 1991), these taxa are examined on the basis of the topotypical and typical materials from Regensburg (Germany) and the Pontine Archipelago respectively. The diagnostic surface features were studied by scanning electron microscopy, the only method providing good definition in these dark and highly sclerotized mites.

CARABODES CORIACEUS C. L. Koch

Tegeocranus coriaceus, Michael, 1884: 316, tav. 20, fig. 1-8, tav. 22, fig. 11.
Carabodes coriaceus, Michael, 1898: 37, fig. 10.
Carabodes coriaceus, Oudemans, 1937: 2644, fig. 1141.
Carabodes coriaceus, Sellnick & Forsslund, 1953: 381, fig. 7.
Carabodes coriaceus, Pérez-Iñigo, 1971: 281, fig. 16.

1. Department of Evolutionary Biology, University of Siena, via P. A. Mattioli, 4, Siena, Italy.

Carabodes nepos Hull, 1914 : 284, Plate C, figs 2, 10.
(Synonymy determined by Luxton, 1987).

Diagnosis.

Notogastral microsculpture constituted by tubercles arranged in labyrinthlike ridges with deep interposed furrows. Lamellar microsculpture areolate. Prodorsal basal protuberances massive and medially separated. Interlamellar setae long, phyliform and generally erect. Sensillus long, slender, curved and with an externally ciliate head. Dorso-sejugal depression wide and deep. Anterior notogastral margin with one pronounced prominence. Centronotogastral setae long, phylliform, with a finely ciliate surface; marginal notogastral setae thick, backwards directed and relatively short. Aggenital setae long, smooth and slender; three pairs of short, slender, rugose, morphologically similar adanal setae.

Re-description of the adult.

Measurements : the mean average size of ten randomly chosen specimens was 690 $\mu$m $\times$ 475 $\mu$m.

Colour : dark brown to black.

Cerotegument : an amorphous waxy cerotegumental layer covers the whole body (Fig. 9).

Cuticle : notogastral microsculpture consists of rounded tubercles arranged in ridges, separated by furrows, irregular (Figs 1, 8) especially anteriorly, but tending to be longitudinal and parallel posteriorly (Fig. 1, 14). Tubercles are also present on the basal protuberances of the prodorsum. In the lamellar, podosomal, infracapitular and epimeral regions and in the proximal leg segments the tubercles are substituted by areolae of variable depth (Figs 3, 6, 11, 15). Similar pits also occur on the external surface of the bothridium and on the tutorium (Figs 5, 12). Those of the genital and anal plates are small and deep (Fig. 16). The rest of the ventral surface is ornamented by similar tubercles less pronounced than those of the notogaster (Fig. 16). All these kinds of microsculpture have very fine, superimposed punctation (Figs 3, 8, 14, 16, 18, 19).

Prodorsum : the basal protuberances are pronounced and medially separated, with the posterior margin slightly bilobate. A ridge arises from the medial interruption of these structures and runs sagittally towards the rostrum. This longitudinal, rounded ridge is separated from the lamellae by longitudinal depressions and from the basis of the basal protuberances by equally deep hollows (Figs 1, 3). Interlamellar setae curving towards the medial ridge arise laterally to the two basal protuberances. The in setae are long, phylliform and barbed (Fig. 2). The areolate lamellae run laterally. The thick and spinose le setae are inserted on the antiaxial side of the lamellar apex; they lie accumbent to the narrow carina which extends the lamella. The ro setae, inserted anteriorly on the carina, are more slender, only slightly rugose, accumbent and sagittally curved (Fig. 6). The sensillus is long and slender; its head is externally ciliate and apically pointed; the stem is bent near the bothridium, curving forwards, outwards or upwards in the different specimens (Figs 4, 5). Exobothridial setae are lacking.

Lateral characters : the margin of the camerostoma is integral. The tutorium, a thick sclerotized ridge, runs parallel below the lamella; other shorter ridges are disposed between the tutorium and the free margin of pedotectum I. The latter consists of an extended lamina covering the first acetabulum and a strong triangular prominence below the bothridium and strictly adjacent to the upper margin of the first lamina (Figs 11, 12). Pedotectum II is much thinner and shorter. The discidium is a strong triangular carina extending to cover leg acetabula III and IV. Its surface is longitudinally grooved. Behind coxa IV there is a rectangular hollow, partially surrounded by a carina (Fig. 13). All these sclerotized features, together with the withdrawn legs and tanatosis reaction, enable the mite to escape predation (Fig. 11).

Notogaster : the dorso-sejugal furrow is wide and deep with a finely punctated surface and four cavities on the prodorsal side (Fig. 1). The function of these cavities may be related to the highly sclerified prodorsal basal protuberances and sup-
Figs. 1-7: *Carabodes coriaceus* Koch;

Figs. 8-14: Carabodes coriaceus Koch.
Port for the mouth muscles. The anterior notogastral border bears a pronounced, medial, obtuse tooth. The notogaster is proportionally large and there is a circumgastric depression. It bears ten pairs of setae, six pairs of which are disposed centrally and the rest marginally. The former are large, long and phylliform, ciliate on the external surface and glabrous on the inferior surface (Figs 1, 10). The others are more slender and shorter with a rugose or slightly barbed surface (Figs 1, 9, 14). The lyrifissures and the gla opening (Fig. 7) are in the usual position.

Ventral characters: the margins of the areolate epimera are defined by deep epimeral furrows; sternal depressions occur between epimera I and II, and epimera II and sj (Fig. 15). The epimeral chaetotactic formula is 3-1-3-3 with heteromorphic setae: 1a, 1c, 2a and 3a are very short, thick and rugose, the others long, slender and smooth. The four pairs of genital and the pair of aggenital setae (Figs 15, 16, 17) are long, slender and slightly rugose. The two pairs of anal setae are shorter but equally slender and rugose than the former; all three anal setae have the same morphology but are thicker and more ciliate than the other ventral setae (Figs 16, 18). The iad lyrifissures (Fig. 19) are situated laterally near the ad3 setae.

Gnathosoma: the characters of this region are the same as in other congeneric species (Figs 11, 15).

Legs: the legs are monodactylous (Figs 20-23). The chaetotactic formulae (famulus included and solenia in brackets) are as follows:

I) (1-4-3(1)-4(2)-15(2-1)); II) (1-4-3(1)-4(1)-15(2)-1); III) (2-3-1(1)-2(1)-14-1); IV) (1-2-2(1)-12-1).

Some distal setae on each tarsus have a curled apex and flattened tip. The u setae of tarsi I are long with attenuated tips whereas on the other legs they are short and blunt (Figs 20-23).

Variations

Analysis of several populations showed variations in certain characters as follows:

— the sensillar head may vary in thickness and pointedness (Figs 4, 5).

— the posterior outline of the prodorsal basal protuberances may by linear and continuous or bilobate.

— the anterior notogastral tooth may be more or less pronounced (Figs 1, 24).

The above characters vary in an apparently random manner whereas the following characters show a trend:

— the centronotogastral setae vary in length and width.

— the marginal notogastral setae vary in length and width; they may be thick and rugose or slightly phylliform and barbed.

Both types of setae increase in size and length, the further the populations are located to the south.

Notogastral and ventral microsculptures also show some variations. A population from the Ligurian Apennines is difficult to identify because of variations in the morphology of the notogastral microsculpture and the more slender centronotogastral setae (Figs 24, 25). Not all specimens, however, showed the feature illustrated in Fig. 25. We therefore prefer to regard this population as falling within the intraspecific variations of coriaceus. Biochemical systematics studies of other populations in the region should reveal its true taxonomic status.

Another "atypical" specimen is from Ceresole d’Alba (Piedmont), kept in Berlese’s Collection (see in Material examined). It has two peculiar character-states, namely, the notogastral and ventral microsculpture are more similar to that of the marginatus group and the centronotogastral setae are thicker. Although this specimen seems to occupy an intermediate position, we prefer to regard it, for the time being, as a true coriaceus. Future study of freshly collected and more numerous specimens will clarify the exact taxonomic status of this specimen.

Immature specimens.

The only known juvenile characters of this species date back to Michael’s paper (Michael, 1884).
Figs. 15-19: Carnibodes coriaceus Koch.
19. — Detail of the taud lyrifissure (× 5950).
Material examined.  

GERMANY: Regensburg, Walhalla Garten, moss on the ground, 20.8.1974 (1); ibidem, humus under Fagus silvatica 20.8.1974 (1); ibidem, Kelheim, humus under Fagus silvatica, 20.8.1974 (20); ibidem, Neuhaus, humus under Abies alba, 20.8.1974 (23); Friedersbruch (Germania), deposited in Berlese's Collection at the Istituto Sperimentale per la Zoologia Agraria (henceforth: ISZA) in Florence (2).  

SWEDEN: near Jonkoping, humus in a mixed wood of Picea excelsa and Betula sp., 1.9.1973 (3).  


GREAT BRITAIN: England, theydon Bois, Epping Forest and other unspecified localities, nos. 1930.8.25.538-540 (sub Tegeocranus coriaceus) and nos. 1930.8.25.804-808 (sub Carabodes coriaceus), in MICHAEL's Collection in the British Museum (Natural History), London.  


BULGARIA: Onurtas, humus, 783 m, 12.4.1976 (Coll. T. RENIERI) (25).  

ITALY: Pelos di Cadore, humus, 22.8.1971 (Coll. L. CASTAGNOLO) (4) (UTM ref. 33TTM0550); Conighe (BL), humus under Robinia pseudacacia, 27.8.1971 (Coll. A. DEL PUGLIA) (1) (UTM ref. 33TTM8513); Bosco del Cansiglio (BL), humus in a mixed wood of Abies alba and Fagus silvatica, 7.10.1972 (1) (UTM ref. 33TTM 9908); Mandello Lario, shores of Lake Como, humus under Quercus sp. and Taxus baccata, 2.1.1969 (1) (UTM

2. The number of specimens examined appears in brackets after the collection sites. Where possible the locality names are accompanied by the UTM references. Unless otherwise indicated the specimens examined were collected by Fabio BERNINI and are kept in his collection in the Department of Evolutionary Biology of the University of Siena.
Figs. 22-23: Carabodes coriaceus Koch.

22. — Leg IV, antiaxial. 23. — Tarsus and tibia of the leg II, antiaxial.

The first preparation can be identified as Carabodes arduinii Valle (see next species), the second as C. reticulatus Berlese. The specimen from Ceresole d'Alba (Piedmont) is discussed above. Berlese's Collection contains other specimens of C. coriaceus preserved in alcohol. The first specimen (3°/144) was determined to be a true coriaceus (see above). The original label of the second specimen (3°/145) is strange because it states asperulus (a nomen incognitum), the author's name is not clear (Berl. or Bait.) and the locality, «Rua Padova», was simplified by Berlese to «Padova». Nevertheless, the specimen belongs to a species of the marginatus group. The author reported the name coriaceus in his own catalogue (Castagnoli & PegaZZano, 1985), ignoring the previous original asperulus.

We also checked the specimens reported in
several localities of the Apennines between Tuscany and Romagna (Zangheri, 1966). The preparations, some preserved in vials and some in slides, are kept in Zangheri's Collection in the Museo Civico di Scienze Naturali of Verona:

33986. Polenta (Bertinoro), terriccio castagneti, 29.6.1943 (Det. G. Lombardini). This specimen is *C. quadrangulus* Bernini.
7200. Campigna, terriccio faggete, 30.6.1924 (Det. M. Sellnick). All specimens of this preparation belong to *C. arduinii* Valle.

Since the latter and nos. 33987-33988 are preserved in vials that cannot be examined, it is not possible to check their exact status. Nevertheless, recent collections in the whole area of the Apennines between Tuscany and Romagna (see later) have constantly revealed the presence of *C. arduinii* and the absence of *coriaceus*. We therefore think that the latter species does not occur in this area.

**Geographical distribution and ecology.**

The biogeographical and ecological observations will be discussed together with those relative to *Carabodes arduinii* Valle, 1955.
CARABODES ARDUINII Valle

Carabodes arduinii Valle, 1955 : 12-13, fig. 1, tav. 1, 2-6

Diagnosis.

Tuberculated ridges of notogastral microsculpture prevalently longitudinal in pattern. Interlamellar setae long, phylliform, strongly sagittally curved with externally ciliate surface. Lamellae areolated. Sensillus long, slender, medially curved with externally ciliate head. Centronotogastral setae long and widely phylliform with finely barbed external surface; marginal setae slightly shorter and strongly sagittally curved. Aggenital setae long and heteromorphic: \(a_d\) and \(a_d^2\) similar to marginal notogastral setae; \(a_d\) thick and ciliate.

REDESCRIPTION OF THE ADULT.

Owing to the close morphological affinity between \(C.\) coriaceus and \(C.\) arduinii, the present redescription will stress the differences rather than repeating all similar characters.

Measurements: the mean average size calculated from ten randomly chosen specimens was 735 \(\mu m\) \(\times\) 482 \(\mu m\). The holotypus from Zannone island is a male measuring 780 \(\mu m\) \(\times\) 510 \(\mu m\).

Colour: black.

Cerotegument: a thin unconspicuous cerotegumental layer covers the body.

Cuticle: notogastral microsculpture generally as in \(C.\) coriaceus; the tuberculated ridges are disposed more regularly and in prevalently longitudinal patterns, except between the surface defined by the \(ta\) and \(ti\) setae where they are labyrinth-like (Figs 27, 32, 33). This pattern is repeated on the prodorsal basal protuberances and in the ventral surface behind the 4th epimeral furrow (Figs 29, 41, 45). The remaining body portions are as in \(C.\) coriaceus, including the fine punctation over the whole surface (Figs 31, 39, 45).

Prodorsum: differences with respect to \(C.\) coriaceus consist in the shape of the prodorsal setae (Figs 27, 28, 29): the \(ro\) setae are thicker and more rugose, although relatively slender; the \(le\) setae are phylliform, slightly enlarged at the distal end and heavily barbed on the upper surface; the \(in\) setae are largely foliaceous with the upper side covered in barbs. Sensillus as in \(C.\) coriaceus but generally even more slender with a sharp-ended head (Figs 30, 31).

Lateral characters: as in \(C.\) coriaceus.

Notogaster: The differences with respect to \(C.\) coriaceus involve the general shape (arduinii is stouter and larger), the morphology of the «shoulders» (very prominent), the greater regularity of the longitudinal ridges (Figs 27, 32, 33) and the shape of the notogastral setae. With respect to \(C.\) coriaceus, they are all larger and spoon-shaped (Figs 27, 32, 34, 37). The most marked differences concern the marginal notogastral setae: in coriaceus they are smaller than the centro-dorsal setae, whereas in arduinii they have the same morphology, are slightly smaller and strongly sagittally curved (Figs 27, 35, 36, 38, 39, 40).

Ventral characters: as in \(C.\) coriaceus for the epimeral region; the microsculpture between the anal and genital plates shows some differences; the transverse ridge in the sagittal region is symmetrical in arduinii with large deep furrows adjacent to the anal and genital plates (Fig. 41). The furrow adjacent to the genital plates is almost non existent in coriaceus and very narrow. There are also slight differences in the shape of the cavity behind the fourth acetabula (Fig. 42). In this and in the cavities at the sides of the genital and anal plates as well as in the above-mentioned ano-genital furrows (Figs 41, 45) the surface is free of tubercles, whereas in coriaceus they are even visible by transmission microscope. Differences in chaetotaxy of the ventral surface behind the 4th epimeral furrow regard the adanal setae: they are heteromorphic and always thicker, longer and larger than in coriaceus. They increase in size from \(a_d^3\) to \(a_d^1\) (Figs 44, 45, 46).

Gnathosoma and legs: as in \(C.\) coriaceus (Fig. 43).
Figs. 27-33: *Caraboides arduinii* Valle.

Figs. 34-40: *Carabodes arduinii* Valle.

Variations.

The many populations examined may be divided, according to their external morphology, into two general phenotypes: the first is characterized by larger marginal notogastral and adanal setae (Figs 34, 35, 38, 44); in the second these structures are half the size (Figs 36, 37, 39, 45). Analysis of the specimens showed that this was not due to sex and/or age differences. The geographic distribution (Fig. 47) of these two phenotypes and the presence of populations with intermediate character-state means that neither form has taxonomic value. Thorough searches, particularly in sites at different altitudes (Corsica), suggest that altitude influences the dimensions of the above-mentioned setae.

In one of the specimens examined by SEM, an extra notogastral marginal seta was found (Fig. 40).

Immature specimens: unknown.

Material examined.

ITALY: Zannone island, Pontine Archipelago, « terriccio », May 1950 (Coll. E. ZAVATTARI) (2) (UTM ref. 33TU1F3636); S. Brigida di Moncalieri, Torino, humus, 600 m (Coll. A. DEL PUIGLIA) (1) (UTM ref. 32TLQ6684); S. Fruttuoso, Portofino, Liguria, humus, 5.2.1976 (Coll. G. GARDINI) (1) (UTM ref. 32TNQ1606); Apuan Alps, Mt. Forato, moss on stones, 400 m, 16.6.1970 (2) (UTM ref. 32TPP1876); Ibidem, moss under Castanea sativa, 700 m, 19.5.1992 (Coll. M. BARATTI) (1); Camaldoli, La Lama forest, Tosco-Romagnolo Apennine, 1100 m, 3.11.1969 (Coll. R. DALLAI) (1) (UTM ref. 33TQP283572); Alpe di S. Benedetto, Mt. Peschiena, Tosco-Romagnolo Apennine, humus in a decaying log of Fagus silvatica, 1200 m, 27.4.1983 (Coll. D. DUCHI) (2); La Verna, Tosco-Romagnolo Apennine, humus and decaying wood under Fagus silvatica and Abies alba, 1100 m, 2.6.1992 (Coll. P. OMODEO and E. ROTA) (1); S. Rossore, Tenuta Presidentiale, humus under very thick Mediterranean maquis, 13.5.1971 (6) (UTM ref. 32TPP0444); Boboli Gardens, Florence, humus, 23.5.1970 (2) (UTM ref. 32TPP812482); Fioreta, Siena, moss on stones in oak wood, 350 m, 23.4.1991 (Coll. A. M. AVANZATI) (152) (UTM ref. 32TPP813035); Val di Farma, southern Tuscany, humus under Taxus baccata, 26.9.1977 (Coll. G. CALLAINI) (8) (UTM ref. 32TPN8373); Ibidem, humus under Alnus glutinosa, 250 m, 3.2.1978 (Coll. G. CALLAINI) (25); Argentario Promontory, southern Tuscany, Colle Fiorentino, humus, 10.7.1971 (Coll. M. FALCONI) (1) (UTM ref. 32TPN877043); Tuscan Archipelago, Elba Island, Mt. Perone, humus under Castanea sativa, 700 m, 25.11.1976 (3) (UTM ref. 32TN986371); Mt. Reatini, Mt. Terminillo, Vallonina, moss and humus in a beech wood, 1700 m, 15.11.1969 (5) (UTM ref. 33TUIH3406); Ibidem, moss on trunk, 1700 m, 15.11.1969 (19); Ibidem, humus in beech log, 1900 m, 15.11.1969 (24); Colli Laziali, Monteporzio, moss and humus, 15.2.1972 (28) (UTM ref. 33TUG1032); Foresta Umbra, Gargano Promontory; Apulia, humus, 500 m, 10.4.1970 (Coll. R. LAMPIARELLI) (1); Pollino Massif, Colle del Dragone slopes, humus under ferns and meadow, 14.10.1976 (1) (UTM ref. 33SW9171); Ibidem, Colle del Dragone Pass, humus under Fagus silvatica, 1550 m, 13.10.1977 (15); Ibidem, Piano Ruggio, humus under Fagus silvatica, 1500 m, 18.9.1981 (Coll. F. GIUSTI) (4); Sicily, Madonie, Refuge Marini, moss on rocks, 1700 m, 1.6.1963 (Coll. A. VALLÉ) (5) (UTM ref. 33SVB5696); Ibidem, Mis. Nebrodi, Mt. Malabotta, moss on the ground, 1200 m, 17.9.1981 (Coll. R. ARCIACONIO) (1) (UTM ref. 33SWC3143); Ibidem, Mt. Soro, humus under Fagus silvatica, 1450 m, 24.10.1981 (Coll. R. ARCIACONIO) (1) (UTM ref. 33SVB1292); Ibidem, Val di Caronia, moss in beech wood, 1330 m, 14.5.1991 (Coll. M. BARATTI and M. MIGLIONI) (9) (UTM ref. 33SBS5696); Sardinia, Parco di Laconi, humus under Quercus ilex, 2.5.1975 (7) (UTM ref. 32SNK0412); Ibidem, La Duchessa, Iglesiente, humus under Quercus ilex, 21.3.1976 (Coll. E. MALATESTA) (4) (UTM ref. 32SMJ6759); Ibidem, Belvi, Gennargentu Massif, moss on log of hazel-tree, 1.4.1978 (51) (UTM ref. 32SNK1524).


SPAIN: Sierra de Monseny, Catalonia, humus in a mixed wood of Quercus ilex, 1100 m, 22.8.1983 (8).

ALGERIA: Forêt d'Akfadou, Great Kabylia, humus under Quercus mirbeckii, 1230 m, 3.5.1983 (1); Ibidem, moss and ferns near stream in Quercus aferes wood, 1230 m, 3.5.1983 (33); Talu Guilef, Massif du Djurdjura, Great Kabylia, humus under Cedrus atlantica, 1700 m, 9.5.1983 (1); Fontaines des singes, Tifrit nait el Hadij, humus under Quercus mirbeckii and Q. suber, 700 m, 11.5.1983 (30); Mt. M'Sidi Ech Cheta, Lesser Kabylia, humus under Quercus aferes, 1200 m, 5.11.1984 (21); Col du Malab, Lesser Kabylia, humus under Quercus suber and Q. mirbeckii, 600 m, 6.11.1984 (13); Tamanart, Lesser Kabylia, humus under Quercus suber, 50 m, 7.11.1984 (1).
Figs. 41-46: Carabodes arduinii Valle.

TUNISIA: Ain Draham, humus under Quercus canariensis, 700 m, 30.4.1983 (5); Ibidem, humus inside an oak log, 700 m, 30.4.1983 (105).

Geographic distribution and ecology.

Carabodes arduinii and Carabodes coriaceus will be considered together under this heading.

According to RAJSKI (1968), C. coriaceus is known throughout the European continent with sporadic stations in North America (SENGBUSCH, 1957) and North Africa (MICHAEL, 1890). This distribution is confirmed by MARSHALL et al. (1987). An extension of this range can be found in KARPPINEN et al. (1986), who report the species in the "arid land" of Asia without mentioning the exact locality as they do for all the other species. The quotation seems improbable and should be checked. The same is true of the North-American quotation. With regard to the African quotation, one of us (F.B.) unsuccessfully checked the original slide in Michael's Collection in the British Museum (Natural History) of London: there were no preparations of coriaceus from Algeria. Recent collections in Algeria and Tunisia have only revealed C. arduinii. For the time being, coriaceus can therefore be regarded as an European species with uncertain holarctic quotations. Many of the quotation (see Material examined) reveal a high degree of uncertainty between the southern reaches of the distributions of coriaceus and arduinii. Ignorance of the latter species has led to the misidentification of specimens and consequently to the confusion of the distributional ranges of the two taxa.

In southern European countries, the distribution of the two species can be summarized as follows: in Spain, coriaceus has been found in the north (Santander, Vizcaya, western Pyrenees) and centre (Sierra de Guadarrama) but is replaced by arduinii in the south (Sierra de Monseny, Catalonia) (PÉREZ-IÑIGO, 1971; SUBIAS, 1977; MORAZA et al., 1980; ITURRONDOBEITA & SUBIAS, 1981; this paper). In France, coriaceus has been quoted near Paris (CANCELA DA FONSECA, 1965) but it seems substituted by arduinii in the south (Massane, Sidobre, Sainte Baume, Port Cros, sub C. cf. coriaceus, and Corsica) (TRAVE, 1963; LIONS, 1972; BONNET et al., 1975; TRAVE, 1984; this paper). In Italy, coriaceus was quoted by BERLESE (1886) and ZANHERRI (1960), but Michael (1898) and the present study reveal the inconsistency of many of these quotations. In fact coriaceus can be found in northern Italy (Liguria, Alps, near Padova) but arduinii takes its place in the peninsular Apennines and in Mediterranean environments.

In eastern Mediterranean countries the data is more sporadic and controversial. In the Balkans, coriaceus is quoted in Slovenia (TARMAN, 1983), the Ionian islands (Levkas) (MAHUNKA, 1974) and Bulgaria (KUNST, 1958 and this paper). In the Caucasus, it is quoted in Georgia (KARPPINEN et al., 1987), however this bibliographic data requires checking in order to determine whether arduinii is present and to distinguish its distributional range from that of coriaceus.

As regards ecology, coriaceus is recorded as a rare species preferring forest soils (RAJSKI, 1968; LUXTON, 1981). In contrast, arduinii is well represented in Mediterranean environments of different altitudes, rich in organic materials. Its connection with forest soils is much less strict than for coriaceus as demonstrated by the large number of specimens collected in moss at Fioreta (see Material examined).

GENERAL REMARKS

Redescription of the two taxa reveals some elements useful for systematics and zoogeography. New characters have emerged, for example the thick, barbed (but not phylliform) le setae, the peculiar morphology of the tutorium and pedotectum I, and leg and gnathosoma morphology and chaetotaxy. The presence of deep cavities in the dorsosejugal furrow as in Carabodes of the margnatus group (BERNINI, 1979a) is also confirmed in both species.

The study reveals large intraspecific variations. Besides the random variability present in all populations of both species for some character-states, in C. coriaceus latitude seems to influence the size of the centronotogastral setae and in arduinii altitude seems related to the width of the notogastral marginal setae. Since these very characters are used
Fig. 47: Geographic distribution of the two taxa, *Carabodes coriacellus* Koch (black circles, checked populations; white circles, unchecked populations) and *Carabodes arduinii* Valle (black squares, first phenotype; white/black squares; second phenotype; white squares, unchecked populations). The black stars indicate atypical marginal populations determined as *Carabodes coriacellus*. 
to differentiate the two entities, the question arises as to whether the two species are really separate or simply two latitudinal phenotypes of the same entity. Coriaceus and arduinii are morphologically very similar but their ranges of variability are clearly different. The two "forms" can never be confused: coriaceus has relatively thin (thick and/or slightly phylliform) backward-directed marginal notogastral setae whereas in arduinii they are curved and, in proportion, exaggeratedly large and phylliform. The adanal setae are only consequently different in the two taxa because they are like the marginal notogastral setae: thin in coriaceus and phylliform ad₁-ad₂ in arduinii. The differential diagnosis of the two species is always easy because although the character-states in question are few and apparently of little account they are clearcut. Characters such as the different ecological requirements and the vicariant geographical distribution can perhaps be added to the morphological ones to identify the two species. C. coriaceus seems to be a rare and localized forest species found in northern and central Europe and in the most mesophile environments to the south. On the contrary, arduinii is a Mediterranean species (hitherto documented only in the western Mediterranean); it is not particularly rare, nor is it specific to forests, however it prefers environments rich in organic material. Their geographic distribution only seems to overlap in Piedmont, where arduinii is found near Turin and the southernmost atypical form of coriaceus (if they truly belong to this species) live in the same area and in the Ligurian Apennines. All these entities are well differentiated from each other, demonstrating the absence of any genetic flow between coriaceus and arduinii. The atypical forms can never be interpreted as intermediate between coriaceus and arduinii.

This paper is preliminary to a complete revision of the genus Carabodes in Europe. Some characters, such as the kind of microsculpture, the presence of cavities in the dorsosejugal furrow, the morphology of the sensillus and of the epimeral and genital-aggenital setae, have been considered in order to identify a group of entities related to coriaceus; nevertheless, the value of some of them is doubtful. Kunst (1961) was the first to propose the existence of a group of species characterized by the length of the aggenital setae and the cavities in the dorsosejugal furrow, including C. coriaceus, C. magnus Kunst, C. reticulatus Berlese, C. ornatus Storkan (= C. forsslundi Sellnick) and C. marginatus (Michael). It followed that notogastral microsculpture and the body outline characterize marginatus and another series of Mediterranean species (Bernini, 1979a, b; Avanzati et al., 1991) and/or other taxa such as ornatus (Mahunka, 1987). The coriaceus group then presumably included only arduinii, hungricus and, perhaps, magnus and reticulatus (Bernini, 1981). In the light of the present study, the inclusion of hungricus in this group is highly questionable owing to the vastly discordant character-states, such as the morphology of the le and aggenital setae, and of the sensillus; likewise reticulatus requires thorough redescription before reliable conclusions can be reached. At the same time, it seems that some characters, such as the morphology of the sensillus and the aggenital setae and the presence of tuberules in the notogastral microsculpture, can be utilized to link the species of the coriaceus and the marginatus groups. On the other hand, the methods of biochemical systematics, which allow estimation of the genetic distance between subgenera and groups of species (Bernini & Avanzati, 1991), provide preliminary results which seem to disagree with the morphological data (Avanzati et al., 1991). Divergence from past opinions is evident and lack of information about most of the other Carabodes species prevents us from drawing conclusions for the time being. In particular, we do not know which morphological character-states are valuable for generic framing. The only reliable perspectives in this sense are those given by the study of gene-enzyme systems, see, for example Steganacarus (Bernini & Avanzati, 1991) and Carabodes (Avanzati et al., 1991). Future research with these methods promises to provide solutions to these problems.

Regarding zoogeography, the geodynamic events occurring in the western Mediterranean in the last 25 My (Bernini, 1984) give indications on the age and spread of arduinii. This species probably originated (as a peripheral population) in the south western margins of Europe before the Early-Middle Mio-
cene. The separation of these marginal lands from Provence and Catalonia and their subsequent eastwards translation diffused the species to now widely displaced territories (Corsardinia, Kabylia and the Calabro-Peloritan massif). From there, arduinii spread to secondarily emerged lands such as those of the Italian peninsula (Apennines and so on). With the recent uplifting of the lands around the western Mediterranean, the two ecophenotypes of arduinii may have begun to differentiate. The presence of coriaceus in Piedmont suggests the southward expansion of the species and isolation of some marginal populations by the Alpine Plio-Pleistocene glaciations. In any case, the differentiation of the two species seems to be ancient and the speciation rates very low.

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