

## Notulae Malacologicae, XXXVII.

# New data on *Arion intermedius* NORMAND in Italian Apennines and major Tyrrhenian Islands (Pulmonata: Arionidae).

(Studies on the Sardinian and Corsican malacofauna, VII<sup>1)</sup>)

By

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With 6 figures.

**Abstract:** The authors report the presence of *Arion intermedius* NORMAND in Tuscany, Sicily and Corsica and describe its main anatomical features. A critical examination of the systematic problems regarding the species and tentative hypotheses on the origin of its present geographical distribution in Italy, Corsica and Sicily conclude the paper.

## Introduction.

The malacofauna of the Italian Apennines and major Tyrrhenian islands (Sardinia, Corsica, Sicily) is noted for its lack of species of the genus *Arion* (see ALZONA 1971). This lack becomes progressively more marked as we proceed away from Liguria towards central and southern Italy. In the Ligurian Apennines from Colle di Cadibona to Tuscany there are four species (*A. lusitanicus* MABILLE, *A. subfuscus* [DRAPARNAUD], *A. intermedius* NORMAND, *A. franciscoloi* BOATO, BODON & GIUSTI) (see BOATO, BODON & GIUSTI 1985) but in Tuscany there are only two certain species (*A. intermedius* and *A. franciscoloi*) and one doubtful species

<sup>1)</sup> V: GIUSTI, F., HOLYOAK, D. T. & MANGANELLI, G. (1985): Notulae Malacologicae, XXXII. *Oxychilus* (*Ortizius*?) *clarus* HELD in Corsica and new data on the systematic position of *Helix hydatina* ROSSMÄSSLER (Pulmonata: Zonitidae). — J. of Conch. London, 32: 17–24. VI: GIUSTI, F. & MANGANELLI, G. (1987): Notulae Malacologicae, XXXVI. On some Hygromiidae (Gastropoda: Helicoidea) living in Sardinia and Corsica. — Boll. Malac., 23: 123–206.

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(*A. "rufus"* sensu CANTRAINE 1840, UZIELLI 1863 and DE STEFANI 1875, 1883; perhaps corresponding to *A. lusitanicus*, see BOATO, BODON & GIUSTI 1985). From Latium southwards there are extremely few sightings, always referred to in the past as "*A. hortensis*" or its varieties (PAULUCCI 1879, STATUTI 1882, LEPRI 1909, FORCART 1965). What they really were is impossible to tell. From certain comments of STATUTI (1882) and LEPRI (1909) it seems that the slugs so named by them might have belonged to other groups (Limacidae). POLLONERA (1889: 18-19, figs. 11-12) had already shown that certain presumed Apennine "*A. hortensis*" (Lucchio, Tuscany; LESSONA & POLLONERA 1882) belonged to another entity: *A. intermedius* var. *apennina* POLLONERA. Recently it was shown (BACKELJAU 1985a) that at least one of the three young specimens collected by FORCART in Calabria (Gambarie; Aspromonte) and determined as "*A. hortensis*" (FORCART 1965) were in fact *A. intermedius*. The problem remains of the other two specimens which BACKELJAU (1985a) believes may be attributed to the "*A. hortensis* complex", made up of three morphologically very similar species: *A. hortensis*, *A. distinctus*, *A. owenii* (see DAVIES 1977, 1979). Before accepting this opinion which would endorse the presence of one of the three entities of the "*A. hortensis* complex" in Calabria, it is preferable to await anatomical confirmation from sexually mature material.

In the major islands, only one endemic species is known in Sardinia (*A. isseli* LESSONA & POLLONERA) (see GIUSTI & CASTAGNOLO 1983) and in Corsica two species have been reported: *Arion* sp., the young specimens of which appeared outwardly similar to *A. subfuscus* (HOLYOAK 1983: 241) and *A. rufus* (see REQUIEN 1848). CAZIOT (1902) and GERMAIN (1930) doubted the latter report by REQUIEN, but QUICK (1961: 147) appears to confirm it, admitting that he had examined spirit materials (see also HOLYOAK 1983: 241). During many recent research expeditions to Corsica we have never come across young or adult *Arion* which could possibly belong to *A. rufus* (LINNAEUS) and we are therefore inclined to consider this an erroneous report or at best based on the sighting of sporadic specimens imported from France which have not given rise to established populations.

In Sicily, species of the genus *Arion* have never yet been reported (see ALZONA 1971). The report by PHILIPPI (1844) of "*Arion rufus*", as those in other Italian regions (Emilian Apennine: BONI 1869, COCCONI 1881, PICAGLIA 1892; the Naples area: COSTA undated), have never been considered reliable (see LESSONA & POLLONERA 1882: 61).

In order to clear up uncertainties and prevent future erroneous attributions, we examined all the material of the genus *Arion* in the GIUSTI collection, gathered over a period of years in the Apennines, Corsica and Sicily. All the material examined had the necessary characteristics for the "morphospecies" *A. intermedius* NORMAND. As this entity is still relatively little known in Italy, we shall list the synonyms for the area in question and give the anatomical details of the populations identified.

### *Arion intermedius* NORMAND.

*Arion intermedius* NORMAND 1852; Descr. Limaces: 7. [Locus typicus: Valenciennes, France.]

? *Arion (Prolepis) hortensis*, — STROBEL 1877; Bull. Soc. malac. it., 3: 87 [non FÉRUSAC 1821].

? *Arion (Prolepis) fuscus*, — STROBEL 1877; Bull. Soc. malac. it., 3: 87 [non MÜLLER 1744].

- ? *Arion hortensis* var. *grisea*, — PAULUCCI 1879; Esc. scient. Calabria. Fauna malacologica: 17 [non MOQUIN-TANDON 1855].
- Arion hortensis*, — LESSONA & POLLONERA 1882; Mem. r. Accad. Sci. Torino, (II), 35: 63-64 [partim, non FÉRUSSAC 1821].
- Arion intermedius* var. *apennina* POLLONERA 1889; Atti r. Accad. Sci. Torino, 24 18-19, Figs. 11-12. [Locus typicus: Lucchio (Lucca, Tuscany)].
- Arion intermedius* var. *apennina*, — POLLONERA 1890; Boll. Mus. Zool. Anat. comp. r. Univ. Torino, 5 (87): 24.
- ? *Arion hortensis*, — PICAGLIA 1892; Bull. Soc. malc. it., 16: 91-92 [= *A. hortensis* + *A. fuscus* STROBEL 1877], [non FÉRUSSAC 1821].
- Arion* (*Arion*, *Microarion*) *intermedius* var. *apennina*, — HESSE 1926; Abhandl. Arch. Moll., 2 (1): 129.
- Arion* (s. str.) *hortensis*, — FORCART 1965; Verh. naturf. Ges. Basel, 76: 93-94 [? partim, non FÉRUSSAC 1821].
- Arion* (*Arion*) *hortensis*, — FORCART 1968; Ann. Mus. civ. St. nat. Genova, 77: 87 [non FÉRUSSAC 1821].
- Arion* (s. str.) *hortensis*, — GIUSTI & MAZZINI 1970; Lav. Soc. it. Biogeogr., (N. S.), 1; 245-246 [partim, non FÉRUSSAC 1821].
- ? *Arion* (*Arion*, *Kobeltia*) *hortensis*, — ALZONA 1971; Atti Soc. it. Sci. nat. Museo civ. St. nat. Milano, 111: 137 [partim, non FÉRUSSAC 1821].
- Arion* (*Arion*, *Microarion*) *intermedius*, — ALZONA 1971; Atti Soc. it. Sci. nat. Museo civ. St. nat. Milano, 111: 138.
- Arion* (*Arion*, *Microarion*) *intermedius apenninus*, — ALZONA 1971; Atti Soc. it. Sci. nat. Museo civ. St. nat. Milano, 111: 138.
- ? *Arion* sp., — HOLYOAK 1983; J. of Conch. London, 31: 241.
- ? *Arion hortensis*, — BELLAVERE & PERETTI 1984; Pubbl. Mus. St. nat. Univ. Parma, 1: 69, Fig. 58 [= *A. hortensis* STROBEL 1877], [non FÉRUSSAC 1821].
- ? *Arion subfuscus*, — BELLAVERE & PERETTI 1984; Pubbl. Mus. St. nat. Univ. Parma 1: 69, Fig. 59 [= *A. fuscus* STROBEL 1877], [non DRAPARNAUD 1805].
- ? *Arion hortensis*, — PALAZZI 1985; Atti Soc. Nat. Mat. Modena, 114: 23 [= *A. hortensis* STROBEL 1877], [non FÉRUSSAC 1821].
- Arion intermedius*, — BACKELJAU 1985; J. of Conch. London, 32: 69-70.
- Arion intermedius*, — BOATO, BODON & GIUSTI 1985; Lav. Soc. it. Biogeogr., (N. S.), 9; 291.

### Body characters.

Length of sexually developed specimens 1.2-2.5 cm; highly variable greyish- or greenish-yellow or yellowish-white colour, head and tentacles often darker; a dark band with blue-black spots runs along the sides of the body; these bands are preceded by two bands on the mantle which create a lyre-like pattern; the bands may be reduced or absent; yellowish-white, sometimes orange; mucous yellow.

Comparison with the three major species of the "*A. hortensis* complex" (*A. hortensis*, *A. distinctus*, *A. owenii*; see DAVIES 1977):

A) In common with *A. intermedius*, only *A. distinctus* has dark blue-black pigmentation and grey tentacles. *A. hortensis* and *A. owenii* show traces of red pigment which are never seen in *A. distinctus* and *A. intermedius*. Brown pigmentation also distinguishes *A. owenii* from the other three.

B) The young specimens of *A. owenii* closely resemble *A. intermedius* specimens in general appearance and the form of the tubercles, which are rough. However the ridges of the tubercles are smoothly continuous in *A. owenii* and broken in

*A. intermedius* (see DAVIES 1977). Rough tubercles in a live contracted adult specimen are considered to be a good diagnostic character for distinguishing *A. intermedius* from the species of the "*A. hortensis* complex" (see KERNEY & CAMERON 1979, Pl. 5: fig. 8b). In spirit materials this detail is hardly ever evident.

### Anatomical Characters.

The genital tract of the specimens we examined is similar to that of various European populations (WIKTOR 1973, CASTILLEJO-MURILLO 1982, GITTENBERGER et al. 1984). The most significant characters are:

A) The genital atrium has thick glandular walls and in proportion to the rest of the tract, is longer than in the other three species of the "*A. hortensis* complex"

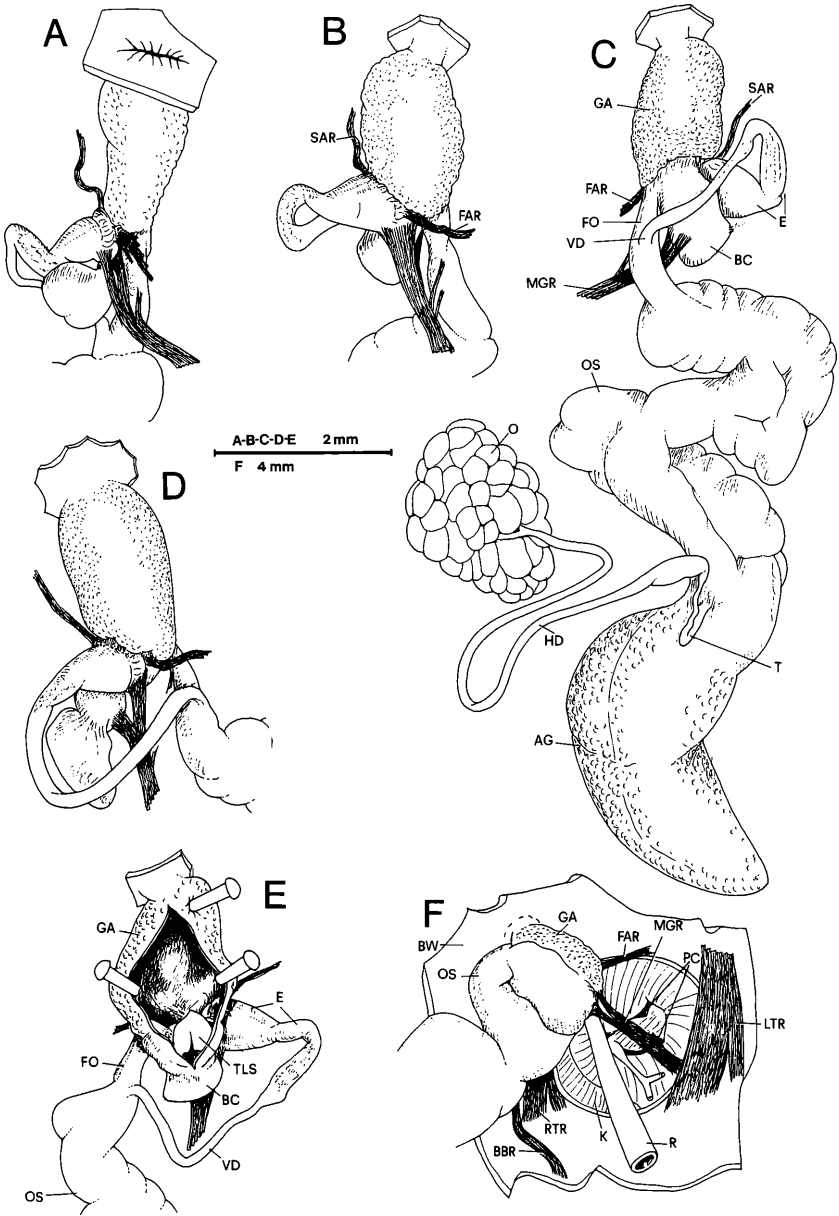
B) The free oviduct is quite short with thin walls and is not differentiated into "firm" and "eversible" portions. This differentiation is found in the species of the "*A. hortensis* complex" except for a few populations of *A. distinctus* which present only the "firm portion" (see DAVIES 1977, BACKELJAU 1985b). Inside the free oviduct there is no trace of the typical ligula or ligula-like longitudinal folds described in the species of the "*A. hortensis* complex" when the eversible portion is present (QUICK 1961, DAVIES 1977).

C) The vas deferens is slender, has thin walls and some folds on its inner surface. A fairly long epiphallus follows the vas deferens. The inner surface of its wall have rows of small polygonal papillae which also occur on the inner surface of the epiphallus walls of the three species of the "*A. hortensis* complex". The end of the epiphallus enlarges in the manner of a cup which connects it to the basal (= proximal) portion of the genital atrium. Where the epiphallus opens into the genital atrium is bordered by a sort of papilla (= epiphallus outlet) which is ring shaped and frequently corrugated so as to appear to be formed by a series of connected knobs. Its appearance is thus very different from that observed and described (DAVIES 1977, BACKELJAU 1985b, BACKELJAU & VAN BEECK 1986) in the three species of the "*A. hortensis* complex". It is also different from the scheme published by BACKELJAU & VAN BEECK (1986: fig. 5) for specimens from Barvaux (Belgium). These were supposed to have an epiphallus outlet with a sort of finger-like lateral expansion, similar to that described in *A. owenii*.

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Fig. 1. *A. intermedius* NORMAND from Mt. Soro, eastern Sicily. A-B, D: distal portions of the genital ducts; C (the same specimen as B): a whole genital apparatus; E: a distal portion of a genital apparatus with the atrium opened to show the tongue-like structure in the duct of the bursa copulatrix; F: ventral view of the pallial region showing the relationship between the distal portion of the genital duct and two of its retractor muscles, the distal portion of the rectum, the kidney and pericardial cavity and the cephalic retractor muscles. AO aorta, AG albumen gland, BR buccal bulb retractor, BC bursa copulatrix (= gametolytic gland), BCD bursa copulatrix duct, BW body wall, E epiphallus, OE epiphallus outlet, FAR first accessory genital retractor, FO free oviduct, GA genital atrium, HD hermaphroditic duct, K kidney, LTR left tentacle retractor, MGR main genital retractor, O ovotestis, OBC opening of the bursa copulatrix duct, OS ovispermiduct, PC pericardial cavity, R rectum, RTR right tentacle retractor, SAR second accessory genital retractor, T talon, TLS tongue like structure, V ventricle, VD vas deferens.

D) The duct of the bursa copulatrix (= gametolytic gland) is short and wide. The inside of the duct has a ring shaped thickening from which, on the side facing the epiphallus, a peculiar tongue-like structure slightly protrudes into the genital



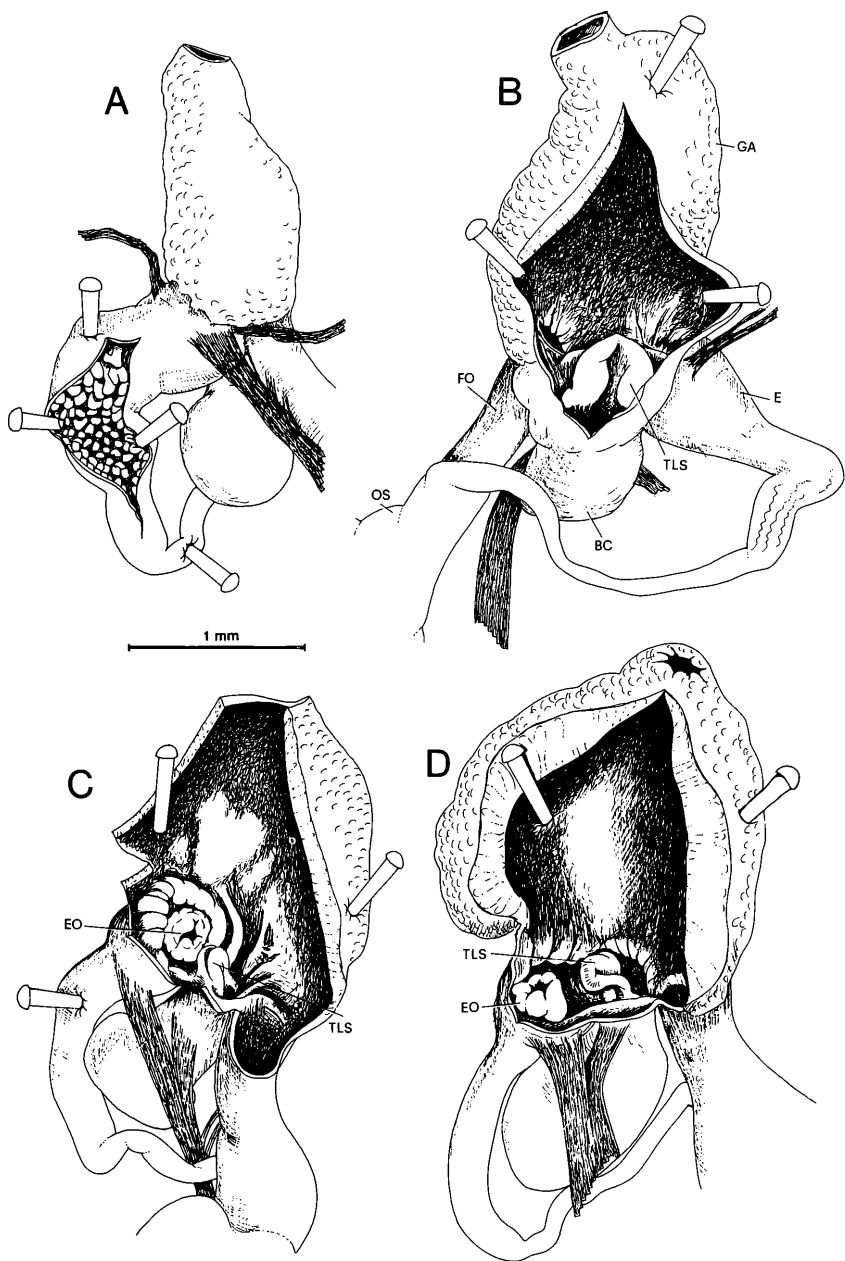


Fig. 2. Distal portions of the genital duct of *A. intermedius* NORMAND from Mt. Soro, eastern Sicily (A-C) and from Mt. Amiata, Tuscany (D). The epiphallus (A) and the atrium (B-D) are opened to show their inner structure (Symbols as in Fig. 1).

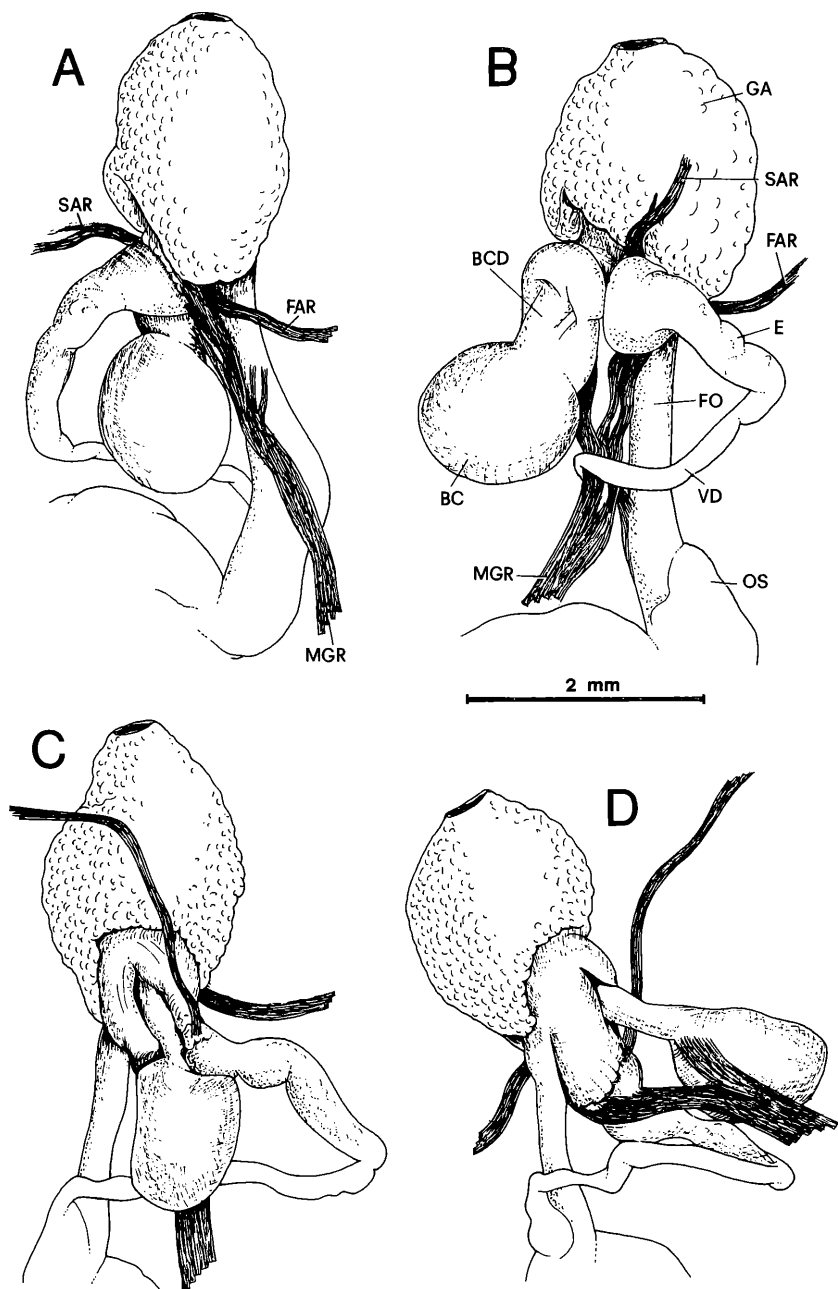


Fig. 3. Distal portions of the genital duct of two specimens of *A. intermedius* NORMAND from Bocognano, Corsica. Note the peculiar arrangement of the genitalia in the specimen (C-D): the duct of the bursa copulatrix is partially invaginated into the lower atrium (Symbols as in Fig. 1).

atrium. No such structure has been noticed in the three species of the "*A. hortensis* complex". The bursa copulatrix (= gametolytic gland) is of variable width, roundish or irregular in shape.

E) Many small muscles comprise the genital retractor system, which appears to be substantially constant in its disposition and structure in all the populations examined by us. The most constant feature is a fairly large muscle distally divided into two branches, which starts from the body wall near the left margin of the diaphragm covering the pallial cavity (MGR = main genital retractor). The largest branch ends on one side of the distal portion of the epiphallus. Some small muscular strands also connect it to the free oviduct walls. The smaller branch ends on the walls of the duct of the bursa copulatrix. This muscle is very similar to that described in the "*A. hortensis* complex" (see QUICK 1961).

A slender muscle (FAR = first accessory retractor) arises in the body wall near the anterior margin of the pallial cavity and ends in the wall of the distal portion of the epiphallus facing the free oviduct. Another slender muscle (SAR = second accessory retractor) arises in the body walls near the genital pore and ends near where the distal portion of the epiphallus enters the genital atrium. This muscle is often poorly visible. These two muscles were present in all the specimens of the populations examined from the Apennines, Sicily and Corsica. They have never been described before and are not known in the three species of the "*A. hortensis* complex". Nevertheless in specimens of *A. distinctus* from South Croydon (Sussex England; S. DAVIES leg.) a small muscle has been observed which ends in the proximal portion of the genital atrium (= lower or basal atrium) between where the canal of the bursa and the epiphallus enter the same atrium. It seems likely that this muscle has the same function as one of the two above mentioned muscles of *A. intermedius*.

F) The radula of the Sicilian and Corsican specimens examined has constant characteristics and corresponds to that of "conspecific" individuals collected at Hessen (Vogelsberg/Oberhessen, Forst Störndorf; JUNGBLUTH et al. 1985: Pl. 3, fig. 16) and to that of other species of the Arionidae as far as tooth form, at least, is concerned (JUNGBLUTH et al. 1985: Pls. 2-3).

The formula is as follows: 28-35 + C + 28-35. The central tooth is tricuspidate and has a wide perfectly symmetrical basal plate. The mesocone is long, slender and pointed. The ectocones are short (about half the length of the mesocone) and pointed. The first lateral teeth are quite robust. The basal plate is wide with only the external vertex prominent; the mesocone long and robust. A slight indentation at about  $\frac{2}{3}$  of its length on the centre facing side is reminiscent of a regressed endocone. The ectocone is short but wide and sharp. The basal plate gradually reduces in thickness and the mesocone and ectocone in size (the latter tending to curve centrewards) as we pass from the lateral to the extreme marginal teeth. It is not possible to identify an intermediate zone of lateromarginal teeth. The teeth near the extreme lateral margins are distinguished by their marked reduction in size and the endocone which often has an apex with 2 or 3 small points.

The mandible does not present any noteworthy features. It is "odontognathous" and traversed by 10-15 ribs.

G) Other anatomical features: the ovotestis lies inside the mass of lobes of the digestive gland, so that it is not usually visible from the outside; its dimensions are



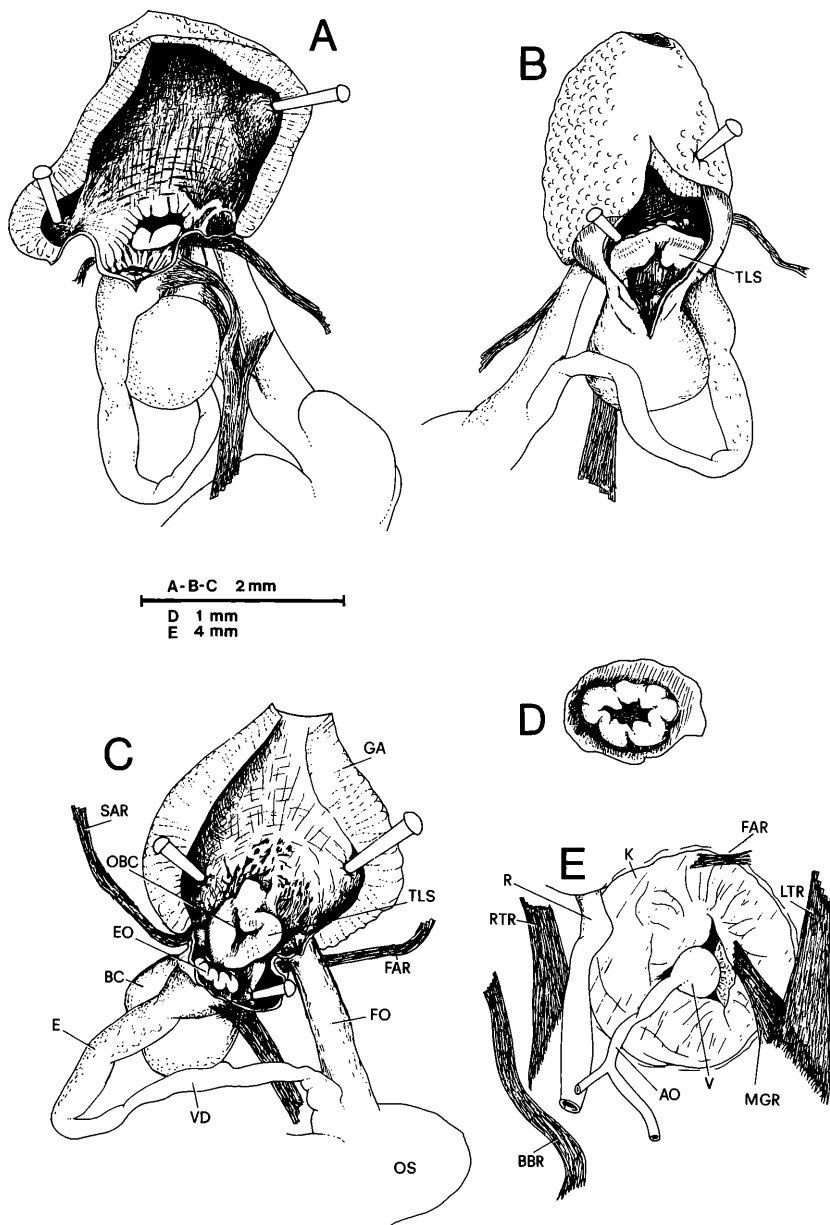


Fig. 4. *A. intermedius* NORMAND from Bocognano, Corsica. A-C: distal portions of the genital duct with the atrium opened to show different views of the epiphallus outlet and of the tongue-like structure; D: an isolated epiphallus outlet; E: ventral view of the pallial region (Symbols as in Fig. 1).

rather small and it is composed of very small acini. The first hermaphrodite duct is very slender and long. The albumen gland and the ovispermiduct (= second hermaphrodite duct) are well developed.

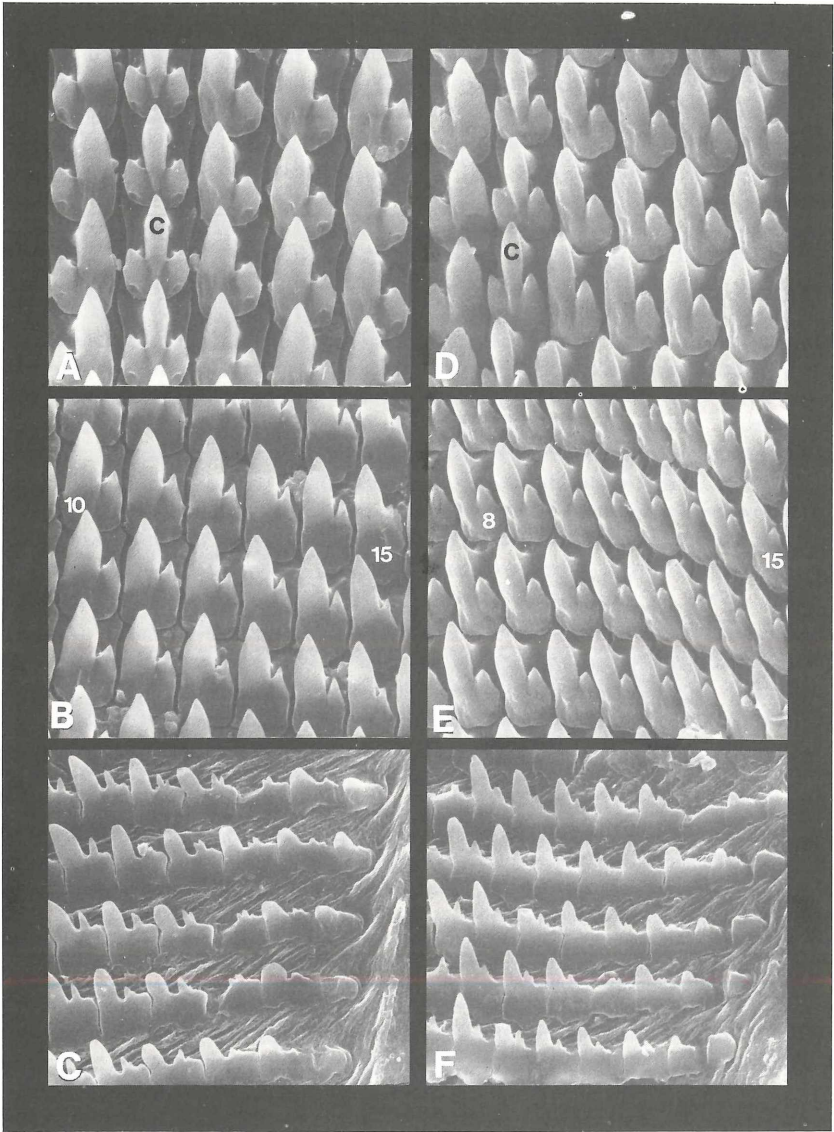


Fig. 5. Radula of specimens of *A. intermedius* NORMAND from Mt. Soro, eastern Sicily (A-C) and Bocognano, Corsica (D-F). A, D: central tooth (C) and first lateral teeth; B: 10th-15th lateral teeth; E: 8th-15th lateral teeth; C, F: marginal teeth. A-C 540  $\times$ ; D-F 440  $\times$ .

The alimentary canal shows 2 or 3 loops depending on the stage of growth and body dimensions. The stomach is large, shows a small posterior coecal sac and communicates with the digestive gland via two openings. The pallial complex corresponds perfectly to that described by WIKTOR & LIKHAREV (1980) in the same species.

#### Material examined.

Graie Alps: Rupe di Salto (Cuorgè, Torino), 500-550 m BODON leg. 27.8. 1983 (1 sp.). Ligurian Apennines: Rio di Montenotte, between Casa Isola and Montenotte inferiore (Cairo Montenotte, Savona), BOATO leg. 16.9. 1982 (2 sp.); Rocca dell'Adelasia (Cairo Montenotte, Savona), BOATO leg. 22.11. 1981 (1 sp.), 16.9. 1982 (1 sp.), 6.10. 1983 (3 sp.); Cascina Sardinia (Bosio, Alessandria) GAITER leg. 18.10. 1981 (1 sp.); Alta Val Garenna, (Genova), BODON leg. 14.4. 1982 (1 sp.); Travizio, Monte Gattero (Sesta Godano, Spezia), BODON leg. 11.9. 1982 (1 sp.). Tuscany: Monte Freddone (Apuan Alps, Lucca), 29.10. 1969 (1 sp.), GIUSTI & MAZZINI 1970 det. as *A. (s. str.) hortensis*; Passo della Calla (Arezzo-Forlì), 19.9. 1971 (1 sp.); Camaldoli (Arezzo), 9.8. 1971 (1 sp.); Monte Luco (Siena), 30.9. 1984 (1 sp.); Monte Amiata (Siena-Grosseto), 5.11. 1982 (6 sp.); Monte Amiata (Siena-Grosseto), AMADII & FERRINI leg. 11.1982 (1 sp.). Sicily: Monte Soro (Messina), 17.9. 1981 (7 sp.). Corsica: Bocognano, 3.11. 1983 (5 sp.); Ghisonaccia, 30.11. 1983 (1 sp.); near Olmeto, 1.12. 1983 (1 sp.); near Sartene, 22.4. 1980 (1 sp.).

#### Taxonomical notes.

As hinted in the introduction, anatomical analysis of small *Arion* collected in Corsica, Sicily and Tuscany has not revealed any distinguishing morphological character. According to current taxonomical practices, all the different populations can thus be assigned to a single "species": *Arion intermedius* (NORMAND).

Recent biological studies of the species confirm that mating behaviour has never been observed, that spermatophores have never been found in the genital tract of sexually mature specimens and that the eggs of individuals raised in isolation are viable (DAVIES 1977). Genetic variation studies based on enzyme electrophoresis demonstrate the constant homozygosity of many different populations (McCRACKEN & SELANDER 1980, on 20 loci; FOLTZ et al. 1982, on 10 loci). The above favours the opinion that *A. intermedius* consists of one or more monogenic strains resulting from an automictic mode of reproduction, probably self-fertilization (McCRACKEN & SELANDER 1980, FOLTZ et al. 1982, FOLTZ et al. 1984, BACKELJAU 1985b, BACKELJAU & DE WINTER 1987, BACKELJAU et al. 1987). It is still impossible to determine the systematic rank of these strains and which of them might eventually constitute true biological species. The "species" *Arion intermedius* NORMAND should thus not necessarily be considered to correspond to a single biological species but rather a complex of more or less genetically differentiated populations or "morphospecies" in the sense intended by GIUSTI (1986: "a fairly uniform set of monophyletic populations in which as yet not clearly morphologically differentiated biological species are possibly included"). If genetic analysis is able to establish levels of genetic difference between strains sufficient to qualify some of them for the rank of true biological species in the absence of morphological dislocation, the

concept of "supraspecies" as proposed by GENERMONT & LAMOTTE (1980) and reconsidered by GIUSTI & MANGANELLI (1989) could be applied to *A. intermedius*. The use of the term *Arion* suprasp. *intermedius* NORMAND would avoid defining "species" which are not unequivocal biological species and would not put country researchers in the position of not being able to define their materials.

In this case as in others which precede it (see BOATO, BODON & GIUSTI 1983, 1985) we shall not define a precise subgeneric category. However we agree with WALDÉN (1976), DAVIES (1979), BACKELJAU (1985b), BACKELJAU & DE WINTER (1987a) that *A. intermedius* cannot be distinguished from the other species usually included in the subgenus *Kobeltia* (*A. hortensis*, *A. distinctus*, *A. owenii*, *A. fagophilus*) on the basis of its morphological, chromosomic and genetic characteristics. Thus if it is considered opportune to use subgeneric categories, *Microarion* HESSE 1926 (type species: *A. intermedius* NORMAND) should be taken as junior synonym of *Kobeltia* SEIBERT 1873 (type species: *A. hortensis* sensu SEIBERT 1873, non FÉRUSAC 1821 = *A. distinctus* MABILLE 1868; see BACKELJAU & DE WINTER, 1987).

### Zoogeographical notes.

*A. intermedius* is distributed throughout central-western Europe and its presence in U. S. A. is probably due to passive transport. Reports of its presence in the Alps resulting from doubtful diagnoses of the past (SIMROTH 1910: 337, fig. 13: *A. minimus* [s. *intermedius* NORM.] *rhaeticus* n. var.) have only recently been confirmed (M. BODON leg. et det.: Rupe di Salto, Cuorgè, Piemonte). It is not surprising to find it in the Tuscan Apennine as these zones are continuous with the western Alps via the Ligurian Apennine. On the other hand, its absence from the central and central-south Apennine and its reappearance at the tip of Calabria (Aspromonte) and in one site in eastern Sicily (Mt. Soro) is surprising. Its presence in Corsica and absence from Sardinia is also puzzling.

One can always resort to the explanation of passive transport in such cases. Selfing-species such as *A. intermedius* have been shown to be more successful in colonizing new areas (FOLTZ et al. 1984). This explanation is not only the simplest but it is also the most simplistic. There are at least two other possible explanations.

The first is that *A. intermedius* like many other species of terrestrial and freshwater molluscs (GIUSTI 1976, 1977; GIUSTI & CASTAGNOLO 1983; GIUSTI & MANGANELLI 1984; GIUSTI et al. 1985) belonged to the malacofauna of the southwestern flank of Europe in pre-Miocene times before the drift phenomena which led the microplate of Corsica and Sardinia to separate from the mainland. The successive drift phenomenon which caused the separation of the Calabro-Peloritan microplate from the Sardo-Corsican one (see GIUSTI 1976; GIUSTI & MANGANELLI 1984) would account for the presence now of the species in Calabria and in eastern Sicily.

The absence of the species in Sardinia might be due to its extinction fairly recently by occasional or other factors (competition with other slugs particularly the endemic *Arion isseli*?). This seems to explain the presence of the species in Sicily and the southern Apennines and its absence in the central Apennines.

The second explanation is that many different phenomena have determined the present discontinuous distribution of *A. intermedius* in Italy and the major Tyrrhe-

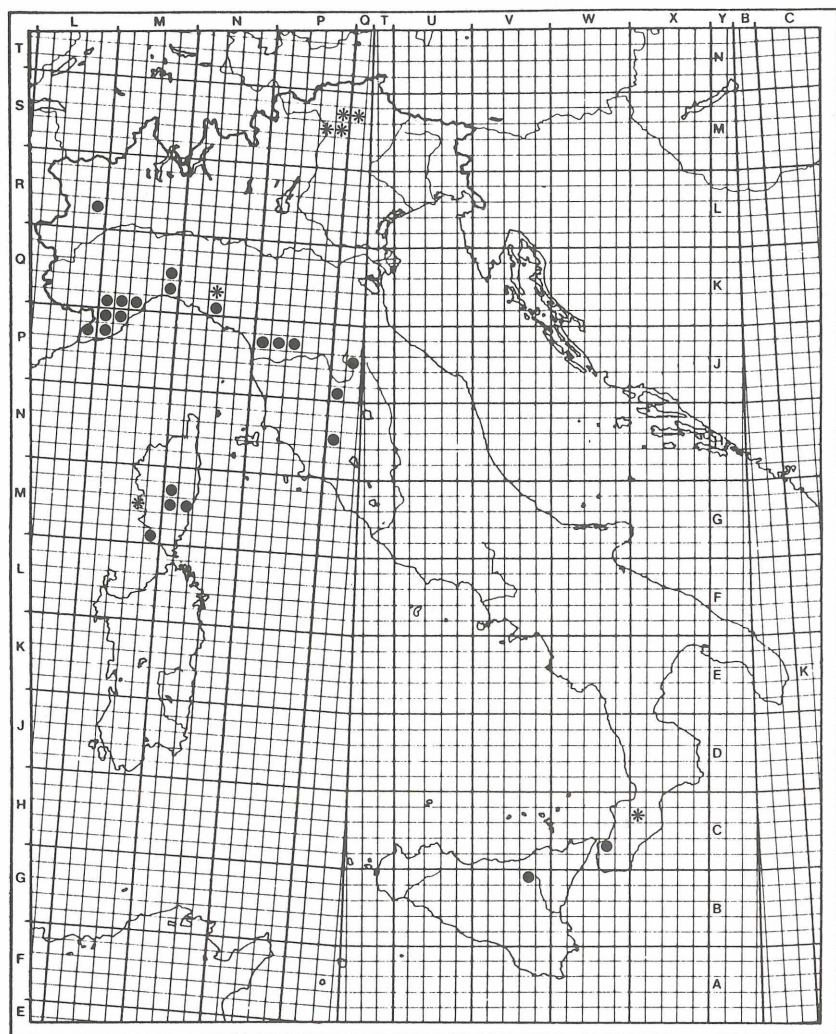


Fig. 6. Distribution of *A. intermedius* NORMAND in Italy, Corsica and Sicily on a UTM map plotted on 20×20 kilometre squares. Black dots refer to recent material classified after anatomical study or reported by BOATO, BODON & GIUSTI 1985. Asterisks refer to old or uncertain data from literature (STROBEL 1877, PAULUCCI 1879, SIMROTH 1910, HOLYOAK 1983).

nian islands. In Corsica the species may have arrived fairly recently by passive transport, but in Italy it may have come during one of the Quaternary ice ages and spread as far as Calabria. The linking of Calabria and Sicily at that time by the lowering of the sea level, or successive passive transport may have brought the species to eastern Sicily and the improvement in climate after the glaciation may

have facilitated its disappearance from many zones of the central Apennines. According to DAVIES (1977) *A. intermedius* is a winter or northern species, better adapted than other small *Arion* to cold climates. If this is so it is clear why it has survived only in restricted mountain areas where climatic conditions were favourable and limited the number of competing species.

This interpretation again raises the question of the Corsican populations, most of which live at sea level. It can only be supposed that these are characterised strains better adapted to the Mediterranean climate.

### Acknowledgments.

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