



The genus *Ammonicera* (Heterobranchia, Omalogyridae) in the Eastern Atlantic. 1: the species of the Iberian Peninsula

El género *Ammonicera* (Heterobranchia, Omalogyridae) en el Atlántico oriental. 1: las especies de la Península Ibérica

Joan Daniel OLIVER* & Emilio ROLÁN**

Recibido 20-X-2013. Aceptado 10-I-2015

ABSTRACT

The species of the genus *Ammonicera* of the Iberian Peninsula (Atlantic and Mediterranean) are revised, using extensively the Scanning Electron Microscopy (SEM) with which mainly details of the protoconch and the microsculpture were studied. Essential differences are shown to discriminate the two previously known species *Ammonicera rota* and *A. fischeriana*. The intraspecific variability was explored and this allowed us to conclude that there are additional species, of which six (*A. columbretensis*, *A. andresi*, *A. nodulosa*, *A. superstriata*, *A. arrondoi* and *A. galaica*) are described as new to science. The highest species diversity is found in the Balears, with up to five sympatric species, followed by Columbretes Islands and the Strait of Gibraltar, with 4 species.

RESUMEN

Se revisan las especies del género *Ammonicera* de la Península Ibérica (Atlántico y Mediterráneo), utilizando ampliamente el Microscopio Electrónico de Barrido (MEB) con el que se estudiaron principalmente los detalles de la protoconcha y su microescultura. Se muestran diferencias esenciales que discriminan las dos especies previamente conocidas *Ammonicera rota* y *A. fischeriana*. La variabilidad intraespecífica fue explorada y de ello se concluyó que había especies adicionales, de las cuales seis (*A. columbretensis*, *A. andresi*, *A. nodulosa*, *A. superstriata*, *A. arrondoi* y *A. galaica*) se describen como nuevas para la ciencia. La mayor diversidad de especies se encuentra en las Islas Baleares, con un máximo de cinco especies simpátricas, seguido de las Islas Columbretes y el Estrecho de Gibraltar, con 4 especies.

INTRODUCTION

The family Omalogyridae O. Sars, 1878, although known for a long time, has been neglected in malacological studies because of its small size. Therefore it has been assumed to comprise only few taxa separated by few and poorly defined characters. It is included in the superfamily Omalogyroidea, in the subclass Hetero-

branchia Gray, 1840 (BOUCHET & ROCROI, 2005). Years ago it would be regarded as "*incertae sedis*" (FRETTER & GRAHAM, 1962) or be included among the marine Rissooidea (FRETTER & GRAHAM, 1978; NORDSIECK, 1968; SABELLI ET AL., 1990).

The genus *Ammonicera* Vayssière, 1893 is considered as belonging to the family

* c/Alcorisa 83, 12-C 28043, Madrid.

** Museo de Historia Natural de la Universidad, Campus norte, Parque Vista Alegre, 15782 Santiago de Compostela.

Omalogyridae. The species of this genus are all very small, almost always less than 1 mm, representing among the smallest dimensions recorded among the gastropods (BIELER & MIKKELSEN, 1998). The shell shape is discoid, planispiral. The soft parts, with cylindrical cephalic tentacles and a small snout in between has some similarity with those of the rissoids (GOFAS ET AL., 2011). Because of their small size they were hardly studied until the advent of Scanning Electron Microscopy (SEM).

Thereafter, several works appeared in different countries, like those of HABE (1972) for Japan; SLEURS (1983, 1985a, 1985b) for New Guinea and the Maldives; PALAZZI (1988, 1992) and PALAZZI & GAGLINI (1979) for the Mediterranean and Macaronesian islands; ROLÁN (1992a, 1992b) for Cape Verde Islands and the Caribbean; KNUDSEN (1995) for the Azores; SIMONE (1997) for Brazil; BIELER & MIKKELSEN (1998) for Florida; CHERNYSHEV (2003) for Japan; ROLÁN, LUQUE & PEÑAS (2009) for Namibia; SARTORI & BIELER (2014) for Australia and the Pacific coast of Mexico.

Since many years, the general works on the molluscs of Europe or the Mediterranean would either mention *Ammonicera rota* as the sole species (e.g. FRETTER & GRAHAM, 1962, 1978; GRAHAM, 1988; POPPE & GOTO, 1991; KNUDSEN, 1995) or *Ammonicera rota* and *Ammonicera fischeriana*, as the species existing in the area (e.g. NORDSIECK, 1968; PARENZAN, 1970; ROLÁN, 1983; ROLÁN & OTERO SCHMITT, 1996).

Some authors have used as a taxonomic criterion the presence of cords and ribs and the colour of the shell to distinguish the European species. Nevertheless, with such small shells with so similar aspect, the use of the scanning electron microscope (SEM) is essential for the study of their sculpture. This is even more essential regarding details of their tiny protoconch, which may be determined genetically and have a greater taxonomic value than characters of the teleoconch that may be influenced by environmental conditions.

In the CLEMAM database, the genus *Ammonicera* is considered to comprise

four species in the North-East Atlantic and Mediterranean. Two of these are recorded in the Mediterranean, *Ammonicera rota* (Forbes & Hanley, 1850) and *A. fischeriana* (Monterosato, 1869), and two more, *A. lignea* (Palazzi, 1988) and *A. rotundata* (Palazzi, 1988), are Macaronesian species. AARTSEN ET AL. (1984) indicated the presence of *A. rota* and *A. fischeriana* in the Strait of Gibraltar, but illustrated both species with specimens from Italy. FRETTER & GRAHAM (1978) considered that *A. fischeriana* and *A. rota* are the same species, while other authors, like GAGLINI & CURINI GALLETI (1978), considered them distinct, although they concluded that it was still unsettled. AARTSEN ET AL. (1984), after studying the collection of Bucquoy, Dautzenberg and Dollfus, supported the second option, attributing to *A. rota* evenly coloured shells presenting rather developed ribs, and to *A. fischeriana* the typically larger shells, with weak ribs visible in the first whorl and brown spiral lines.

PALAZZI (1988) described two additional species of *Ammonicera* from Madeira: *A. rotundata* and *A. lignea*, and ROLÁN (1992a) extended to the Cape Verde Islands the range of *A. rotundata*, mentioning also that, in the Mediterranean, *A. fischeriana* would only be present in meso- and infralittoral bottoms, and *A. rota* most frequent in circalittoral bottoms.

PALAZZI (1988) presented a key to these four species: *A. rotundata* without a keel (as shown in lateral view), while the other three are carinate. In addition, this species has a whitish colour and marked radial wrinkles. *Ammonicera rota* would present prominent radial ribs and no clear medium carina, contrary to the other two that would clearly be tricarinate. Finally, *A. lignea* is distinguished by a uniform colour, while *A. fischeriana* would present light gold brown lines on the carinae, on a light background. PALAZZI (1988) also provided SEM micrographs of these species in apical, abapical and lateral views. However, these pictures raise questions when confronted with the key, espe-

cially regarding the relevance of the carinae. For example, the specimen illustrated by this author as *A. fischeriana* (PALAZZI, 1988, fig. 11), from Catania, is more similar to his figure of *A. lignea* (PALAZZI, 1988, fig. 8) than to the other shell illustrated as *A. fischeriana* (PALAZZI, 1988, fig. 12). This shell, from the island of Pantelleria, is very similar to that figured as *A. fischeriana* by AARTSEN *ET AL.* (1984), which is not surprising, considering that these authors also illustrated material from the Italian coast.

Not much is known on the biology of this genus. The data provided by FRANC (1948) must be taken with caution because this author mentions flap-like cephalic tentacles which suggest that the animal observed was an *Omalogyra*, not an *Ammonicera*. The type of reproduction (known for *A. fischeriana*) involves relatively large ovigerous capsules (KNUDSEN, 1995) containing one or two eggs in its interior, with intracapsular direct development, and which the animals sometimes drag attached to the umbilicus (GOFAS *ET AL.*, 2011). This form of reproduction presupposes a very low rate of growth of the populations. The examination of the protoconch reveals that these animals probably lack a planktonic larval phase. For this reason we believe that the dispersion of this genus can be mediated by floating vegetation (rafting) transported by currents and which may have retained living specimens due to their small size. These circumstances, in our opinion, increases the possibility that some populations could be isolated, for example on islands, favouring both intraspecific diversification and speciation.

In this paper we aim to reach conclusions that can be sustained over time and therefore we have studied a large number of specimens and images, representing different populations from many points of the study area. Given the existing variability, many more images than usual have been needed and we have made the choice to show many of them in order to support our conclusions.

We believe that this large number of images is needed to show the variability or the constancy of certain characters which can define each taxon, or each population in the different locations.

MATERIAL AND METHODS

The geographic scope of the study is focused on the Atlantic and Mediterranean coasts of the Iberian Peninsula, the Balears, Columbretes, Alborán and Chafarinas Islands. However samples of other parts of the Western Mediterranean and of neighbouring Atlantic coasts (from Brittany to the Moroccan Atlantic coast) have been examined and photographed. Localities from which material has been examined and their coordinates are included in the section of material studied for each species. For comparison, other material including some specimens from Mauritania, Canary Islands, Ghana, São Tomé, Príncipe and Annobon, has been also examined.

The material studied comes in a large part from the collection of the authors. The empty shells have been found by sorting fine sediment (less than 1 mm or 1.5 mm) under the stereomicroscope. The living specimens have been obtained washing algae or brushing rocks at levels ranging from the intertidal to the subtidal first meters, then screening the sediment through fine sieves. Other material was obtained from some museum collections (MNCN, MNHN, MHNS mainly) coming from collections made in various campaigns through dredgings or collecting in subtidal or intertidal levels.

For each species the total number of the shells examined is indicated at the beginning of the "Material examined" section. Also the proportion of the forms in some species.

The correct separation between some species cannot be made without the use of Scanning Electron Microscopy (SEM). Although, the SEM micrographs have been used profusely, not all the studied specimens were examined

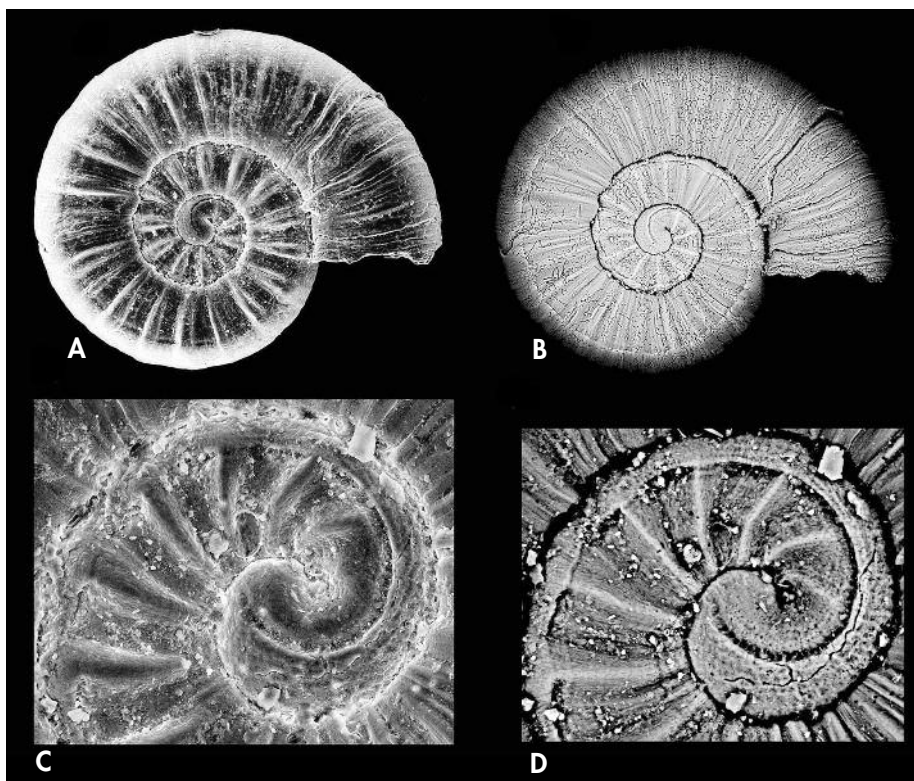


Figure 1. SEM images. A, B: Images of the same shell with the method of secondary electrons (A) and backscattered electrons (B); C, D: images of the protoconch with the same two methods.

Figura 1. Imágenes al MEB: A, B: imágenes de la misma concha según el método de electrones secundarios y retrodispersados; C, D: imágenes de la protoconcha según los mismos métodos.

under SEM, so the assignment of shells studied only under the stereomicroscope must be taken with caution.

In the study of shells with the SEM, two kinds of detectors have been used, allowing a better understanding of their sculpture. With the usual detector (secondary electrons) we have a better vision of the volume and of its sculpture (Figs. 1A, 1C) while the detectors BSED (backscattered electrons) allows a better view of the outline of the sculpture (Figs. 1B, 1D).

Morphological features studied

Sculptural pattern in *Ammonicera*:

The sculptural pattern of the majority of the *Ammonicera* is distributed in three areas: an adapical zone (Figs. 2A,C: 1) a

medium or peripheral band (Figs. 2A-D: 2-6) and an abapical zone (Figs. 2B,D: 7), often separated by grooves. The mid-band may be subdivided into three cords and two interspaces (which in some species are also occupied by cords): top cord (Figs. 2A,C: 2), top interspace (Figs. 2A,C,D: 3), peripheral cord (Figs. 2A-D: 4), lower interspace (Figs. 2B,C,D: 5) and lower cord (Figs. 2C,D: 6). This pattern is more or less conspicuous depending the particular species and specimens considered.

Microsculpture: The above mentioned pattern may be, or not, overlapped by secondary spiral microsulci. Regarding the axial ornamentation, the shells of *Ammonicera* may have ribs which cross the cords to form nodules

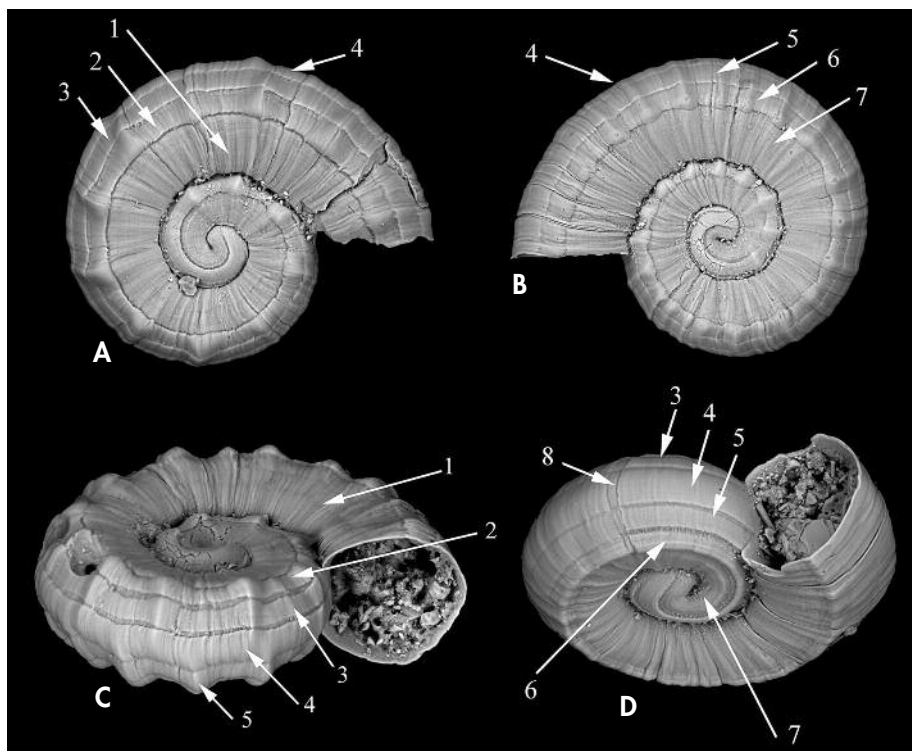


Figure 2. Designation of the portions of the shell. A and C: apical view (adapical) of the shell; B and D: basal view (abapical) (1: adapical area; 2-6: medium or peripheral band; 2: upper cord; 3: upper interspace; 4: cord peripheral; 5: lower interspace; 6: lower cord; 7: abapical zone; 8: scar of transition the zone protoconch-teleoconch).

Figura 2. Designación de las partes de la concha. A y C: visión apical (adapical) de la concha; B y D: visión basal (abapical) (1: zona adapical; 2-6: banda media o periférica, 2: cordón superior, 3: interspacio superior, 4: cordón periférico, 5: interspacio inferior, 6: cordón inferior; 7: zona abapical; 8: cicatriz de la zona de transición protoconcha-teleoconcha).

or tubercles. Juvenile shells tend to be more ornate than the adults.

Protoconch: In this group of molluscs, unlike most others, the end of the protoconch is not precisely marked: it is not coincident with the first rib, because the microsculpture of the protoconch proper continues even after the appearance of several ribs (see for example Figs. 1D, 7E, 7I, 11B). For this reason, the termination of the protoconch and the protoconch-teleoconch transition zone is not clear in any case, which constitutes a problem for comparisons.

At the beginning of the spire, there is an area which we consider to be the

nucleus of the protoconch (according to the definition of VERDUIN (1976; N in Figs. 3A-B). From this point, there is a space (which probably belongs to the protoconch) which we find very consistent within each species, spanning from the nucleus to the first rib, and which we will call "space without ribs" (SWR) (Figs. 3A-B). This space has been found very important for the species separation.

We have considered the extension of this area (SWR) along with its microsculpture and that of the nucleus of the protoconch as characters empirically more useful than others of the teleo-

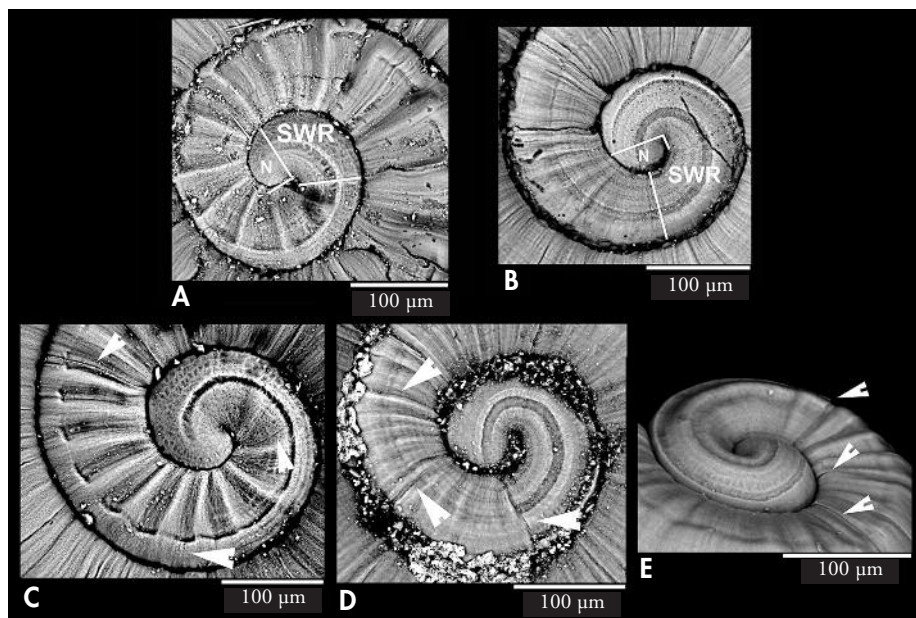


Figure 3. Details of the protoconch and protoconch-teleoconch transition zone. A, B. Images of the “space without ribs” (SWR), portion of the protoconch following the nucleus previous to the emergence of the first rib. A: with a little more than a quarter-whorl; B: with $\frac{3}{4}$ whorl (N = nucleus of the protoconch). C-E. Scars in the protoconch-teleoconch transition zone; the arrows mark the three scars that can be frequently observed.

Figura 3. Detalles de la protoconcha y zona de transición protoconcha-teleoconcha. A, B. imágenes de la porción de la protoconcha previa a la aparición de la primera costilla (SWR). A: con un poco más de $\frac{1}{4}$ de vuelta; B: con $\frac{3}{4}$ de vuelta (N = núcleo de la protoconcha). C-E. Cicatrices en la zona de transición protoconcha-teleoconcha; las flechas marcan las tres cicatrices que se pueden observar frecuentemente.

conch (such as ribs, striae, the peripheral grooves, etc.) that have been quite variable from some populations to others.

Most of the protoconchs (Figs. 3C-E) have a scar between 1 and 1.2 whorls. In some of the studied specimens of several species, one or two inconspicuous scars can appear between 0.5 and 1 whorl before the start of the sculpture, or once started the sculpture which will continue on the teleoconch. We therefore took into account the existence of two scars in the area which we consider as the transition from protoconch to teleoconch (not always perceptible in all the species and in all the shells of the same species) and considered the third scar as the first one definitely belonging to the teleoconch. We do not know the meaning of these scars, but given their

constancy we prefer to take them into account in the descriptions.

There is much variability in many of the characters which will be studied in the shells of *Ammonicera*. However we believe that those belonging to the protoconch are more likely genotypically determined characters and less influenced by the environment, contrary to the characters of the teleoconch. Therefore we have given them a greater value in the separation of the species.

Since we do not know where the protoconch ends, we will not use this name in the descriptions, but instead “protoconch-teleoconch transition zone”.

Apical view: The shells of different species tend to be similar both in apical (adapical) view and in basal (abapical) view; the sculptural differences, if any,

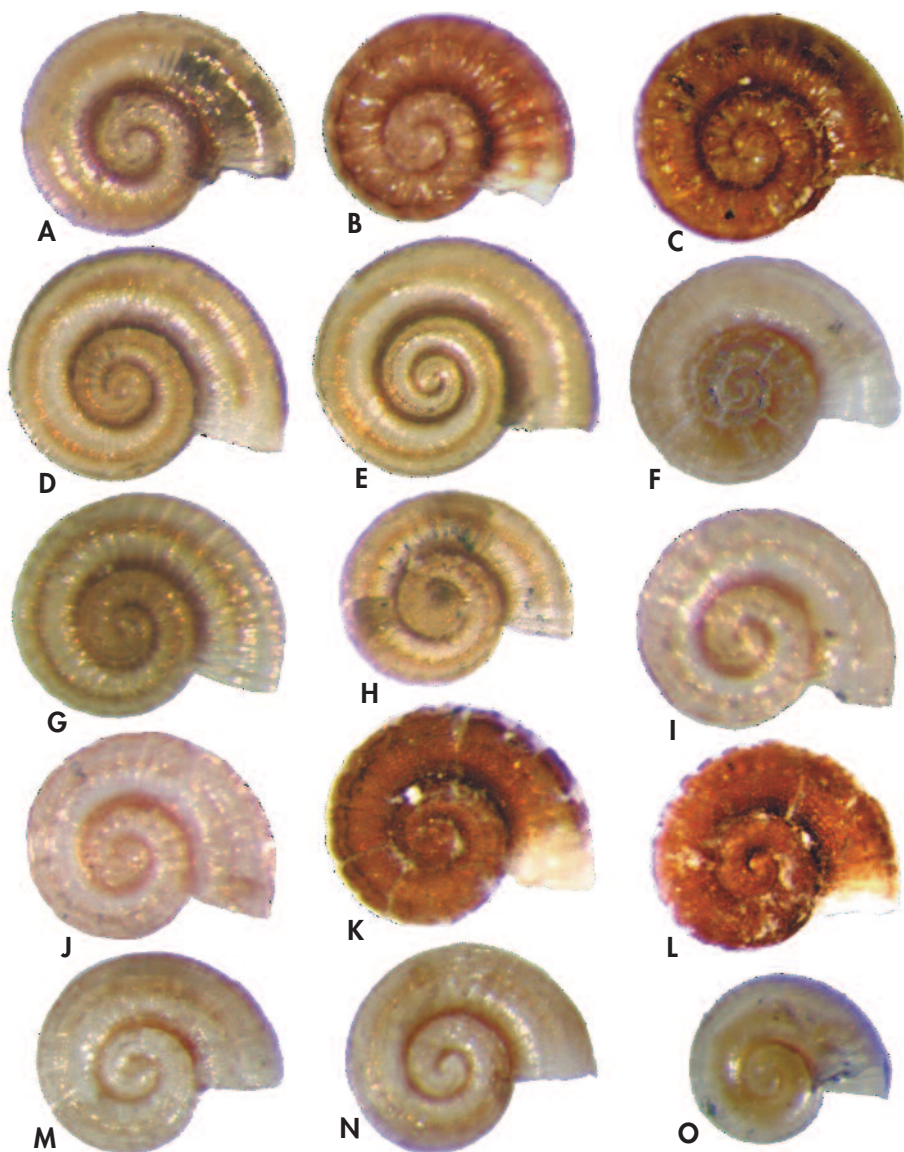


Figure 4. Colouration of the shells of the studied species of *Ammonicera*. A: *A. rota* (Forbes & Hanley, 1850), Tarifa; B, C: *A. columbretensis* spec. nov., Columbretes; D, E: *A. fischeriana* (Monterosato, 1869), Menorca and Cullera, respectively; F: *A. fischeriana* (atlantic form), Hendaye (MNHN); G, H: *A. andresi* spec. nov., Ibiza and Chafarinas, respectively; I, J: *A. nodulosa* spec. nov., Menorca; K, L: *A. superstriata* spec. nov., Ibiza; M, N: *A. arrondoi* spec. nov., Ibiza, paratypes (MNCN); O: *A. galaica* spec. nov. 0.43 mm, Cape Silleiro, paratype (MHNS).

Figura 4. Coloración de las conchas de las especies de Ammonicera estudiadas: A: *A. rota* (Forbes & Hanley, 1850), Tarifa; B, C: *A. columbretensis* spec. nov., Columbretes; D, E: *A. fischeriana* (Monterosato, 1869), Menorca y Cullera, respectivamente; F: *A. fischeriana* (forma atlántica), Hendaya (MNHN); G, H: *A. andresi* spec. nov., Ibiza y Chafarinas, respectivamente; I, J: *A. nodulosa* spec. nov., Menorca; K, L: *A. superstriata* spec. nov., Ibiza; M, N: *A. arrondoi* spec. nov., Ibiza, paratypes (MNCN); O: *A. galaica* spec. nov. 0.43 mm, Cabo Silleiro, paratype (MHNS).

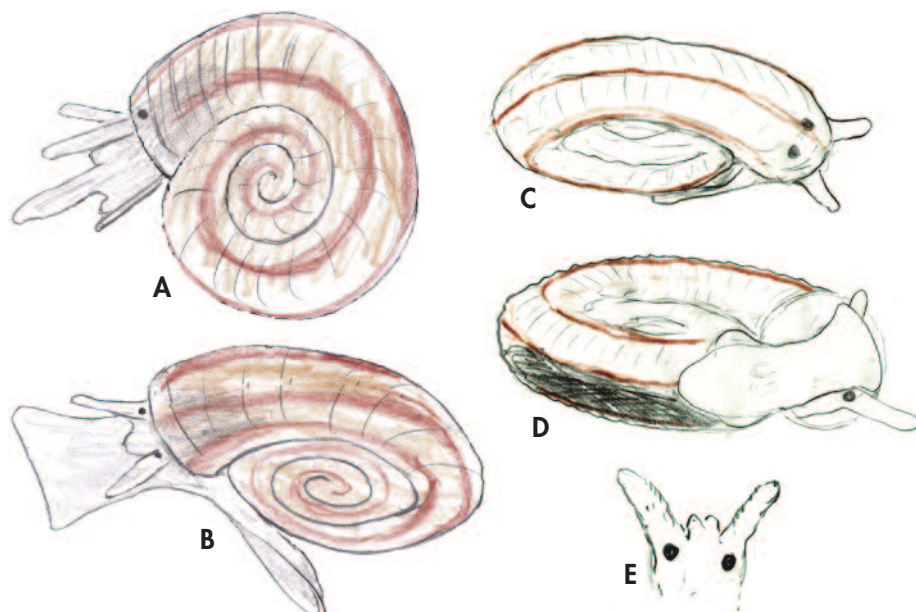


Figure 5. Drawings of living animals of *Ammonicera*. A, B: *A. fischeriana*, specimen from Denia, Alicante, Spain (drawing by Joan Daniel Oliver); C, D: *A. cf. fischeriana*, specimen from Baleeiera harbour, near Cape St Vincent, Portugal (drawing by Serge Gofas); E: detail of the head of the latter specimen. Shells are approximately 0.8 mm in diameter.

Figura 5. Dibujos de animales vivos de *Ammonicera*. A, B: *A. fischeriana*, ejemplar de Denia, Alicante (dibujo de Joan Daniel Oliver); C, D: *A. cf. fischeriana*, ejemplar del puerto de Baleeiera, cerca del Cabo de San Vicente, Portugal (dibujo de Serge Gofas); E: detalle de la cabeza de este último ejemplar. Las conchas miden aproximadamente 0,8 mm en diámetro.

have been found of little taxonomic significance. Sometimes the outer groove is closer to the suture on an apical view than in the abapical or basal. In this work, unless otherwise stated, the descriptions correspond to the apical view of the shell.

Colour: Most of the species tend to be more or less transparent, with a yellowish colour or without colour and, often, with three reddish brown spiral lines located on the upper, peripheral and lower cords. Some species are more or less dark reddish brown with a lighter aperture. Although there may be some chromatic variability in each species, we believe that it is less than what is often pointed in different works and with some practice many species can be differentiated by their colour, in

well preserved shells (Fig. 4). There is also a precedent in the genus *Omalogyra* in which the colour has proven to be a fairly steady character, to the point that in some cases it was used to define species (*Omalogyra atomus* and *O. simplex*, for example, the first of chestnut colouration, the second with oblique brown spots on a yellow background). ROLÁN (1992a) has used the colour for the separation of some species (such as *Ammonicera nolai* and *A. oteroi*).

Soft parts: Although many specimens have been collected alive, we have only few drawings (Fig. 5) and no photographs of the soft parts. The head of *Ammonicera* species typically bears two elongated tentacles on the sides of a small snout, being in this respect very different from *Omalogyra* which bears

two broad, semicircular flaps (FRETTER & GRAHAM, 1962).

On some lots with many live-collected specimens, we will distinguish "s" and "spms" but in most cases we will record "s" even if some specimens may have the animal inside.

Abbreviations

AD Aquarium Donostia, San Sebastián, Spain

MNCN Museo Nacional de Ciencias Naturales (CSIC), Madrid

MNHN Muséum National d'Histoire Naturelle, Paris

MHNS Museo de Historia Natural, Santiago de Compostela

CJDO-JT/MNCN research coll. Joan Daniel Oliver and José Templado (Museo Nacional de Ciencias Naturales, CSIC), Madrid

CFP coll. Fernando Pires, Sesimbra, Portugal

CFS coll. Frank Swinnen, Lommel, Belgium

SWR space of the protoconch from the nucleus to the first rib

spms shells with rest of soft parts inside

s shell; it can have inside the soft parts
j juvenile

SYSTEMATIC PART

Family OMALOGYRIDAE G.O. Sars, 1878

Genus *Ammonicera* Vayssi re, 1893

Ammonicera rota (Forbes & Hanley, 1850) (Figures 4A, 6A-I, 7A-I, 26A)

Skenea rota Forbes & Hanley, 1850, vol. 3: 160, pl. 73, fig. 10, pl. 88, figs. 1-2 [type locality: Donegal, Ireland].

Homalogyra rota (Forbes & Hanley, 1850) - Jeffreys, 1867, vol. 4: 71

(non) *Ammonicera fischeriana* (Monterosato, 1869) - Rodr guez-Babio & Thiriot-Qu ievreux, 1974: 534, pl. 2 F-H [recorded from Roscoff, Brittany].

Type material: Supposedly in The Natural History Museum, London, but could not be located in the type and general collections (pers. comm., Andreia Salvador, The Natural History Museum).

Material studied: (40 s): Western France: Bretagne: 6 s, Finist re, Anse de Bertheaume (48 20'N, 04 40'W, 20-30 m) (MNHN). Northern Spain: 1 s, Laredo (43 25.0'N, 03 24.5'W) (MNHN). Galicia: 1 s, Carnota, Coru a (MHNS); 2 s, Baiona, Pontevedra (MHNS); 3 s, Cabo Silleiro, intertidal (42 06.4'N, 08 54.3'W) (MHNS); Vigo: 4 s (MHNS); Islas Cies: 1 s (CJDO-JT/MNCN). Portugal: 2 s, Sesimbra, Setubal, 10-15 m (CFP). Strait of Gibraltar: 2 s, Tarifa (MHNS); 3 s (CJDO-JT/MNCN); 5 s, Barbate (36 11.0'N, 05 56.9'W) (MNHN); 1 s, Benz  (35 54.9'N, 05 22.3'W) (CJDO-JT/MNCN); 3 s, Ceuta, in the harbour (35 53.6'N, 05 19'W) (MNHN); 1 s, Ceuta, Tarajal, infralittoral rocks (35 51.3'N, 05 20.5'W) (MNHN); 3 s, Tangier, beach (35 46.7'N, 05 47.0'W) (MNHN); 2 s, Tarifa, Torre de la Pe a (36 03.3'N, 05 39.8'W) (CFS).

Description: The shell is planispiral, amphiconcave, reaching 0.89 mm in diameter with 2.6 whorls.

The profile of the last whorl is rounded with a peripheral band demarcated from the adapical and abapical areas by a narrow sulcus which is more obvious between the ribs. These ribs (around 15 in the first whorl) arise from the suture, both in the adapical and the abapical area and are attenuated or disappear on the median band, so that shells in apical view present an outline without undula-

tions. The interspaces are similar in width to the ribs (Fig. 7A-C).

The ribs are more pronounced in the juvenile shell and in some shells will persist until the end of the teleoconch (Figs. 7A-B). In others they become attenuated as the shell grows and finally disappear (Figs. 7D, 7H). The latter case is the more usual in the shells from the Strait of Gibraltar.

Protoconch and transition zone: The transition from the protoconch to the teleoconch is unclear; some well preserved

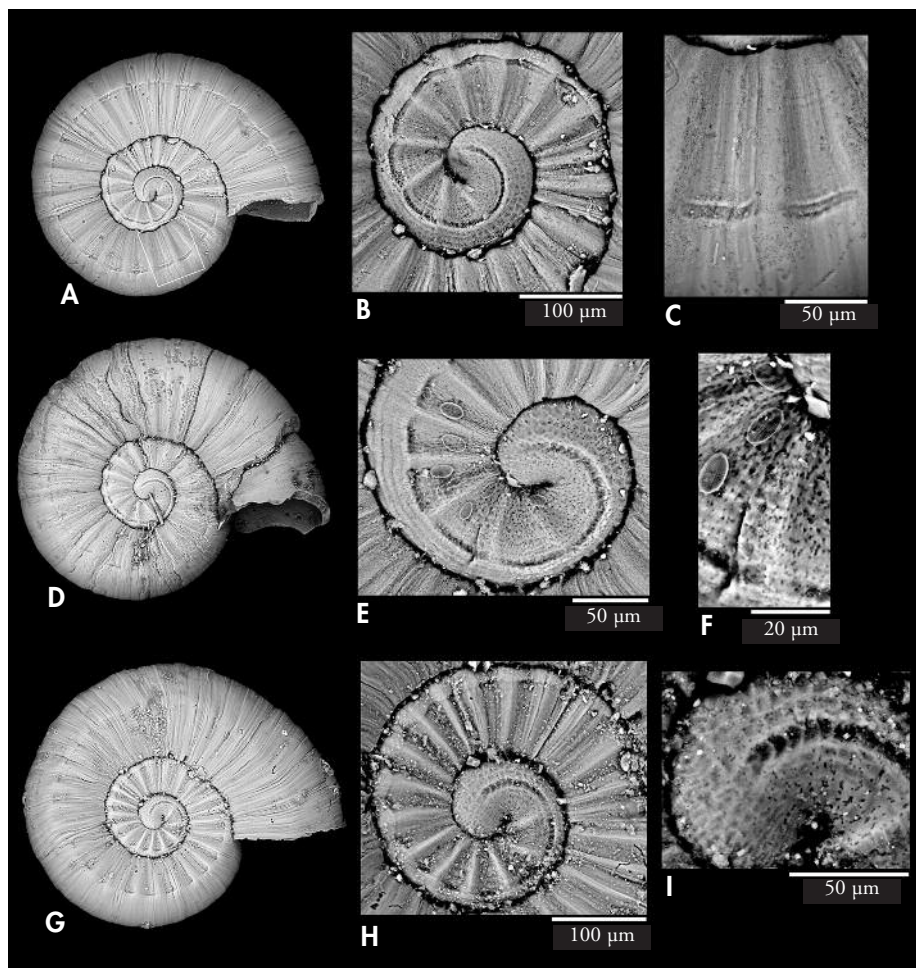


Figure 6. *Ammonicerata rota* (Forbes & Hanley, 1850). A-C. Anse de Bertheaume, Brittany (MNHN). A: shell, apical view, 0.79 mm; B: protoconch; C: detail of the microsculpture. D-F. Carnota (A Coruña) (MHNS). D: shell, 0.75 mm; E: protoconch of another shell; F: detail of a scar in the protoconch-teleoconch transition zone. G-I. Ceuta (CJDO-JT/MNCN). G: shell, 0.89 mm; H: protoconch-teleoconch transition zone; I: detail of the microsculpture of the protoconch.

Figura 6. *Ammonicerata rota* (Forbes & Hanley, 1850). A-C. Anse de Bertheaume, Bretaña (MNHN). A: concha, vista apical, 0,79 mm; B: protoconcha; C: detalle de la microescultura. D-F. Carnota (A Coruña) (MHNS). D: concha, 0,75 mm; E: protoconcha de otro ejemplar; F: detalle de una cicatriz en la transición protoconcha-teleoconcha. G-I. Ceuta (CJDO-JT/MNCN). G: concha, 0,89 mm; H: zona de transición protoconcha-teleoconcha; I: detalle de la microescultura de la protoconcha.

specimens show a faint scar between 0.6 and 0.75 whorl. With 0.6 whorl (Carnota, Galicia, Fig. 6E), diameter is 140 µm; with 0.75 whorl (Brittany, Fig. 6B), diameter is 175 µm. The first clear scar can be seen between 1 and 1.5 whorls and the diame-

ter is then between 200 and 250 µm (Figs. 6B, 6H, 7E, 7G, 7I). Until this scar, the surface has a granular appearance and may have 8-12 radial ribs (Figs. 7E and 7I).

The protoconch presents a single groove, micropartitioned interiorly (Fig.

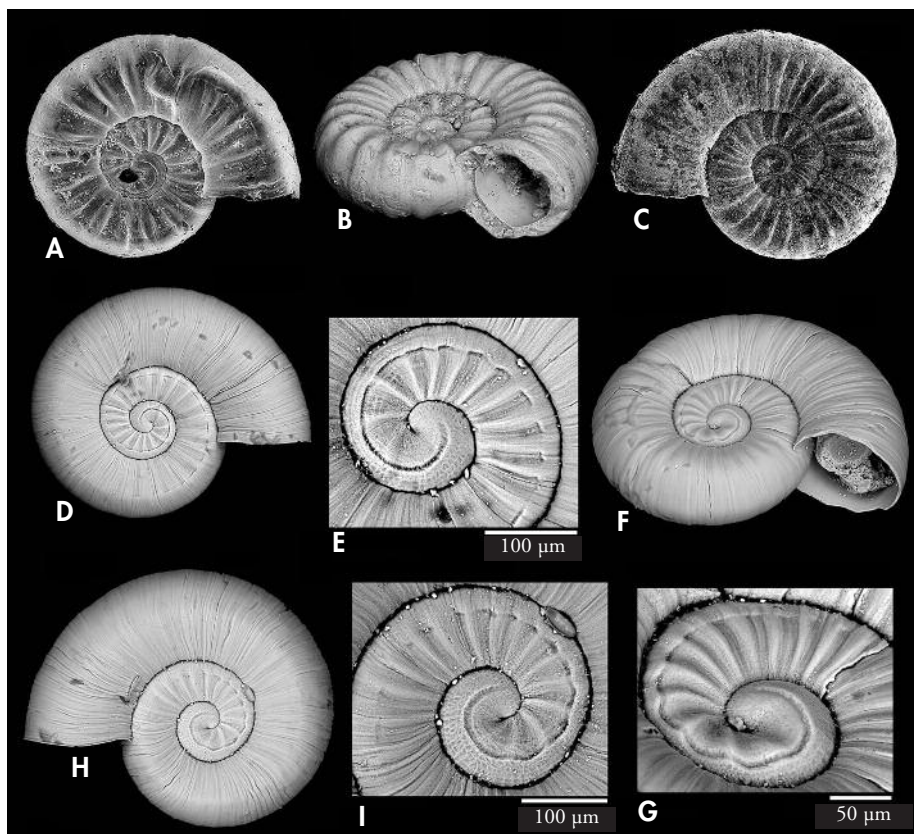


Figure 7. *Ammonicera rota* (Forbes & Hanley, 1850). A. Sesimbra (Portugal), shell, 0.70 mm (CFP). B, C. Vigo. B: lateral view, 0.65 mm (MHNS); C: shell, abapical view, 0.84 mm (MHNS). D-I. Barbate (MNHN). D: shell, apical view, 0.87 mm; E: protoconch-teleoconch transition zone; F: shell, lateral view, 0.61 mm; G: protoconch-teleoconch transition zone; H: shell, abapical view, 0.69 mm; I: transition area of protoconch-teleoconch.

Figura 7. *Ammonicera rota* (Forbes & Hanley, 1850). A. Sesimbra (Portugal), concha, 0,70 mm (CFP). B, C. Vigo. B: vista lateral, 0,65 mm (MHNS); C: concha, vista abapical, 0,84 mm (MHNS). D-I. Barbate (MNHN). D: concha, vista apical, 0,87 mm; E: zona de transición protoconcha-teleoconcha; F: concha, vista lateral, 0,61 mm; G: zona de transición protoconcha-teleoconcha; H: concha, vista abapical, 0,69 mm; I: zona de transición protoconcha-teleoconcha.

6I), which originates practically in the middle of the nucleus, runs near the suture, and is subsequently continued on the teleoconch as a sulcus demarcating the apical area from the peripheral band. The groove can be concealed by the following whorl before reaching the first clear scar (Fig. 6B). When the groove is not covered by the next whorl, the peripheral cord remains visible and is delimited by a weak, discontinuous

spiral sulcus which tends to disappear at the level of this first scar (Figs. 7E, 7I).

The protoconch surface is irregular, riddled with irregular micropits, which are larger above the groove. This microsculpture can be observed even after the emergence of the first ribs, which seems to indicate that some of these would belong to the protoconch rather than to the teleoconch (Figs. 6E, 7E). After the initial nucleus of the protoconch, the space

until the appearance of the first rib (SWR) is slightly more than a quarter-whorl.

Colour: The shell is transparent, and can have a pearl white or yellowish colour with slight reddish lines on the upper and lower peripheral cords. The shells from Galicia (Vigo, Carnota, Baiona) and from Ceuta were yellowish with three reddish lines, upper, lower and peripheral. The two shells from Tarifa and Barbate are yellowish with very faint reddish lines. Shells from Brittany are transparent, pearl white in colour without red lines. FRETTER & GRAHAM (1978) mention a brown colour sometimes darker due the epiphytic growths.

Animal: Not observed. It is described by FRETTER & GRAHAM (1978) but the distribution they indicate (Azores, Arctic Canada, S Florida and Mediterranean) suggests that they are including several different species.

Habitat: Among seaweeds (*Fucus*, *Laminaria*, *Cladophora*, *Corallina*, *Ulvae*) and detritus in rock pools, low water of ordinary spring tides, and dredged to 25 m (FRETTER & GRAHAM, 1978).

Distribution: (Fig. 26A) The distribution is difficult to establish based on the citations because this species was synonymized with *A. fischeriana* by many authors: HIDALGO (1917: as *Homalogyra rota*) mentions it from Gijón down to 100 m depth, NOBRE (1940) records it in Portugal and according to FRETTER & GRAHAM (1962), it is distributed from the British Islands to Mediterranean. HØISÆTER (1968, 2009) and BACKELJAU *et al.* (1984) cite it from Norway. Probably it is an Atlantic species, which is not present in the Mediterranean except in areas close to the Strait of Gibraltar.

Remarks: *Ammonicera rota* seems to be misidentified in many of the works in which it was illustrated. FORBES & HANLEY (1850) described and illustrated *A. rota* from specimens collected in Donegal (northern part of Ireland). They indicated that their shells were pearl white, semi-transparent, or very pale waxy colour. In its description they mentioned, apart from features that are common to all the *Ammonicera*, its sculpture consisting of ribs, showing it also on the illustration. They

pointed out that the ribs start from the suture and do not reach the border of the whorl, are wider than their interspaces and just before the end of the whorls there is occasionally a spiral groove which does not cross them. JEFFREYS (1867) cited a more extensive material and incorporated in the descriptions some features which may apply to *Ammonicera fischeriana* (see below).

The first illustration of this species with scanning electron microscope was presented by RODRÍGUEZ-BABIO & THIRIOT-QUIEVREUX (1974) with specimens from Roscoff (France), identified as *Ammonicera fischeriana*, a species described by MONTEROSATO (1869) from the Mediterranean. They based their identification on a statement by NORDSIECK (1968) that *A. rota* has a flat apical side and a concave abapical side, contrary to their specimens which were amphiconcave.

FRETTER & GRAHAM (1962) indicated that only *A. rota* would be present on the British coasts, whereas HØISÆTER (1968) treated *A. rota* and *A. fischeriana* as synonymous.

GAGLINI & CURINI GALLETTI (1978) photographed specimens of what they consider *A. rota* (one of them without locality data, but probably Mediterranean) and pointed out the polymorphism of this species which they considered to be different from *A. fischeriana*, also illustrated. AARTSEN, MENKHORST & GITTENBERGER (1984), in their work on the malacofauna of Algeciras, also considered *A. rota* and *A. fischeriana* as separate species, but their scanning electron micrographs show specimens from Corsica and Livorno respectively which agree morphologically with those of GAGLINI & CURINI GALLETTI (1978). The species photographed in both works is not the species presented by RODRÍGUEZ-BABIO & THIRIOT-QUIEVREUX (1974) and therefore, in our opinion, is not the true *A. rota*. This error of identification has persisted in later works of PALAZZI (1988), OLIVER BALDOVÍ (2007) and OLIVER, TEMPLADO & KERSTING (2012), in which the species there considered as *A. rota* is here considered as different and will receive the name of *A. nodulosa* spec. nov. (see below).

As mentioned above *A. rota* shows some variability in the sculpture regarding the presence and thickness of the ribs. The shells more similar to the original description (and which coincide largely with the species photographed by Rodríguez Babío and Thiriot-Quievreux) are from Brittany, Vigo and Sesimbra. In contrast, those from the Strait of Gibraltar presented a definitely less developed sculpture which, in many shells, is limited to the juvenile stage, the last whorl becoming com-

pletely smooth. There are intermediate shells which, in addition to the similarity of the protoconchs, suggest intraspecific variability rather than the existence of cryptic species.

Similar species: The protoconch, with a single narrow groove and the short area from the nucleus to the first rib (SWR) allows to clearly distinguish it from the rest of *Ammonicera* except *A. columbretensis* spec. nov. Their differences will be discussed below with the description of the latter species.

***Ammonicera columbretensis* spec. nov.** (Figures 4B-C, 8A-H, 9A-D, 26D)

Ammonicera sp. 2: Oliver, Templado & Kersting (2012: 75, fig. 84-85).

Type material: Holotype in MNCN (catalogue number 15.05/60142H) (Fig. 8F). Paratypes in MNCN (15.05/60142P, 8 s); MNHN (IM-2012-36205, 2 s); MHNS (100699, 1 s).

Other material examined: (31 s): Eastern Spain: Islas Columbretes: 9 s, E side of Fidalgo Bank, 40 m (CJDO-JT/MNCN); 19 s, La Ferrera (39°53.3'N, 00°40.5'E, 22 m) (CJDO-JT/MNCN). Southern France: 3 s, Marseille, Grand Congloue, beneath submarine cliff (43°10.6'N, 05°24.2'E, 33 m) (MNHN).

Type locality: Columbretes Islands, Castellón; E side of the Fidalgo Bank (39°52.1'N, 00°40.0'E, 40 m, sample 277B1 from Fauna IV campaign).

Etymology: The name was after the Islands where the species was first found.

Description: The shell is planispiral amphiconcave, reaching 0.85 mm in diameter with 2.7 whorls.

Both the adapical and the abapical areas are delimited by a groove from a wide peripheral band which extends from the upper to the lower cords. The ribs, somewhat narrower than their interspaces, are most elevated between the suture and the groove (Figs. 7G, 8H), becoming flattened where they meet the peripheral cord. Therefore, the ribs do not protrude on the outline of the shell in apical view. There are no obvious differences between apical and abapical views. In profile view, the shell has a wavy outline on both the upper or lower parts.

Protoconch and transition zone: It is impossible to pinpoint the transition from protoconch to teleoconch. A faint scar may occur between 0.8 and 0.9 whorl. In a shell from Columbretes, it appears at 0.9 whorl with 200 μ m in diameter, while in a shell from Marseille, it appears around 0.8 whorl with 210 μ m. Between 1.2-1.5 whorls (with 230-

270 μ m in diameter), the first scar supposedly from the teleoconch appears.

The protoconch presents a single groove, micropartitioned interiorly (Fig. 8B, D, E), which originates in the central area, at some distance from the beginning of the nucleus and progressively approaches the suture. The first ribs are clearly narrower than their interspace. Between the protoconch scar and the first scar of the teleoconch there are about six more ribs.

The initial part (nucleus and SWR) of the protoconch surface is rough, with small irregular pits. This sculpture is maintained after the emergence of the first ribs. After the nucleus, the space without ribs (SWR) is a little more than one quarter of whorl. The peripheral band in the beginning of the teleoconch is mostly concealed by the following whorl but, when apparent, is demarcated by a subsutural groove which overrides the ribs.

Colour: The shells (Figs. 4B-C) are uniform reddish brown, except around the peristome which is whitish.

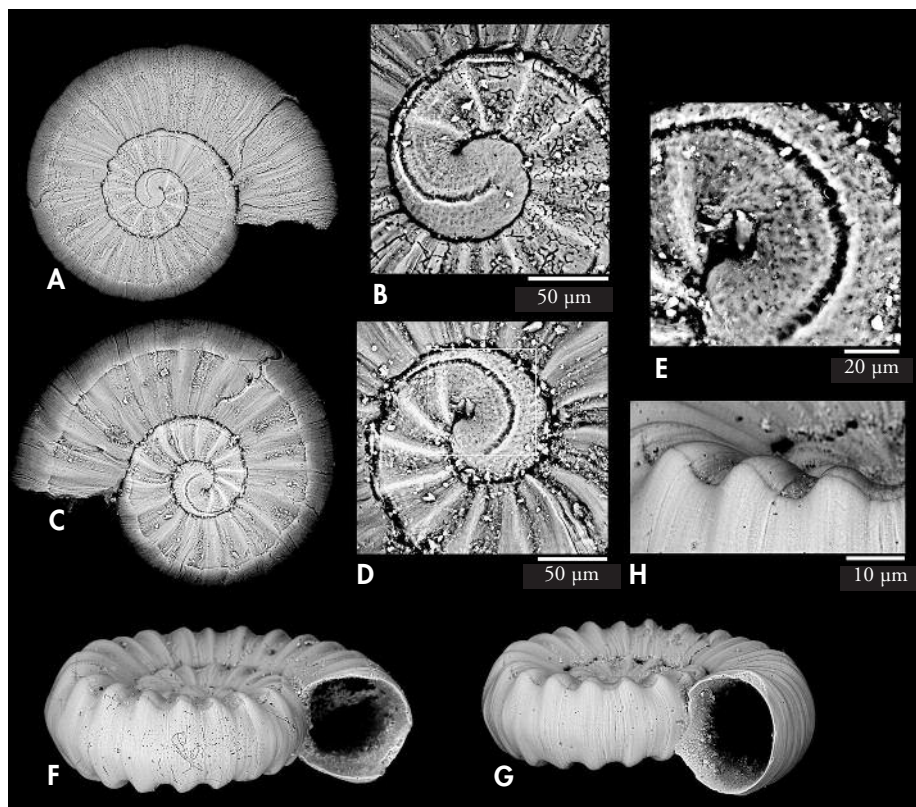


Figure 8. *Ammonicera columbretensis* spec. nov., Columbretes Islands. A, B: shell, 0.85 mm and its protoconch-teleoconch transition area (CJDO-JT/MNCN); C-E: shell, 0.62 mm, and its protoconch-teleoconch transition area, with a detail of the microsculpture of this area (CJDO-JT/MNCN); F: profile view of the holotype, 0.69 mm (MNCN); G: shell in lateral view, 0.79 mm; H: detail of its microsculpture (CJDO-JT/MNCN).

Figura 8. Ammonicera columbretensis spec. nov., islas Columbretes. A, B: concha 0,85 mm y zona de transición protoconcha-teleoconcha (CJDO-JT/MNCN); C-E: concha, 0,62 mm, zona de transición protoconcha-teleoconcha y detalle de la microescultura de dicha zona (CJDO-JT/MNCN); F: vista de perfil del holotipo, 0,69 mm (MNCN); G: concha en vista lateral, 0,79 mm; H: detalle de su microescultura (CJDO-JT/MNCN).

Habitat: The studied shells were located on detrital sediments collected by scuba diving in 33-40 m depth.

Distribution: This species was collected only in Columbretes Islands and in Marseille, France (Fig. 26D).

Remarks: The most similar species to *Ammonicera columbretensis* spec. nov. is *A. rota*. Regardless of the variability of *A. rota*, *A. columbretensis* has enough important characters for being considered a distinct species:

- In both species, a scar appears around 0.8-0.9 whorls (Figs. 7G, 7I and 8B, 8D), but *A. rota* has also a faint but visible scar between 0.6 and 0.75 whorls (Figs. 6B, 6E) and this was not seen in the shells of *A. columbretensis*.

- The profile of the spire, and the aperture of the shell of *A. rota* are also more rounded than in *A. columbretensis* which has a tendency to be somewhat angled (Figs. 7F and 8F may be compared).

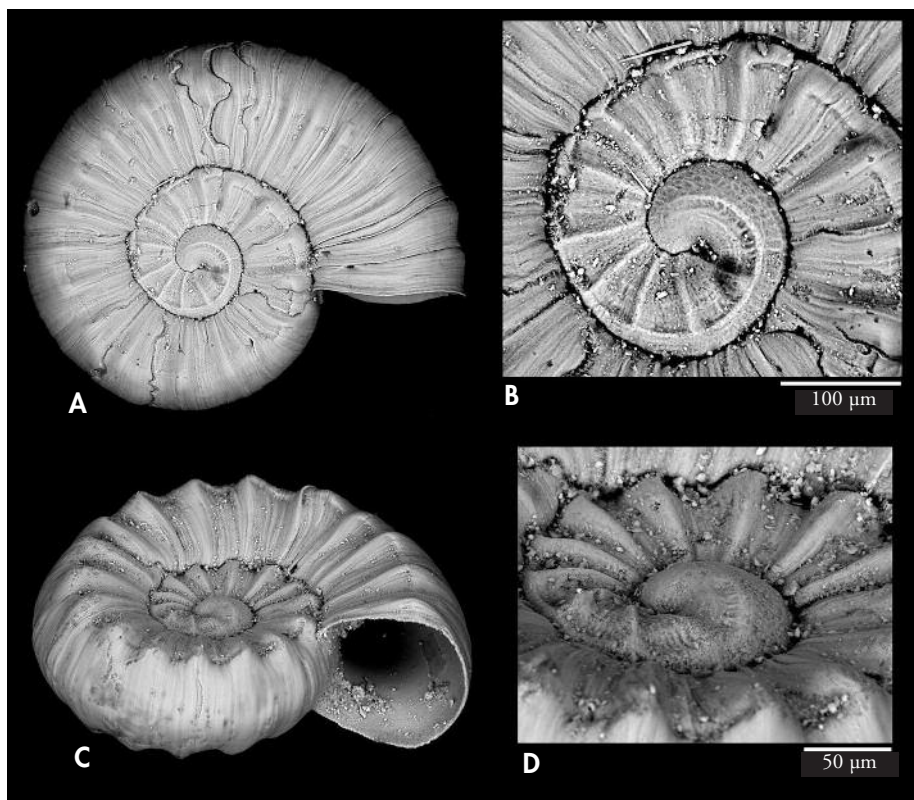


Figure 9. *Ammonicera columbretensis* spec. nov., Grand Congloue, Marseille. A, B: shell, 0.79 mm and its protoconch-teleoconch transition area (MNHN); C, D: shell, 0.67 mm lateral view and its protoconch-teleoconch transition area (MNHN).

Figura 9. *Ammonicera columbretensis* spec. nov., Grand Congloue, Marsella. A, B: concha, 0,79 mm y zona de transición protoconcha-teleoconcha (MNHN); C, D: concha, 0,67 mm, vista lateral y zona de transición protoconcha-teleoconcha (MNHN).

- Adapical and abapical areas are proportionally narrower in *A. rota* than in *A. columbretensis*.

Furthermore, the groove that separates the peripheral band from the apical and abapical areas is deeper in *A. rota* although it is quite discontinuous in many shells because it is not present over all the ribs, while in the shells of *A. columbretensis* this groove is usually continuous.

The ribs of *A. rota* are less voluminous than those of *A. columbretensis*. In many shells of *A. rota* the ribs are restricted to the juvenile part and the rest tends to be smooth, while in *A.*

columbretensis they are present on all the shell.

Ammonicera rota has a pearly yellowish colour with more or less evident reddish lines, while *A. columbretensis* (included the shell of Marseille) is reddish brown with the aperture whitish. This character is the most obvious for the separation of both species.

Under the stereomicroscope, *A. columbretensis* can also be confused with *A. superstriata* described in the present work (see below) which has also the same brown colour, but the sculpture is thoroughly different.

Ammonicera fischeriana (Monterosato, 1869)

Homalogyra fischeriana Monterosato, 1869. *J. Conchyl.*, 17 (3): 274, pl. 12, fig. 1. [Type locality: Ognina, Catania, Sicilia].

Type material: Supposedly in the Monterosato collection in Museo Civico di Zoologia, Roma. So far, author's specimens from Lipari island (Sicily) and Ulbo island (Croatia) could be located, but not the type specimens from Ognina (Sicily) (pers. comm., Massimo Appolloni, Museo Civico di Zoología)

Original description (MONTEROSATO, 1869): "*Testa minima, discoidea, planorbiformis, utrinque parum concava, regularis, translucida, striis incrementi obsoletis munita, albida, zonis 3 (1 supera, 1 media, 1 infera) fulvis, aequidistantibus cingulata; anfr. 4 regularites involuti, ultimus rotundatus; apertura circularis; peristoma implex, non reflexum nec incrassatum. Dia, maj. 1 mill.*"

In this study based only on conchological characters, it has not been possible to determine with absolute certainty

whether *Ammonicera fischeriana* is a single, very variable species or a group of cryptic species. Being as conservative as possible, we have kept these forms in the same taxon of *A. fischeriana*, but could distinguish several morphological types:

- A typical form, being the most common and widespread in the Mediterranean;
- Intermediate and smooth forms;
- A spirally striated form, more widespread in the Atlantic.

Mediterranean form of *A. fischeriana* (Figures 4D-E, 10A-H, 11A-O, 12A-H, 15A-D, 16A-D, 26B)

Material examined: (+731 s and spms): Eastern Spain: Columbretes Islands: 5 s, Isla Grande (39°53.8'N, 00°41.1'E, 44 m, FAUNA IV, 277B1) (MNCN, 1505/54511); 8 s, East side of Fidalgo Bank (39°52.1'N, 00°40.0'E, 40 m, FAUNA IV, 277B), (MNCN, 1505/54512); 14 s, (MNCN); 52 s + 10 s (smooth form), detritic sediment from several places: Puerto Tofiño (39°54.7'N, 00°41.3'E, 16 m) (CJDO-JT/MNCN); Escalera de España (39°53.7'N, 00°41.0'E, 32-36 m) (CJDO-JT/MNCN); El Carallot (39°51.0'N, 00°40.8'E, 17 m (CJDO-JT/MNCN); La Ferrera (39°53.3'N, 00°40.5'E, 22 m) (CJDO-JT/MNCN); La Foradada (39°52.5'N, 00°40.5'E, 22 m (CJDO-JT/MNCN). Valencia: 5 s, Oliva (38°55.3'N, 00°04.4'W, beach sediment) (CJDO-JT/MNCN); 13 s, Cullera (39°10.9'N, 00°12.9'W, 0-10 m) (CJDO-JT/MNCN). Alicante: 14 s, Portitxol, Jávea (38°45.6'N, 00°13.1'E, 3 m) (CJDO-JT/MNCN); 11 s, Denia (38°49.5'N, 00°10.0'E, 0-5 m) (CJDO-JT/MNCN). Murcia: 1 s, Mar Menor (37°45.6'N, 0°44.7'W, beach sediment) (CJDO-JT/MNCN); 2 s, Hormigas islands (37°39.4'N, 00°38.9'W, 22 m) (CJDO-JT/MNCN); Balears: Mallorca: 1 s, Pollença (39°56.1'N, 3°11.9'E, 32 m, FAUNA III 190B8) (MNCN 1505/27559); 1 s, Punta Foradada (39°45.1'N, 2°37.1'E, 27 m, FAUNA III 185B2) (MNCN 1505/27636); 15 s, Cabo Pinar (39°53.0'N, 3°11.8'E, 23 m, FAUNA III 191B1) (CJDO-JT/MNCN). Menorca: 20 s, Cap de Cavallería (40°04.9'N, 4°05.8'E, 20-25 m) (CJDO-JT/MNCN); 125 s and spms, Punta na Gal (39°55.9'N, 3°55.9'E, 14 m) (typical form) and 5 s (smooth form) (CJDO-JT/MNCN). Ibiza: 1 s, Bleda Mayor (38°58.3'N, 01°09.9'E, 45 m, FAUNA III 258B1) (CJDO-JT/MNCN); 120 s and 6 s (smooth form), Punta Galera, Isla Espardel (38°47.7', 01°28.3'E, 35 m FAUNA III 240B4) (CJDO-JT/MNCN); 5 s, west Islets (39°02.3', 01°38.7'E, 40 m FAUNA III 236B) (CJDO-JT/MNCN). Southeastern Spain: 17 s, Los Escullos, Almería (36°47.8'N, 02°03.6'W) (MNHN); 5 s, Playa de los Genoveses, Almería, Posidonia meadow (36°44.6'N, 02°06.8'W, 5 m) (MNHN); 1 s, Rodalquilar, Almería, algal wash (36°51.5'N, 02°00.2'W, 0-1 m) (MNHN); 23 s, Punta de la Mona, Almuñecar, Granada (36°43.4'N, 03°44.3'W, 15-27 m) (CJDO-JT/MNCN); 2 s, Benalmádena costa, Málaga (36°35.3'N, 04°31.7'W) (MNHN). Strait of Gibraltar: 1 s, Getares (CJDO-JT/MNCN); 1 s, Benzú, Ceuta (10-20 m) (CJDO-JT/MNCN); 40 s, Tarifa (MHNs). Southern France: 4 s, Carnon, shell-grit on the beach (43°32.6'N, 03°59.0'E) (MNHN); 1 s, La Grand Motte, shell-grit on the beach (43°33.3'N, 04°05.3'E) (MNHN); 18 s (typical form) + 18 s (smooth form), Marseille, Grand Congloue, beneath

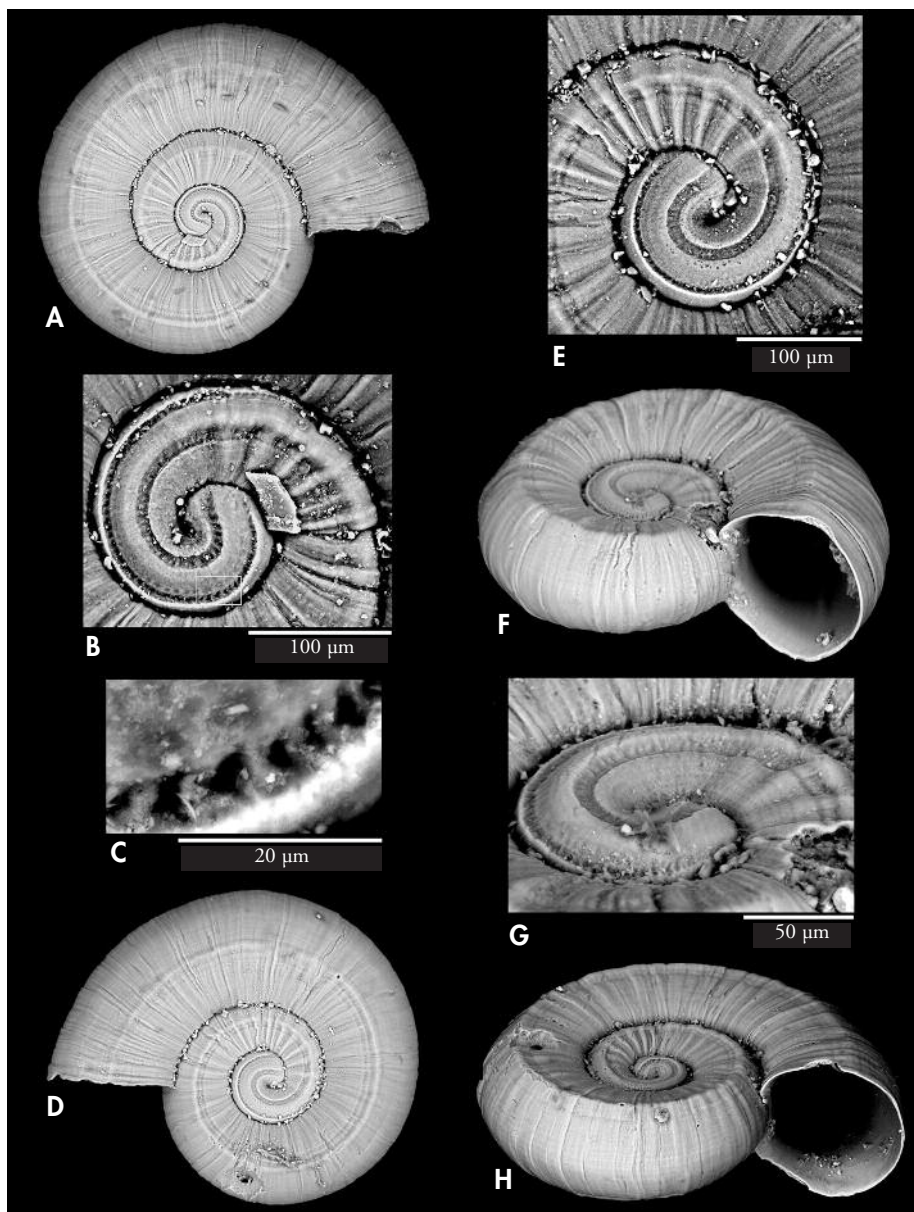


Figure 10. *Ammonicera fischeriana* (Monterosato, 1869) (Mediterranean form), Portitxol, Jávea (Alicante). A-C: shell, 0.86 mm (CJDO-JT/MNCN) apical view, protoconch and transition area of protoconch-teleoconch and detail of the inner microsculpture of the external groove; D, E: shell, 0.70 mm (CJDO-JT/MNCN) and transition area of protoconch-teleoconch; F, G: shell, 0.5 mm (CJDO-JT/MNCN) and detail of the transition area of protoconch-teleoconch. H: shell, 0.7 mm (CJDO-JT/MNCN).

Figura 10. Ammonicera fischeriana (Monterosato, 1869) (forma mediterránea), Portitxol, Jávea (Alicante). A-C: concha, 0,86 mm (CJDO-JT/MNCN), vista apical, protoconcha e inicio de la teleoconcha y detalle de la microescultura interna del surco externo; D, E: concha, 0,70 mm (CJDO-JT/MNCN) y zona de transición protoconcha-teleoconcha; F, G: concha, 0,5 mm (CJDO-JT/MNCN) y detalle de la zona de transición protoconcha-teleoconcha. H: concha, 0,7 mm (CJDO-JT/MNCN).

submarine cliff (43°10.6'N, 05°24.2'E, 33 m) (MNHN); 8 s, Cap Morgiou, calanque de la Triperie, sand in a cave (43°12.2'N, 05°26.9'E, 22 m) (MNHN); 9 s, Les Embiez, Plage des Salins, rocky place (43°04.9'N, 05°47.0'E, 0-1 m) (MNHN); 20 s (typical form) + 1 s (intermediate form) + 1 s (abnormal form), Les Embiez passe du Gaou, rocky place, photophilous algae (43°04.3'N, 05°47.2'E, 0-3 m) (MNHN); 31 s, typical form + 2 s, smooth form, Les Embiez, north coast and Petit Rouveau, rocky place with photophilous algae (43°05.0'N, 05°46.7'E, 0-1 m) (MNHN); 3 s, Porquerolles, Plage Notre Dame, rocky place (43°00.6'N, 06°13.8'E, 0-1 m) (MNHN); 7 s, Le Dramont, beneath submarine cliff (43°24.7'N, 06°51.7'E, 22-30 m) (MNHN); 1 s, Le Brus, Plage du Cros, rocky place (43°05.1'N, 05°48.3'E, 0-1 m) (MNHN); 59 s, Le Lavandou, Plage St. Clair, infralittoral rocks (43°08.2'N, 06°23.1'E, 0-1 m) (MNHN). Cyprus: 1 s, Ayia Napa (CFS). Malta: 18 s, Gawia Point, 1-3 m (CFS); 1 s, Gacoca Point (CFS). Italy: 3 s, Sestri Levante (CFS); 1 s, Taranto (CFS).

Description: We have considered as a typical form of *A. fischeriana* that one which best agrees with Monterosato's description, and in our study has proven to be the most common and abundant. Our description is based on shells from Portitxol (Jávea, Alicante, SE Spain) (Fig. 10A-H). We here provide several illustrations of shells from other localities (Fig. 11A-O) to record features which vary between populations and those that remain constant. Moreover we considered appropriate to highlight differences between Mediterranean and Atlantic forms which can be found together in some localities in the Strait of Gibraltar.

The shell is planispiral, amphiconcave, reaching 0.85 mm in diameter with almost 2.6 whorls.

The peripheral band is generally, but not always, clearly demarcated from adapical and abapical area (Figs. 10F, 10H, 11C, 11F, 11H-I); usually it is weak and limited to juvenile shells. Apically, on the position of the upper cord, there

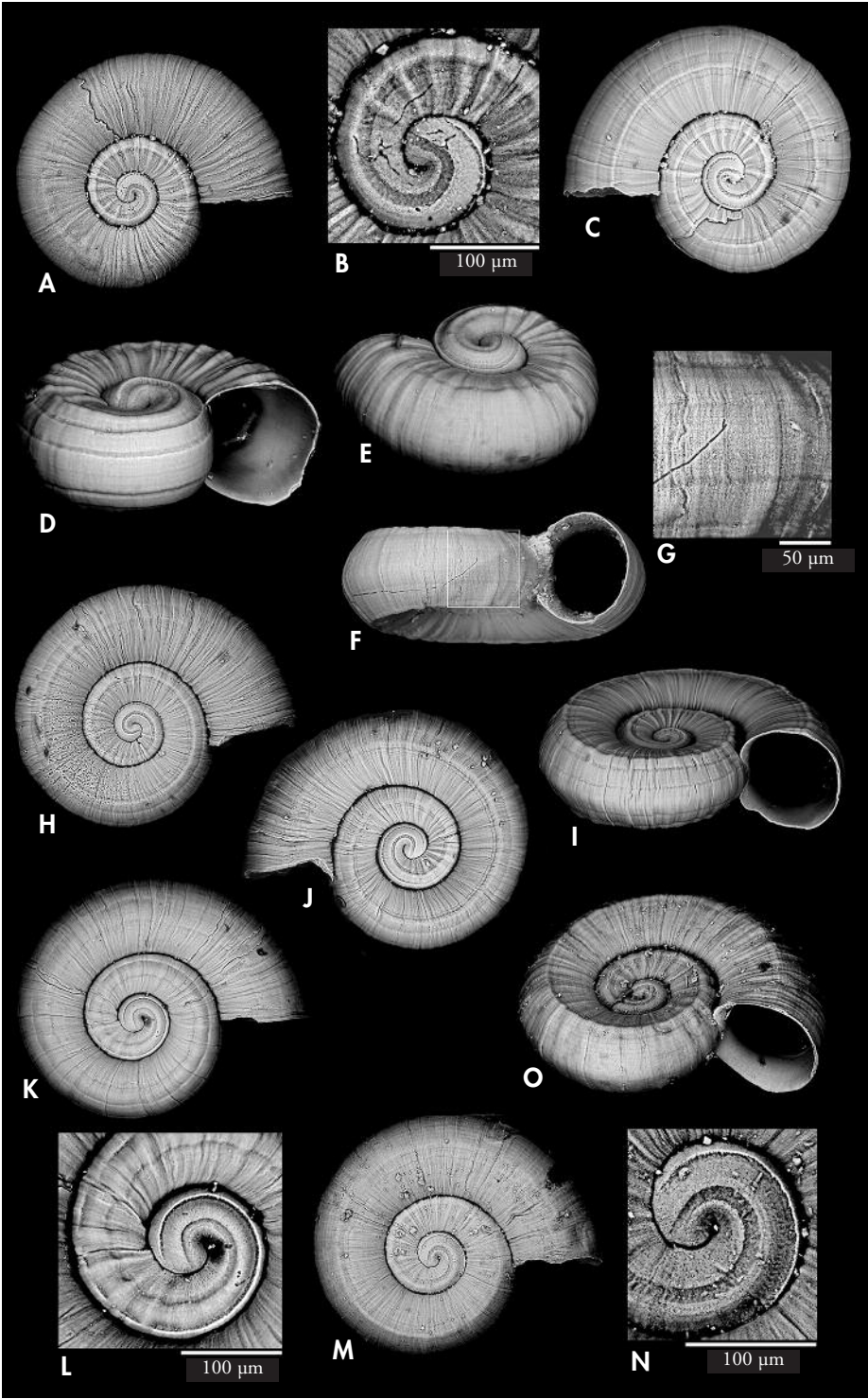
is usually an inconspicuous keel, narrower than the cord and fading out as the shell grows. This keel is separated from the apical area by a shallow groove within which a faint spiral cord may be seen (Fig. 10E, lower left). From the upper keel to the suture the profile of the shell is fairly flat in the juvenile shell but it becomes increasingly convex as the shell grows.

The axial sculpture is formed by weak ribs, a little narrower than their interspaces, most evident on the first half of the teleoconch. The ribs rise and form irregular and inconspicuous nodules at their intersection with the upper keel. Both the ribs and the nodules tend to disappear as the shell grows. With the SEM, growth lines can be seen over all the shell (Fig. 10H).

There is usually no clear peripheral keel, although in some juvenile shells it can be hinted. The peripheral area also lacks definite ribs crossing axially the shell, and those are limited to wrinkles, most notable in the juvenile shell and vir-

(Right page) Figure 11. *Ammonicera fischeriana* (Mediterranean form). A-C. Menorca (CJDO-JT/MNCN). A: shell, 0.75 mm, in apical view; B: transition area protoconch-teleoconch; C: shell, 0.65 mm, abapical view. D, E. Ibiza (CJDO-JT/MNCN), juvenile shells, 0.34 mm and 0.38 mm. F, G. Columbretes (CJDO-JT/MNCN), shell, 0.71 mm and detail of the microsculpture. H-J. Cullera (CJDO-JT/MNCN), shells, 0.87 mm, 0.63 mm and 0.79 mm. K, L. Marseille (MNHN), shell, 0.88 mm, apical view, and transition area protoconch-teleoconch. M-O. Tarifa (Cádiz) (MHNS). M, N: shell, 0.76 mm and protoconch; O: shell, 0.66 mm.

(Página derecha) Figura 11. *Ammonicera fischeriana* (forma mediterránea). A-C. Menorca (CJDO-JT/MNCN). A: concha, 0,75 mm, en vista apical; B: zona de transición protoconcha-teleoconcha; C: concha, 0,65 mm, vista abapical. D, E. Ibiza (CJDO-JT/MNCN), conchas juveniles, 0,34 mm y 0,38 mm. F, G. Columbretes (CJDO-JT/MNCN), concha, 0,71 mm y detalle de la microescultura. H-J. Cullera (CJDO-JT/MNCN), conchas, 0,87 mm, 0,63 mm y 0,79 mm. K, L. Marseille (MNHN), concha, 0,88 mm, vista apical y zona de transición area protoconcha-teleoconcha. M-O. Tarifa (Cádiz) (MHNS). M, N: concha, 0,76 mm y protoconcha; O: concha, 0,66 mm.



tually non-existent in the adult shells. In some shells, weak longitudinal cords can be seen, especially along the keels (Figs. 11C, 11F-H). The aperture of the shell is circular in adult shells but, in the juveniles, may be somewhat angular in the position of the keels. Abapically the shell is similar in aspect to the apical view.

Protoconch and transition zone: The transition from the protoconch to the teleoconch is not at all evident and therefore is very difficult to be interpreted and measured. On the other hand, after the nucleus, there is clearly and constantly a section (SWR) of $\frac{3}{4}$ of whorl in which there are no axial ribs (Figs. 10B, 10E, 11B, 11N). The most evident scar that appears in all the shells is usually between 1 and 1.2 whorls with a diameter of 210 μm , but before this scar may be other scars, very weak in some shells but more marked in others (Fig. 3E). The first scar usually appears around 0.75 whorl and often before the beginning of the ribs. The following one usually appears around 0.85 whorl with a diameter of 155 μm (the nucleus being ca. 60 μm). Between these two scars, ribs are already developed, but the texture of the protoconch seems to persist.

The study in lateral view of juveniles in which the adult shell has not covered completely the protoconch (Figs. 11D, 15A-B) suggests that the first scar, around 0.75 whorl, indicates the end of the protoconch. Then there is a zone of transition of less than a quarter whorl in which the protoconch sculptural patterns are persisting, more attenuated and with those of the teleoconch taking over. After one or several more scars, the ornamentation of the teleoconch is established.

Apically on the protoconch, there are two grooves delimiting the central cord which is slightly rugose. The inner groove is clearly wider than the outer one. The external groove contains transverse lamellae that give a micropartitioned appearance (Figs. 10B, 10C, 11B, 15C). These lamellae can be seen or hinted also in the wider internal groove. We do not know if the absence or presence of these lamellae can have taxonomic value.

The width of the cord delimited by both grooves is a little more than the twice the width of the inner groove. The outer groove tends to be concealed by the growth of the shell, a little before that it reaches the first scar. When the protoconch is viewed in profile, the internal groove is higher than the external one, so that the cord forms a ramp, somewhat stepped by the presence of minor spiral striae (Figs. 3E, 10G). Under high magnification, irregularly aligned very weak incisions can be seen over the adapical area of the protoconch (Fig. 3E).

The middle or peripheral band of the protoconch is the part which is hidden by the growth of the shell and can be seen only in immature young specimens. This band shows also spiral grooves, two of which delimiting the peripheral cord which may be, or not, divided by a median groove (compare Figs. 11D and 15B).

The inner edge of the inner groove tends to disappear towards the end of the protoconch while the outer edge transforms gradually into the keel (upper or lower).

The onset of the ribs is seen towards the end of protoconch and is continued on the transition zone to the teleoconch. Usually there are five or six ribs, somewhat narrower than their interspaces, which arise from the suture and reach the upper adapical cord. Inside the internal groove may appear a cordlet that can be continued in the teleoconch (Fig. 11B). The aspect of the protoconch in abapical view is very similar to that presented in apical view (Fig. 10E).

Colour: The colour (Figs. 4D-E) of the studied shells is yellow with reddish lines on the top, bottom, and periphery.

Smooth variety of the Mediterranean form

The sculpture of the Mediterranean form of *A. fischeriana* varies considerably, the most extreme variants being virtually smooth specimens. Although we have considered them simple morphological variants we cannot be sure that they could not represent other cryptic species. To describe this variety,

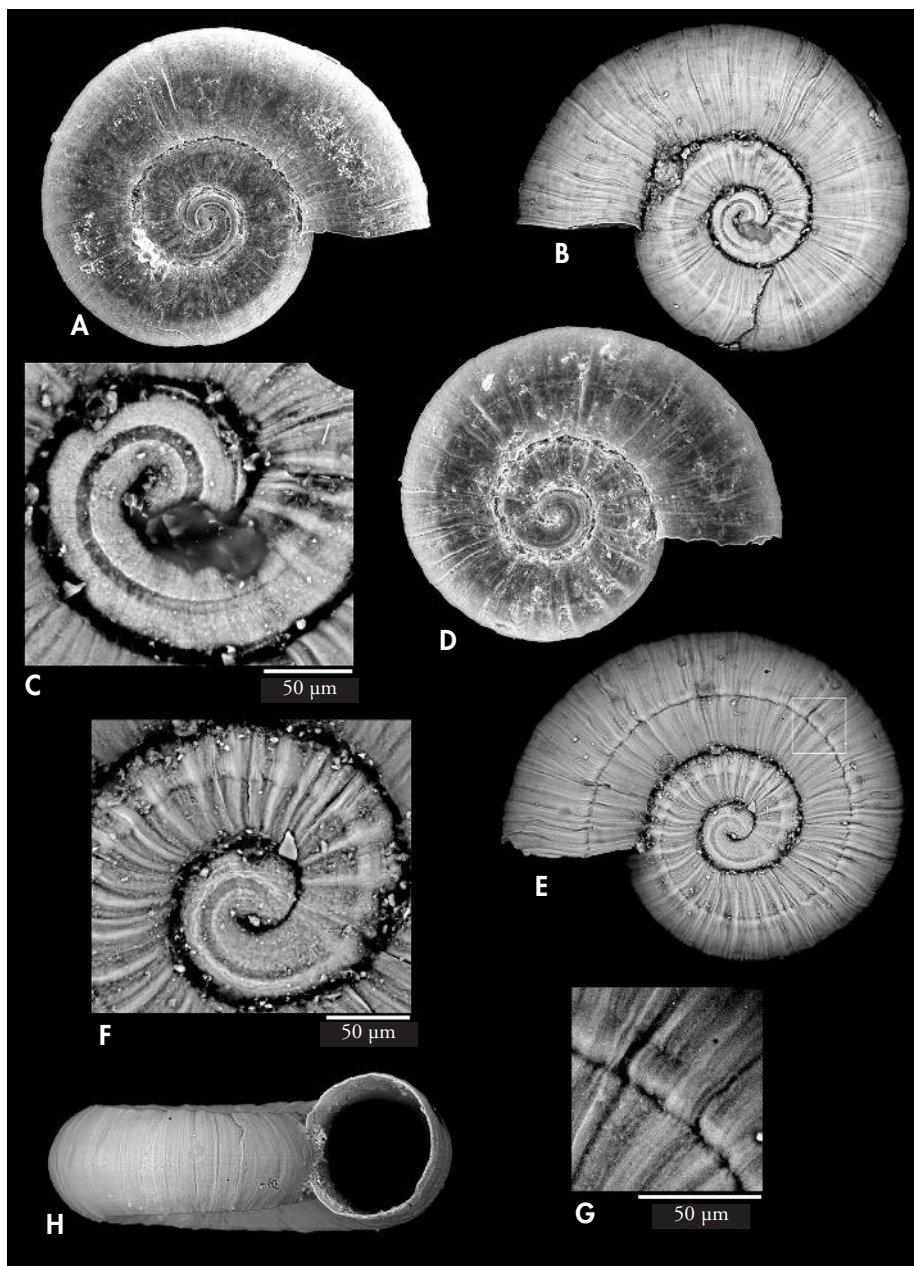


Figure 12. *Ammonicera fischeriana* (smooth variety), Columbretes Islands (CJDO-JT/MNCN). A, B: shell, 0.83 mm, apical and abapical view; C: protoconch-teleoconch transition area; D, E: shell, 0.59 mm, apical and abapical views; F: detail of its sculpture in the protoconch-teleoconch transition area; G: detail of the sculpture; H: lateral view of a shell, 0.8 mm.

Figura 12. Ammonicera fischeriana (variedad lisa), Islas Columbretes (CJDO-JT/MNCN). A-C: concha, 0,83 mm, vista apical, abapical y detalle de su zona de transición protoconcha-teleoconcha; D, E: concha 0,59 mm, vista apical y vista abapical; F: detalle escultural de la zona de transición protoconcha-teleoconcha; G: detalle de la escultura; H: vista lateral de una concha, 0,8 mm.

we have taken as reference shells from the Columbretes Islands.

The shell, with almost 2.4 whorls, may reach 0.85 mm and seems to be growing faster than other forms. In fact the outer groove tends to be quickly concealed. The peripheral band is in most cases not clearly demarcated from adapical and abapical area. The adult shells studied, viewed in profile, tend to reach more height than the other forms of *A. fischeriana*. They also have a more rounded profile of spire since adapical and abapical areas are less flat than in the typical form, something that can be seen in the aperture that is more circular (Fig. 12H).

In some shells, the upper and lower cords can be seen, above all when they are highlighted by the presence of grooves (Fig. 12G). In others, both cords and furrows are absent. Weak spiral ridges along all the teleoconch can also

be seen in some shells. In most of the studied shells, some fairly clear axial ribs can be seen in the juvenile teleoconch (Figs. 12E,F) but not in the adult.

The transition between the protoconch and the teleoconch in the smooth shells of *A. fischeriana* is also difficult to be interpreted. The first clear scar is observed around the end of the first whorl, whereas structures such as the first ribs (Fig. 12F), which will continue in the teleoconch, start to be apparent at $\frac{3}{4}$ whorl. In this area, however, the texture of the protoconch consisting of a fine grained surface with small incisions (Figs. 12C, 12F) seems to persist.

Distribution: Mediterranean Sea and the Strait of Gibraltar area (Fig. 26B). The typical form of *A. fischeriana* has been found in Cullera, Denia, Columbretes, the Balears, Cabo de Gata and Tarifa.

Atlantic form of *A. fischeriana* (Figures 4F, 13A-H, 14A-L, 15E-H, 16E-H, 17A-K, 26C)

Material examined: (+818 s and spms): Western France: Brittany: 1 s, Finistère, Le Conquet, Porsliogan, in *Corallina* (48°20.8'N, 04°46.3'W) (MNHN); 5 s, Anse de Bertheaume (48°20'N, 04°40'W, 20-30 m) (MNHN); 14 s, Ile de Sein, in rocky place, intertidal (48°02.0'N, 4°50.4'W) (MNHN). Aquitaine: 15 s, St. Jean de Luz, infralittoral rocky place (43°23.7'N, 01°39.8'W) (MNHN); +130 s, Hendaye (43°23.1'N, 01°45.2'W) (MNHN). Northern Spain: Basque country: 2 s, San Sebastián (43°19.2'N, 02°00.1'W) (MNHN); 1 s, Ondarroa, Saturrarán, infralittoral rocky place (43°19.4'N, 02°24.6'W) (MNHN). Galicia: 2 s, Baiona (MHNS); 3 s, Silleiro Cape, intertidal (42°06.4'N, 08°54.3'W) (MHNS). Portugal: 1 s, indeterminate locality (MHNS); 1 s, Sesimbra, 10-15 m (CFP). Strait of Gibraltar: 1 s, Tarifa (MHNS); 1 s, Getares (CJDO-JT/MNCN); 12 s, Tangier, shell-grit on the beach (35°46.7'N, 05°47.0'W) (MNHN); 12 s, Tangier, El Ghandouri, infralittoral rocky place (35°47.5'N, 05°46.0'W) (MNHN); 9 s, Tangier, tip of the harbour pier, infralittoral (MNHN); 7 s, Oued er Rmel, shell-grit on the beach (35°53.3'N, 05°30.0'W, now destroyed by harbour construction) (MNHN); 5 s, M'diq, washing *Halopteris* algae (35°41.1'N, 05°19.0'W) (MNHN); 43 s, Ceuta, in the harbour (35°53.6'N, 05°19'W) (MNHN); 2 s, Ceuta, beach inside the harbour (MNHN); 4 s, Ceuta, Tarajal, infralittoral rocky place (35°51.3'N, 05°20.5'W) (MNHN); + 300 s, 2 s, (intermediate form), Barbate, infralittoral blocks (36°11.0'N, 05°56.9'W) (MNHN); 11 s, Chiclana de la Frontera, in rock pool (36°22.2'N, 06°11.3'W) (MNHN); 32 s, Tarifa, Torre de la Peña (36°03.3'N, 05°39.8'W) (MNHN); 6 s, Conil de la Frontera, (36°17.6'N, 06°07.0'W) (MNHN); 12 s, Getares, Punta Carnero, shell-grit on the beach (36°05.0'N, 05°25.4'W) (MNHN). Islas Chafarinas: 150 s (sculptured), 9 s (smooth) and 3 s (intermediate form) Isabel II Island (35°10.1'N, 02°25.6'W, 14 m) (CJDO-JT/MNCN). Western Morocco: 1 s, Essaouira, rocky platform, intertidal (31°30.6'N, 09°46.5'W) (MNHN); 4 s, Temara, Sables d'Or Beach (33°55.3'N, 0°58.0'W) (MNHN); 13 s, El Jadida, rocky platform, intertidal (33°15.1'N, 08°29'W) (MNHN); 4 s, Asilah, washing *Ulvae* (35°28.8' N, 06°01.6'W) (MNHN).

Description: Our description is based on shells from the Basque coast (Hendaye, SW France). The shell reaches 0.79 mm with 2.4 whorls.

The peripheral band is usually clearly demarcated from adapical and abapical area, with upper and lower cords delimited by grooves. This general pattern

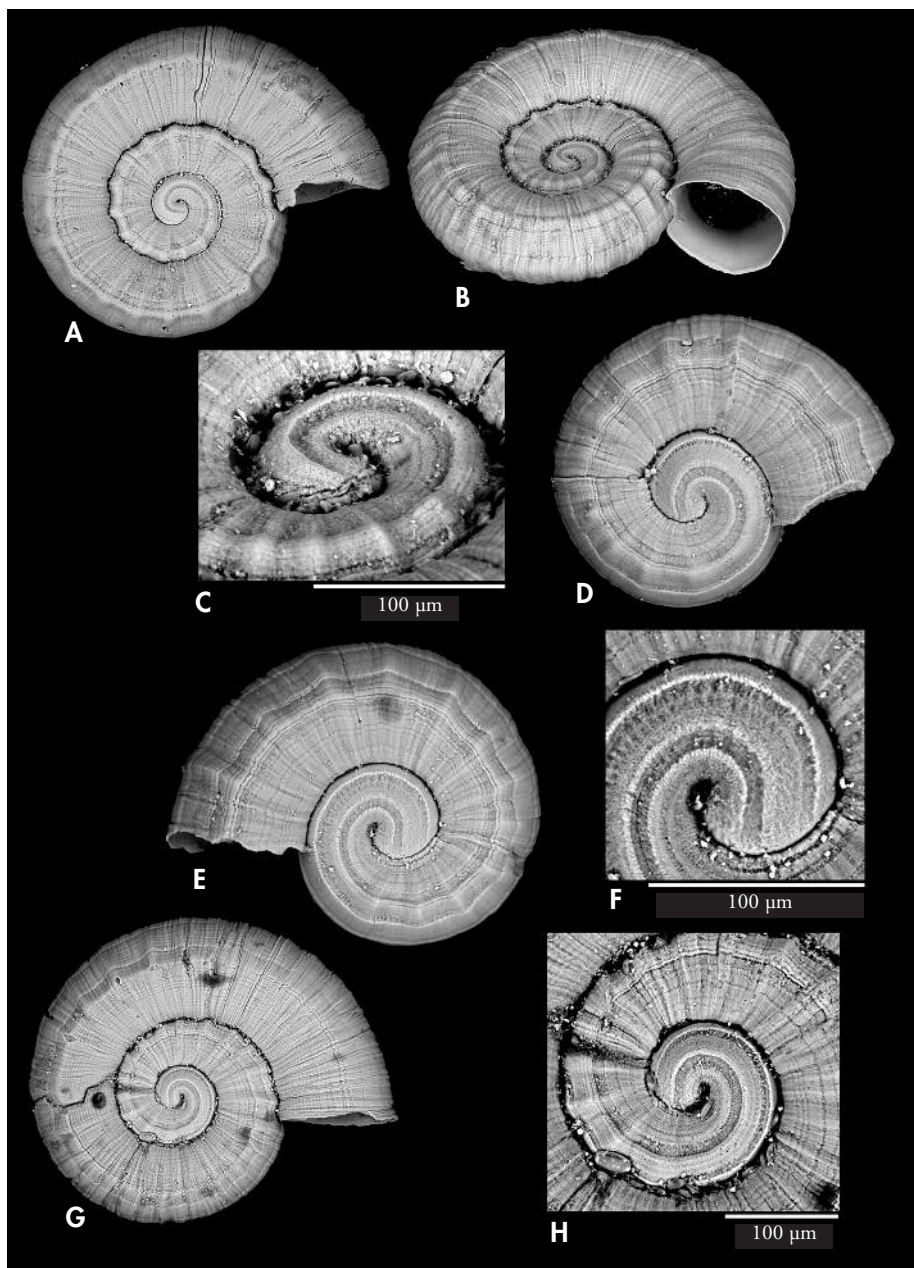


Figure 13. *Ammonicera fischeriana* (Atlantic form). A. Brittany, shell, 0.81 mm (MNHN). B-H. Hendaye (MNHN). B, C: shell, 0.79 mm and area of transition protoconch-teleoconch (MNHN); D: juvenile shell, 0.35 mm; E, F: shell in abapical view, 0.38 mm and its transition area of protoconch-teleoconch; G, H: shell, 0.73 mm and transition area of protoconch-teleoconch.

Figura 13. Ammonicera fischeriana (forma atlántica). A. Bretaña, concha, 0,81 mm (MNHN). B-H. Hendaya (MNHN). B, C: concha, 0,79 mm y zona de transición protoconcha-teleoconcha (MNHN); D: concha juvenil, 0,35 mm; E, F: concha en vista abapical, 0,38 mm y de su zona de transición protoconcha-teleoconcha; G, H: concha, 0,73 mm y zona de transición protoconcha-teleoconcha.

is overlain by a delicate spiral microsculpture over the entire surface, including the cords (Fig. 13H). This microsculpture can only be seen at higher magnifications, and if the shells are not in good condition they may appear smooth under a stereomicroscope.

There are also very weak axial ribs which, in some shells, are arranged radially over the entire surface and, when they cross the grooves and the upper or lower cords, give them a wavy appearance (Figs. 13D-E). These ribs are more obvious in the juvenile teleoconch and tend to disappear as the shell grows. The ribs are also faded on the peripheral cord and so hardly protrude on its outline.

Protoconch and transition zone: As always, it is difficult to interpret where the protoconch ends. The first clear scar that appears in most of the studied shells is located around one whorl, corresponding to a diameter of about 200 μm (Fig. 13H). Earlier, in most of the shells there is no apparent scar. The space from the nucleus to the first rib (SWR) is about $\frac{3}{4}$ of whorl. Only occasionally, something that can be interpreted as a faint scar appears around 0.75 whorl with 155 μm in diameter.

In apical view, the central cord of the nucleus is delimited by two grooves of unequal width, and located at distinct levels, so that it has the appearance of a ramp in lateral view (Fig. 15F). The

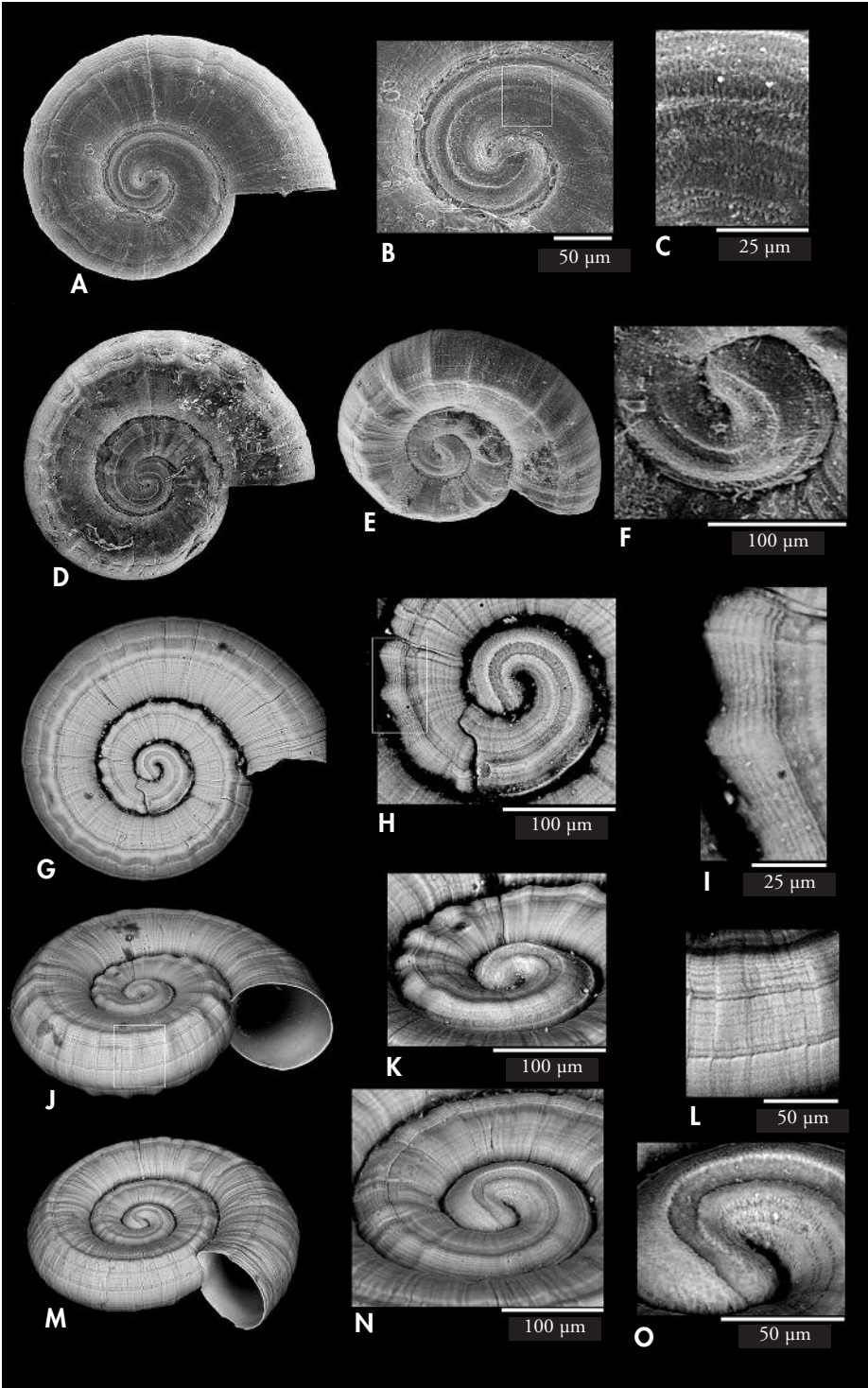
space between the two grooves presents in its beginning a finely granulated surface and later shows a spiral microsculpture (Fig. 15G). The internal spiral groove is somewhat wider than the outer one, which has internally a slight micropartition (Fig. 15H). These grooves can be extended beyond the transition zone protoconch-teleoconch although they are losing relevance.

The external groove runs parallel to the suture and, in many shells, is not concealed by the growth of the following whorl (Fig. 15G). In the upper adapical area of the protoconch, there are spirally arranged micropits which will later become microgrooves (Fig. 15G). This feature seems to be proper of the specimens which present striation on the teleoconch. There are also shells with about four or five ribs which appear more or less at the end of the first half whorl and that undulate the central cord in the transition protoconch-teleoconch zone (Figs. 15E, 15F). The sculpture persists between the end of this area and the first scar (Fig. 13H). Inside the inner groove appears a small cordlet that will persist above the upper cord also in the teleoconch (Figs. 13A, 13G).

Colour: The shells of the Iberian Atlantic are clear, almost transparent and just shows a reddish lines on the cords (Fig. 4F); those from the Moroccan Atlantic are yellowish-orange, without red lines.

(Right page) Figure 14. *Ammonicera fischeriana* (Atlantic form). A-C. Baiona, Galicia (MHNS), shell, 0.55 mm, protoconch and detail of the microsculpture of the protoconch-teleoconch transition zone. D. Santa María de Oia, Galicia, (MHNS), shell, 0.66 mm. E, F. Vigo (MHNS), shell, 0.69 mm, and protoconch-teleoconch transition zone. G-O. Barbate (MNHN). G-I: shell, 0.71 mm, protoconch-teleoconch transition zone and sculptural detail of it; J-L: shell, 0.73 mm, lateral view, protoconch-teleoconch transition zone and detail of the microsculpture of the shell; M-O: shell, 0.76 mm, protoconch-teleoconch transition zone and detail of the protoconch.

(Página derecha) Figura 14. *Ammonicera fischeriana* (forma atlántica). A-C. Baiona, Galicia (MHNS), concha, 0,55 mm, protoconcha y detalle de la microescultura de la zona de transición protoconcha-teleoconcha. D. Santa María de Oia, Galicia, (MHNS), concha, 0,66 mm. E, F. Vigo (MHNS), concha, 0,69 mm, y zona de transición protoconcha-teleoconcha. G-O. Barbate (MNHN). G-I: concha, 0,71 mm, zona de transición protoconcha-teleoconcha y detalle de microescultura de la misma; J-L: concha, 0,73 mm, vista lateral, zona de transición protoconcha-teleoconcha y detalle de microescultura de la concha; M-O: concha, 0,76 mm, zona de transición protoconcha-teleoconcha y detalle de la protoconcha.



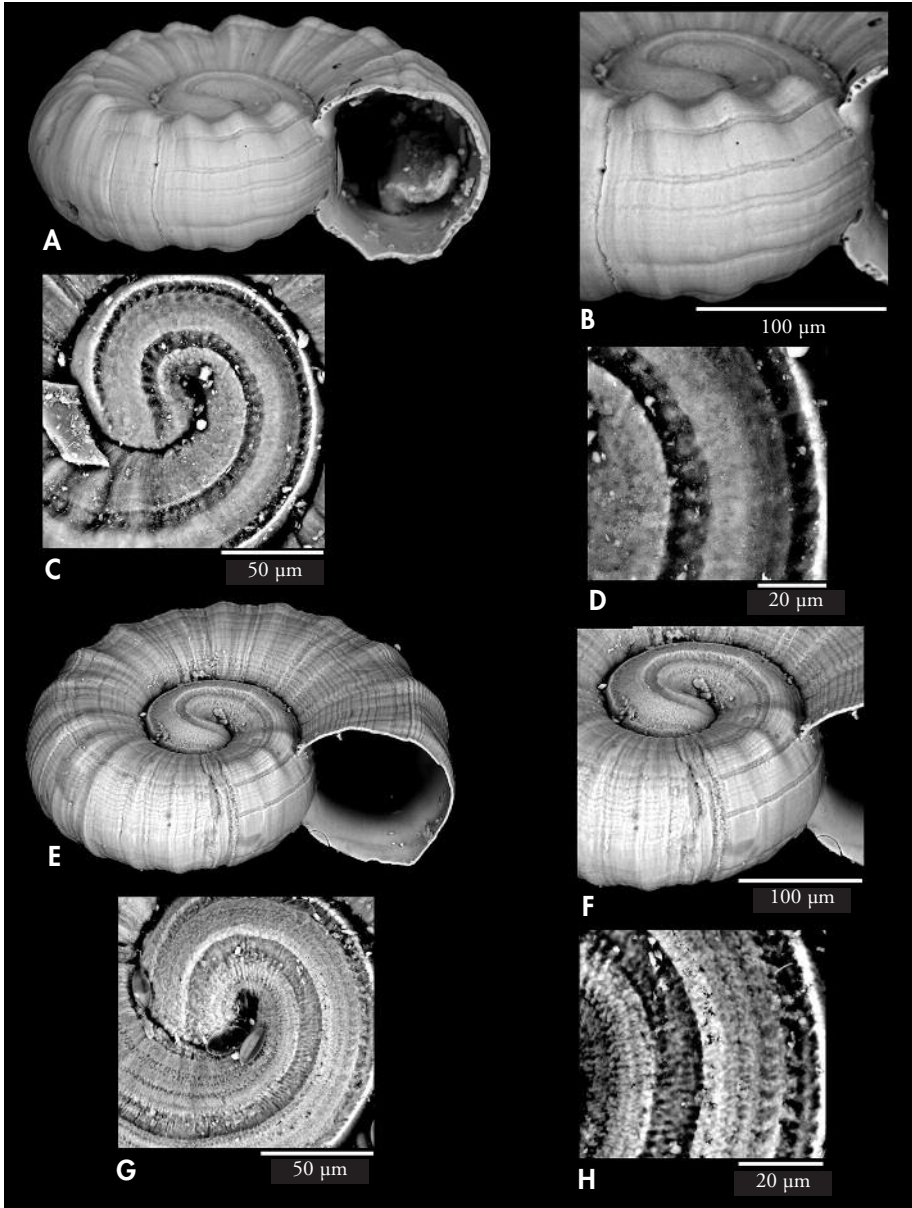


Figure 15. Comparison between juveniles of *A. fischeriana* in the Mediterranean and Atlantic forms. A-D. Juveniles of the Mediterranean form. A: Ibiza (CJDO-JT/MNCN), shell, 0.38 mm; B: protoconch-teleoconch transition zones; C, D: Portitxol, Jávea (CJDO-JT/MNCN), apical view of the protoconch and detail of the sculpture. E-H. Juvenile of the Atlantic form, Hendaye (MNHN). E: shell, 0.44 mm; F: transition area of protoconch-teleoconch; G, H: apical view and detail of it.

Figura 15. Comparación entre juveniles de las formas mediterránea y atlántica de A. fischeriana. A-D. Juveniles de la forma mediterránea. A: Ibiza (CJDO-JT/MNCN), concha, 0,38 mm; B: zona de transición protoconcha-teleoconcha; C, D: Portitxol, Jávea (CJDO-JT/MNCN), vista apical de la protoconcha y detalle de su escultura. E-H. Juvenil de la forma atlántica, Hendaya (MNHN). E: concha, 0,44 mm; F: zona de transición protoconcha-teleoconcha; G, H: vista apical y detalle de la misma.

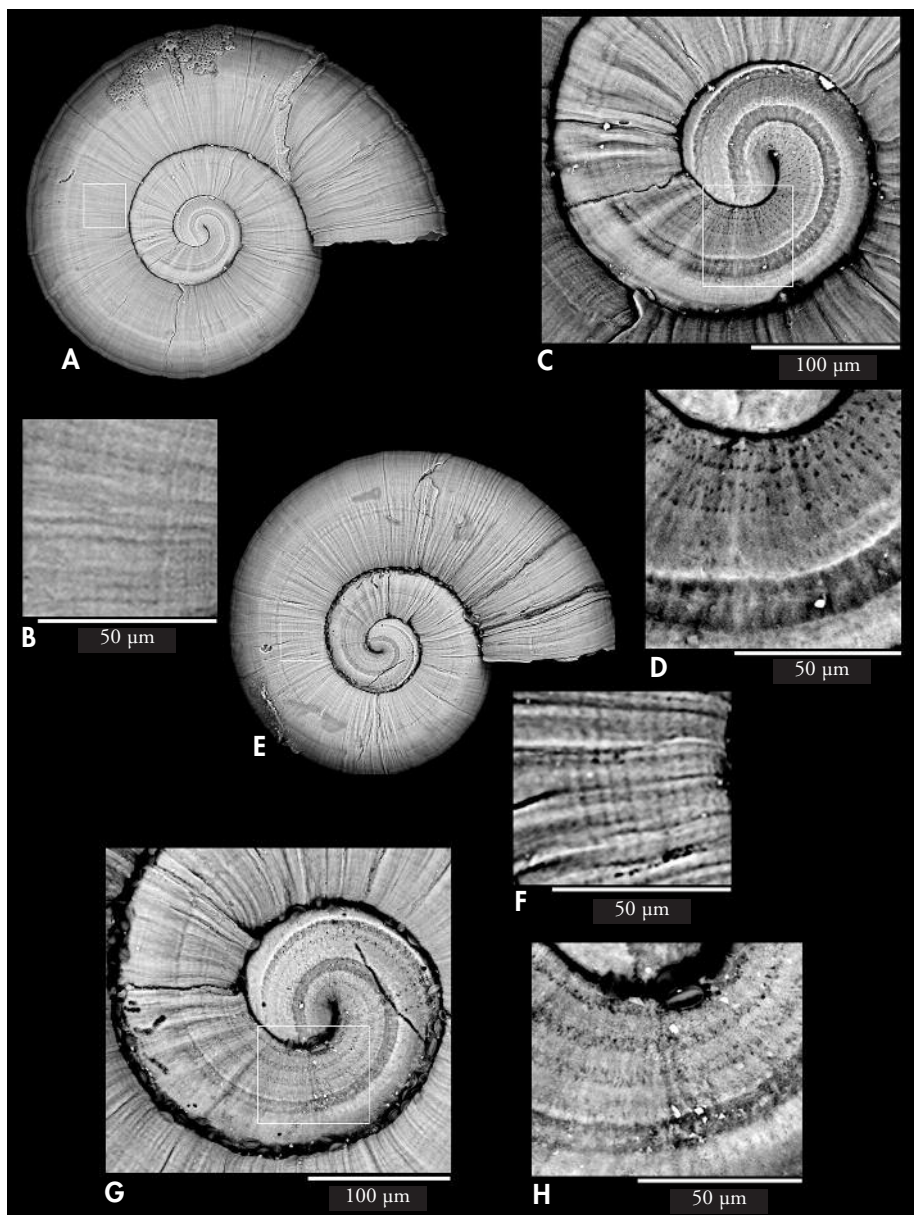


Figure 16. Comparison of the smooth varieties of the Mediterranean and Atlantic forms of *A. fischeriana*. A-D. Mediterranean form, Provence (MNHN). A: shell, 0.85 mm; B: detail of the microsculpture; C, D: protoconch-teleoconch transition zone and detail of the microsculpture of the protoconch. E-H. Atlantic form, Barbate (Cádiz) (MNHN). E: shell, 0.73 mm; F: detail of the microsculpture; G, H: protoconch-teleoconch transition zone and detail of the microsculpture of the protoconch.

Figura 16. Comparación de las variedades lisas de la forma atlántica y mediterránea de *A. fischeriana*. A-D. Forma mediterránea, Provenza (MNHN). A: concha, 0,85 mm; B: detalle de su microescultura; C, D: zona de transición protoconcha-teleoconcha y detalle de microescultura de la protoconcha. E-H. Forma atlántica, Barbate (Cádiz) (MNHN). E: concha, 0,73 mm; F: detalle de su microescultura; G, H: zona de transición protoconcha-teleoconcha y detalle de la microescultura de la protoconcha.

Variability of the Atlantic form of *A. fischeriana*

The intensity of the sculpture also varies in this form, some shells being practically smooth. We have considered convenient to recognize three varieties, the smooth one, the intermediate, and a peculiar one proper to the Chafarinas Islands which, albeit situated within the Mediterranean, is more similar to Atlantic forms.

Smooth form (Figs. 16E-H): specimens without sculpture of Mediterranean and Atlantic forms are at first glance almost identical. In spite of this, a detailed study of the smooth shells coming from different places reveal the presence of some details that seem to indicate that the loss of sculpture could be a phenomenon of convergence and that it would be possible to distinguish whether a shell without sculpture belongs to the Atlantic or Mediterranean form.

Intermediate form (Fig. 17A-C): It is characterized by the typical spiral grooves and a weak or absent axial sculpture. The shell with 2.5 whorls reaches 0.74 mm in diameter. The peripheral band is somewhat demarcated from adapical and abapical area. The upper, peripheral and bottom cords are delimited by shallow grooves but not keeled. There are numerous but inconspicuous ribs, separated by rather marked growth lines which are best observed in a lateral view of the shell. The ribs form nodules when they cross the upper and the lower cords, in such a way that the profile has a wavy appearance.

Chafarinas form (Figs. 17D-K): The shell, with 2.6 whorls, reaches 0.69 mm. In lateral view the juveniles usually have a more angulose profile than other variants of *A. fischeriana* due to that the cords so external, internal as peripheral are more prominent and may form keels. The peripheral band is clearly demarcated from adapical and abapical area. All the surface of the shell is covered by a spiral microsculpture. There are regularly separated ribs which override the upper and lower cords, forming nodules. These are also present,

more attenuated, in the peripheral area especially in juveniles.

The scar of the protoconch is only visible (very light) in some shells at about $\frac{3}{4}$ of whorl (with a diameter of about 150 μm and a nucleus of about 50 μm) (Fig. 17B). The first scar of the teleoconch is very clear and appears between 1 and 1.2 whorls with a diameter about 200 μm . Before this scar, there may be, or not, one or two ribs.

Distribution: (Fig. 26C) The Atlantic form of *A. fischeriana* is distributed from Brittany to the Moroccan coast, also present in the Strait of Gibraltar and on the Mediterranean coast of Northern Africa (form of the Chafarinas Islands).

General remarks on *Ammonicera fischeriana* s.l.

The species here considered as *A. fischeriana* could possibly comprise two or more cryptic species. This could be the case of the Mediterranean and Atlantic forms, but we do not reject that some of the smooth or intermediate forms, overall the insular ones, could also be species of their own. Nevertheless, we have preferred to keep a conservative criterion and consider them as a single taxon.

The typical Mediterranean and Atlantic forms are rather easy to differentiate, if we have well preserved adult shells and a good stereomicroscope (or better, a scanning electron microscope). The most important difference is in the presence of spiral microgrooves clearly visible with SEM, on all the surface of the shell of the Atlantic form of *A. fischeriana*, including cords. In some specimens of the Mediterranean form of *A. fischeriana*, there is also a spiral striation, but it is very light and is not present in all the surface (e.g. not on the cords) nor is it on all the shells (compare *A. fischeriana* from Portitxol, Jávea, Alicante, Fig. 10H, with the Atlantic form from Hendaye, Fig. 13B). We think that the small sculptural differences observed in the protoconch (Fig. 15) have more taxonomical value considering their genetic determination.

The surface of the protoconch of the Atlantic form (Figs. 15G-H) has a

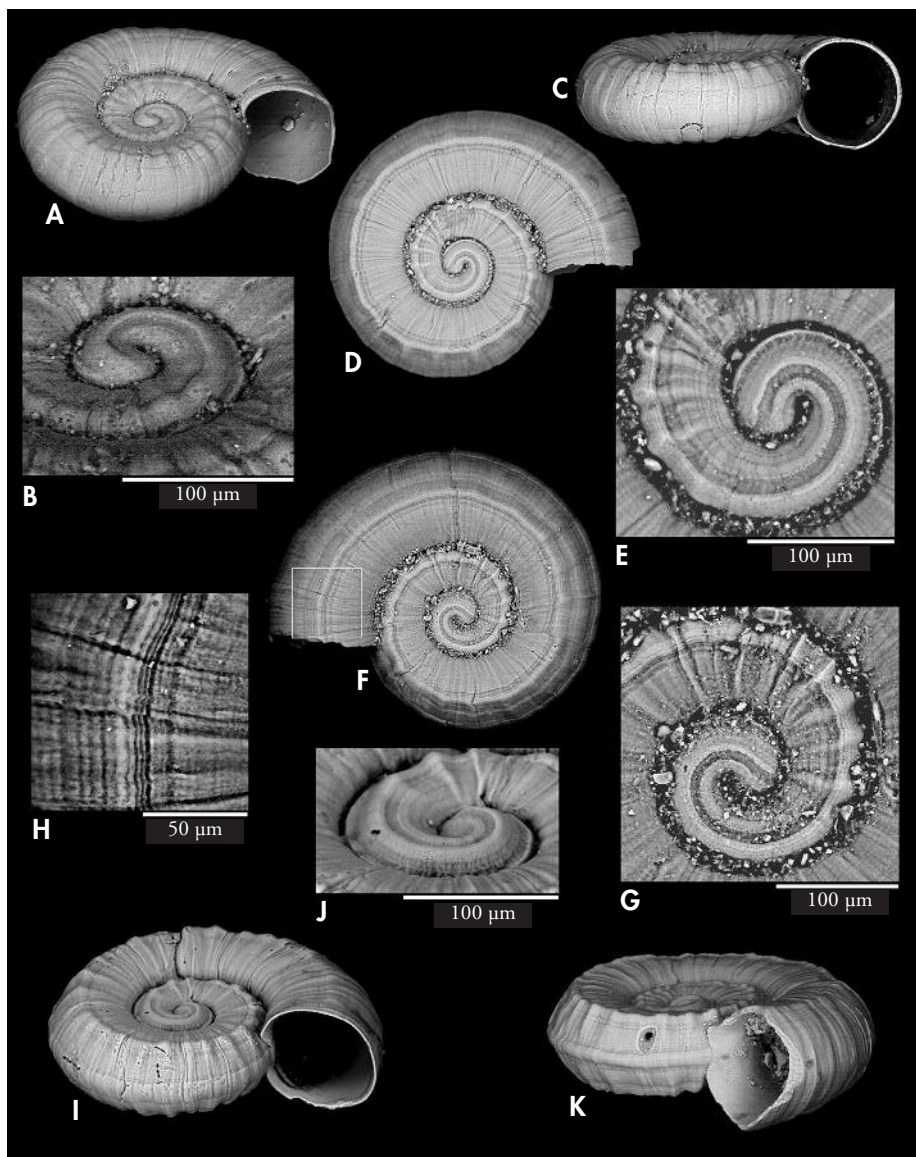


Figure 17. *Ammonicera fischeriana* (Atlantic form), Chafarinas Islands (CJDO-JT/MNCN). A, B: shell, intermediate variety, 0.65 mm and protoconch-teleoconch transition zone; C: shell, 0.64 mm, lateral view; D, E: shell in apical view, 0.64 mm, and protoconch-teleoconch transition zone; F-H: shell, 0.64 mm, abapical view, protoconch-teleoconch transition zone and detail of the microsculpture of the last whorl; I, J: shell, 0.57 mm, upper lateral view, and protoconch-teleoconch transition zone; K: shell with strong peripheral keel, 0.58 mm, lateral view.

Figura 17. Ammonicera fischeriana (forma atlántica), Chafarinas (CJDO-JT/MNCN). A, B: Chafarinas: concha, variedad intermedia, 0,65 mm y zona de transición protoconcha-teleoconcha; C: concha, 0,64 mm, vista lateral; D, E: concha, 0,64 mm, vista apical y zona de transición protoconcha-teleoconcha; F-H: concha, 0,64 mm, vista abapical, zona de transición protoconcha-teleoconcha y detalle de la microescultura de la última vuelta; I, J: concha, 0,57 mm, vista lateral superior, y zona de transición protoconcha-teleoconcha; K: concha con quilla periférica muy marcada, 0,58 mm, vista lateral.

rougher appearance than the Mediterranean form (Figs. 15 C-D). The grooves appear to be somewhat wider in the Atlantic form, and towards the end of the cord delimited by these spiral grooves, the striation that will continue on the teleoconch starts to show. The adapical area of the protoconch in the Atlantic form (between the inner groove and the suture) has tiny incisions aligned spirally in parallel series, which later will continue on the teleoconch as striae. In the Mediterranean form, if these incisions appear they do not align so clearly (compare Figs. 15C and 15G). We believe that this may be a significant taxonomic characteristic. Also some differences on their axial sculpture can be appreciated. In the Mediterranean form the ribs of the protoconch and the juvenile shell are more voluminous and with a more denticulate appearance than in the Atlantic form.

We have not found any samples of the typical Mediterranean form of *A. fischeriana* in the Atlantic nor typical Atlantic forms in the Mediterranean waters. On the other hand, both forms have been collected in the Strait of Gibraltar where they could live sympatrically in some localities. It would need a more in-depth study of shells, habitat, animal and possible molecular data to accurately determine whether they are different species, while at present we have decided to treat them as conspecific.

On the other hand the smooth varieties of *A. fischeriana* are present in both the Atlantic and the Mediterranean. We believe that this is due to a process of

convergence and, as a result, the smooth shells of both forms are almost identical. However, a detailed study of various locations from smooth shells reveal the presence of some details that allow us to distinguish between them. In Fig. 16 we represent a smooth Mediterranean form coming from Provence, and a smooth Atlantic form from Barbate (Cádiz). In the protoconch of the Atlantic form, the micro-incisions are aligned in parallel series while in the Mediterranean form they are more irregularly arranged. They may be compared also with the typical Mediterranean forms appearing in the Strait of Gibraltar (Tarifa, Figs. 11M-N) or with the typical Atlantic forms from Barbate (Figs. 14M-N).

A peculiarity that seem proper of the shells of the smooth variety from Chafarinas Islands (although more data would be needed to establish it as a characteristic) is that the transition from the protoconch to the teleoconch is easily observed and is located about 3/4 of whorl (Fig. 17E). Studying more than 150 shells from Chafarinas, of which a dozen were smooth, it could be concluded from the colour and the size, and from the presence of intermediate shells, that both forms are members of the same species. This is confirmed by the study of their protoconch (compare Fig. 17E with 17G) in which the presence of the micro-incisions in the upper zone of the protoconcha thus seem to confirm this.

From all the above, it is clear that further studies (primarily biological and molecular) are needed to reach a sound definition of the taxon *A. fischeriana*.

Ammonicera andresi spec. nov. (Figures 4G-H, 18A-H, 19A-G, 20A-G, 26E)

Ammonicera sp. – Oliver Baldoví (2007: 45, fig. 7)

Ammonicera sp1 – Oliver, Templado & Kersting (2012): 75, fig. 82-83)

Type material: Holotype in MNCN (15.05/60142H) (Fig. 18A). Paratypes in the following: MNCN (15.05/60142P, 10 s); MNHN (IM-2012-36206, 10 s); MHNS (100698, 1 s).

Other material studied: (+230 s and spms): Eastern Spain: Columbretes Islands: 4 s, Escala de España (39°53.7'N, 00°41.0'E, 35 m) (CJDO-JT/MNCN), 7 s, E side of Fidalgo Bank (39°52.1'N, 00°40.0'E, 40 m) (CJDO-JT/MNCN); 15 s, Columbretes Islands (39°54.7'N, 00°41.3'E, 16 m) (CJDO-JT/MNCN). Alicante: 1 s, Denia, (38°49.5'N, 00°10.0'E, 0-5 m) (CJDO-JT/MNCN). Balears: Mal-

Iorca: 1 s, Pollença 39°56.1'N, 03°11.9'E, 28 m, FAUNA III 190B) (MNCN, 1505/27591); 7 s, (CJDO-JT/MNCN). Menorca: 5 s, Cap de Cavalleria (40°04.9'N, 04°05.8'E, 20-25 m) (CJDO-JT/MNCN); 50 s, Fornells (40°03.8'N, 04°07.8'E, 16 m) (CJDO-JT/MNCN). Ibiza: 2 s, Bleda Mayor (38°58.3'N, 01°09.9'E, 45 m, FAUNA III 258B1 (CJDO-JT/MNCN); 100 s and spms, Punta Galera (38°47.7', 01°28.3'E, 35 m, FAUNA III 240B4), Espardell Island (38°47.7', 01°28.3'E, 35 m FAUNA III 240B4) (CJDO-JT/MNCN); 9 s, west islets west Islets (39°02.3', 01°38.7'E, 40 m, FAUNA III 236B) (CJDO-JT/MNCN). Southeastern Spain: 1 s, Los Escullos, Almería, infralittoral rocky place (MNHN). Chafarinas Islands: 20 s, Isabel II Island (35°10.1'N, 02°25.6'W, 14 m) (CJDO-JT/MNCN). Strait of Gibraltar: 1 s, Tarifa, Cádiz (36°00.0'N, 05°36.5'W) (S. Gofas) Southern France: 3 s, Cap Morgiou, calanque de la Triperie, sand in cave (43°12.2'N, 05°26.9'E, 22 m) (MNHN); 3 s, Grand Congloue, beneath submarine cliff (43°10.6'N, 05°24.2'E, 33 m) (MNHN); 2 s, Les Embiez Passe du Gaou, rocky bottom (43°04.3'N, 05°47.2'E, 0-3 m) (MNHN).

Type locality: Punta na Gall, SE Menorca, Balears, Spain, (39°55.9'N, 3°55.9'E, 10-15 m).

Etymology: The species is named after Javier de Andrés (MNCN) in recognition for his kindness and diligence when it comes to provide us material from this museum.

Description: The shell is planispiral, amphiconcave, reaching 0.74 mm in diameter with 2.4 whorls (the holotype has more than two whorls and 0.5 mm in diameter).

The peripheral band is clearly demarcated from adapical and abapical area when the upper, peripheral and lower cords are keeled, mostly in juveniles. In apical view, the upper central cord can be seen to begin on the protoconch and, between this and the suture, there are radial ribs crossing the upper depression, which remains concave. This makes the sculpture reminiscent of the slots of a roulette (Figs. 18A, 19A). The ribs, narrower than the interspaces, maintain a fairly regular distance (being about seventeen in the first whorl) and becoming reduced as the shell grows.

In the juvenile shell the ribs rise over the upper and lower cords, giving a denticulate profile in lateral view. Conversely the ribs do not rise so much on the peripheral cord (Fig. 20C). At high magnifications, spiral striae can be seen, especially in juvenile shells. In some of the shells from Columbretes, spiral grooves could be seen on the entire surface of the shell (Fig. 19G). As the shell increases in size, the sculpture becomes attenuated. Abapically, the appearance of the shell is similar to the apical view.

Protoconch and transition zone: In apical view the transition of the protoconch with the teleoconch is unclear, as in all the species studied. Probably, the protoconch must have something more than $\frac{3}{4}$ of whorl, as we could conclude

from the side view of a juvenile from Ibiza which shows clearly a change in the sculpture (Fig. 18E). However, a shell collected in Menorca (Fig. 18C) has a scar at about 0.6 whorl, where a change in the microsculpture of the protoconch was also noted. This scar is placed between the first rib and next scar which appears about 0.75 whorl, which confirms the difficulty to pinpoint the end of the protoconch in *Ammonicera*. The nucleus of the protoconch measures about 50 μ m. After the nucleus, there is a space without ribs (SWR) which is a little more than $\frac{1}{4}$ whorl. The sculpture of the initial zone in apical view shows two grooves that define the upper cord, the inner groove being somewhat wider.

In lateral view with the SEM, the inner groove is situated higher than the external one, and the interspace forms a kind of ramp which on its inner side (bordering the inner groove) is considerably raised so as to constitute an additional cord (Figs. 18F, 20D). The inner groove is interrupted where crossed by the ribs but remains visible within the slots (Figs. 18C, 20B). The outer groove is micropartitioned (Fig. 18C). All this sculpture will also remain in the juvenile teleoconch.

Laterally, the furrows delimiting the upper and lower interspace of the upper, peripheral and lower cords on the juvenile shell, although they may exist, are not conspicuous (Fig. 18E).

Colour: The shell is transparent golden-yellow (Figs. 4G-H) with reddish-

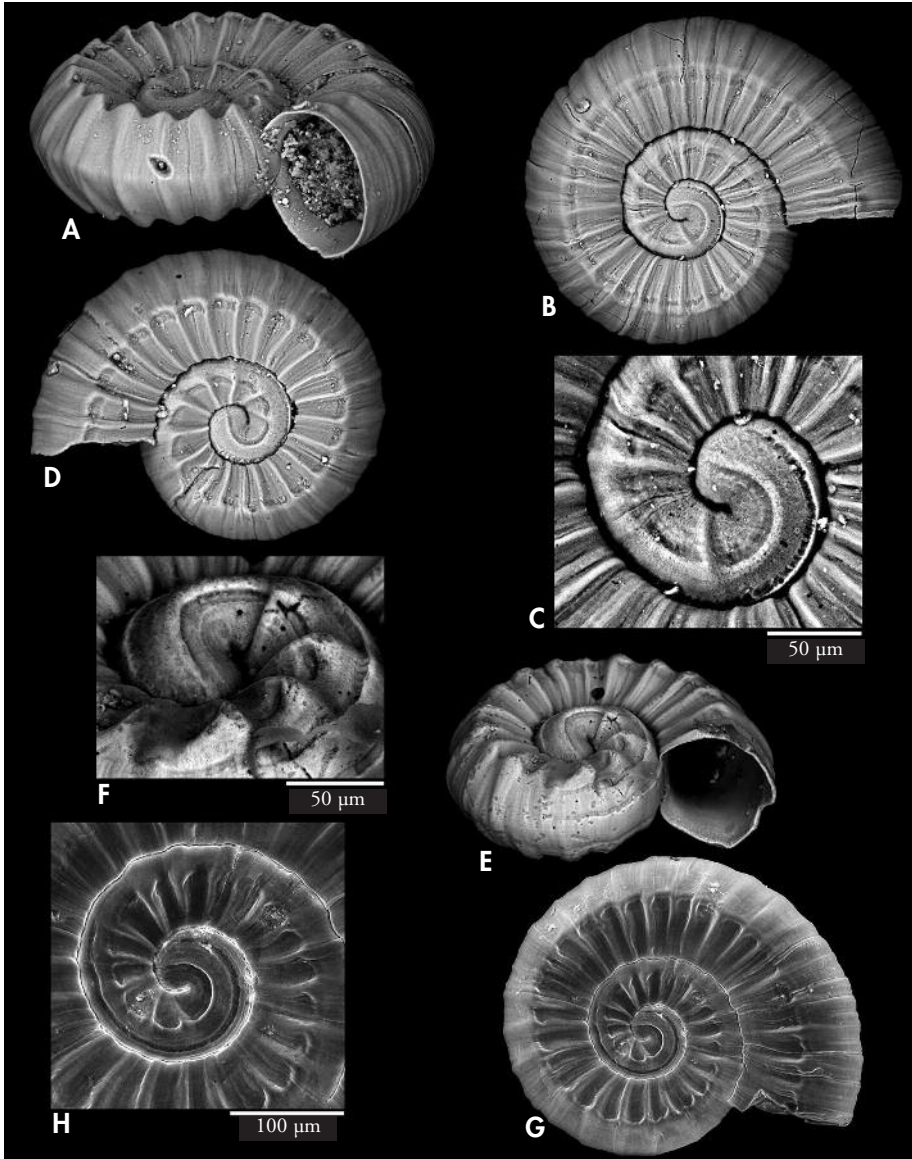


Figure 18. *Ammonicera andresi* spec. nov. A: Punta na Gall, Menorca, holotype (MNCN), 0.5 mm, lateral view; B, C: Menorca (CJDO-JT/MNCN), shell, 0.59 mm, apical view and protoconch-teleoconch transition zone; D: Menorca (CJDO-JT/MNCN), shell, 0.47 mm, abapical view and detail of its protoconch-teleoconch transition zone; E, F: Ibiza (CJDOJT/MNCN), juvenile shell, 0.37 mm and detail of its protoconch-teleoconch transition zone; G, H: Denia (CJDO-JT/MNCN), shell, 0.6 mm, and its protoconch-teleoconch transition zone.

Figura 18. Ammonicera andresi spec. nov. A: Punta na Gall, Menorca, holotipo (MNCN), 0,5 mm, vista lateral; B, C: Menorca (CJDO-JT/MNCN), concha, 0,59 mm, vista apical y zona de transición protoconcha-teleoconcha; D: Menorca (CJDO-JT/MNCN), concha, 0,47 mm, vista abapical y detalle de su zona de transición protoconcha-teleoconcha; E, F: Ibiza (CJDO-JT/MNCN), concha juvenil, 0,37 mm y detalle de su zona de transición protoconcha-teleoconcha; G, H: Denia (CJDO-JT/MNCN), concha, 0,6 mm y su zona de transición protoconcha-teleoconcha.

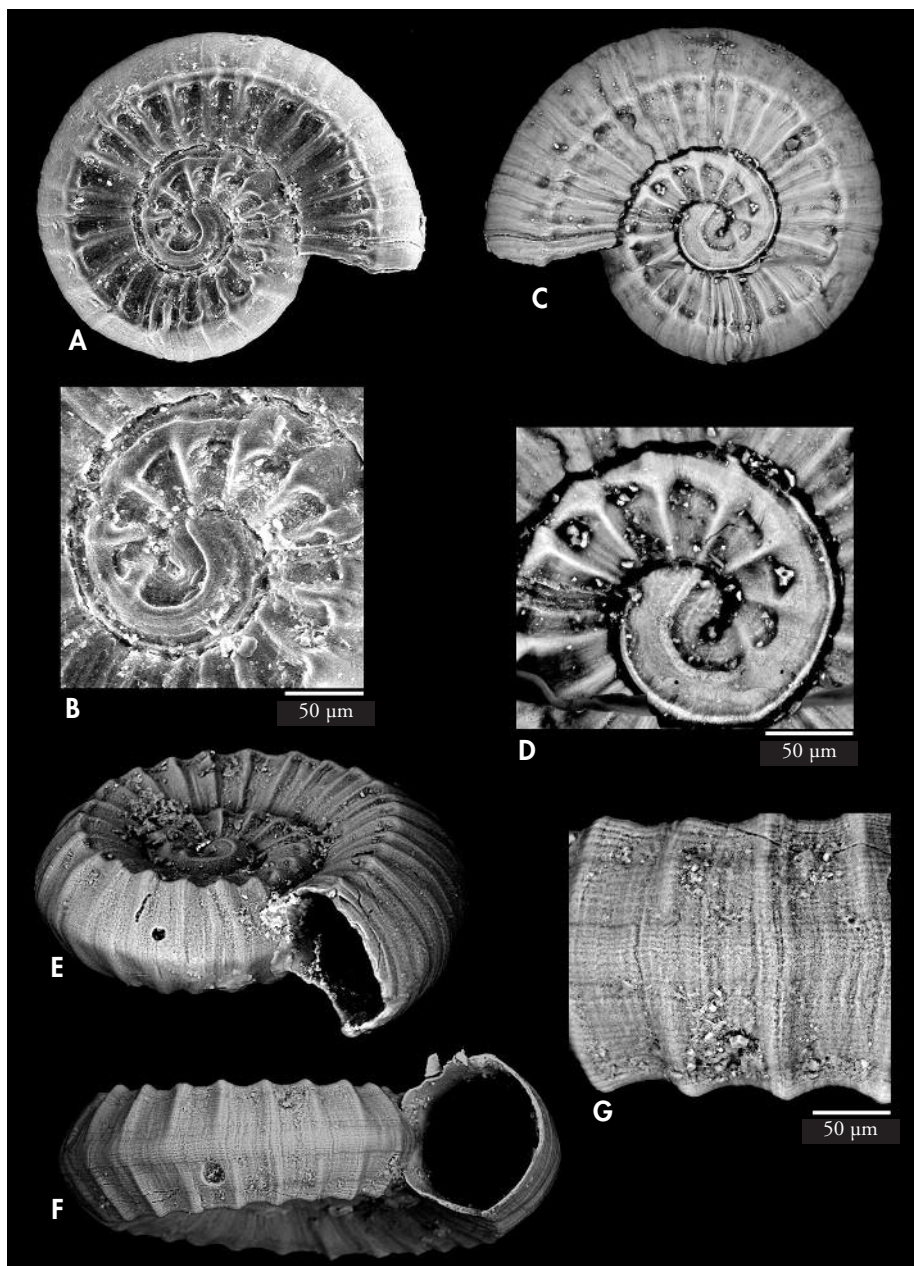


Figure 19. *Ammonicera andresi* spec. nov., Columbretes Islands (CJDO-JT/MNCN). A, B: shell, 0.52 mm, apical view and its protoconch-teleoconch transition area; C, D: the same shell, abapical view and its protoconch-teleoconch transition area; E: shell, lateral view, 0.55 mm; F, G: shell, 0.74 mm, lateral view and detail of its microsculpture.

Figura 19. Ammonicera andresi spec. nov., Islas Columbretes (CJDO-JT/MNCN). A, B: concha, 0,52 mm, vista apical y zona de transición protoconcha-teleoconcha; C, D: la misma concha, vista abapical y zona de transición protoconcha-teleoconcha; E: concha, vista lateral, 0,55 mm; F, G: concha, 0,74 mm, vista lateral y detalle de su microescultura.

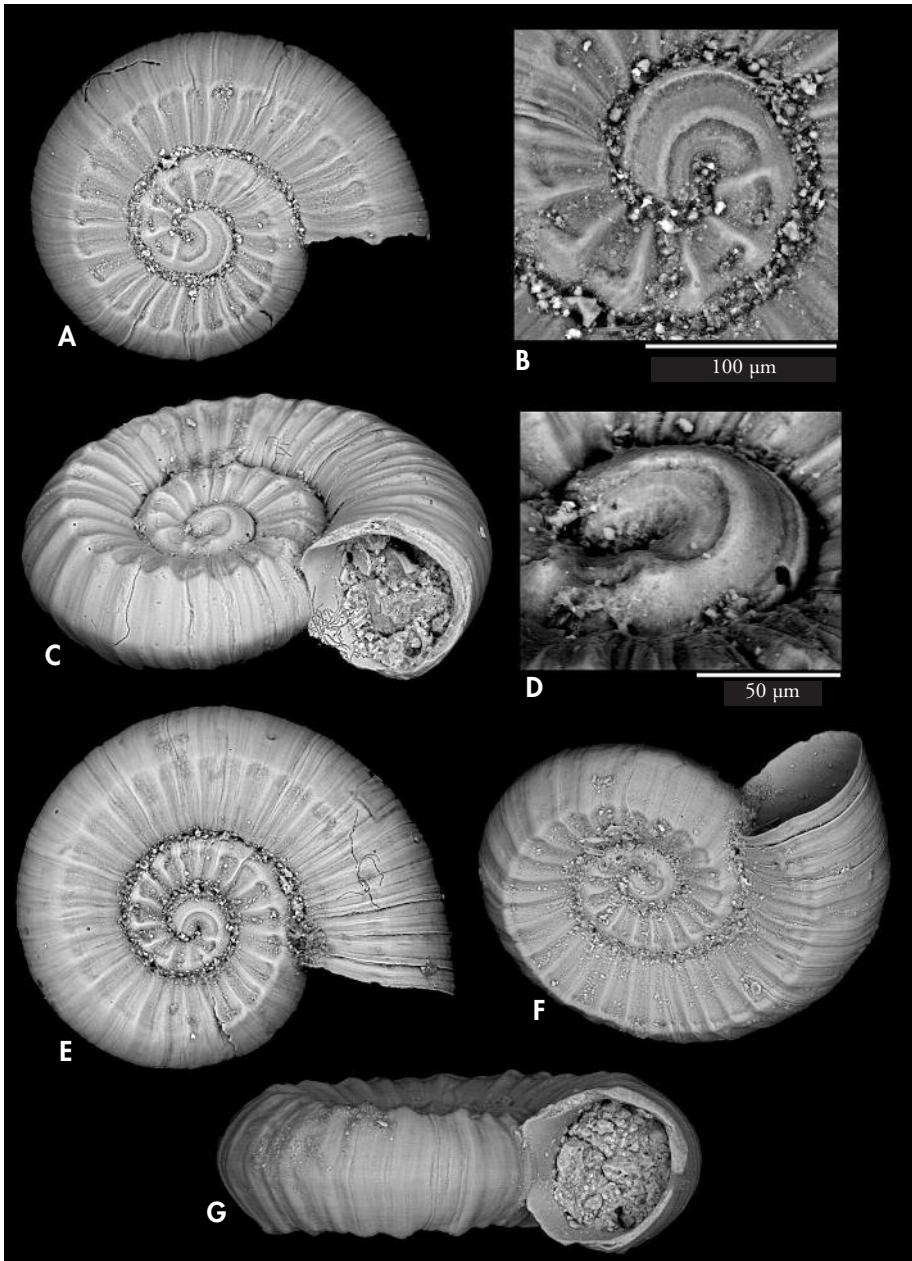


Figure 20. *Ammonicera andresi* spec. nov., Chafarinas Islands (CJDO-JT/MNCN). A, B: shell, 0.51 mm, and its protoconch-teleoconch transition area; C, D: shell, 0.64 mm and detail of its protoconch-teleoconch transition area; E-G: different view of several shells: 0.71 mm, 0.61 mm and 0.62 mm.

Figura 20A-G. *Ammonicera andresi* spec. nov., Islas Chafarinas (CJDO-JT/MNCN). A, B: concha, 0,51 mm y zona de transición protoconcha-teleoconcha; C, D: concha, 0,64 mm y detalle de la zona de transición protoconcha-teleoconcha; E-G: distintas vistas de diversas conchas: 0,71 mm, 0,61 mm y 0,62 mm.

brown lines over the upper, peripheral and lower cords. Its central area has a honey-like colouration.

Distribution: (Fig. 26E) This species was collected in the East and Southeast of the Iberian Peninsula, in the Balears, Columbretes, Chafarinas Islands and the Strait of Gibraltar. It probably has a wider distribution (in all the Spanish Mediterranean) since it is also present in France, but this only will be known after a more complete collecting.

Remarks: *Ammonicera andresi* spec. nov. does not seem to be particularly variable in the study area. In Columbretes Islands *A. andresi* seems to present spiral striations (Fig. 19G) on the surface of the shell. Other locations such as Menorca, Chafarinas or Denia have shells which seem to be rather smooth. On the other hand, some studied shells from Chafarinas (Fig. 20F) with 2.6 whorls and 705 μm in diameter have a sculpture less relevant, almost smooth, in the adult teleoconch.

Due to its size and colour and also because both species tend to appear together in the same samples, *Ammonicera andresi* can be confused with the more sculptured forms of *A. fischeriana*, although with practice they can be separated even under the stereomicroscope. With the SEM they are easily separated. Juveniles of these two species appear clearly different (compare Figs. 15A, 15E with Fig. 18E). In the protoconch, the

smooth part without ribs after the transition area (SWR), is something more than $\frac{1}{2}$ of whorl in *A. andresi* spec. nov., and $\frac{3}{4}$ of whorl in *A. fischeriana*. The aspect of the cords (upper and lower) together with the grooves that delimit these and the junction with the ribs is also different. In *A. andresi* the cord forms an outer flange on the inner groove and rises in a kind of denticulate crest incised by the inner groove, while on *A. fischeriana* the ribs only produce an undulation.

The teleoconch of *A. andresi* can be distinguished by the sculpture in the form of roulette boxes, especially in the juvenile teleoconch. In *A. fischeriana* with a strong sculpture, the separation between the ribs is not so regular nor are the interspaces so sunken. The profile of the sculptured juvenile of *A. fischeriana* is wavy and more shallow, while in *A. andresi* is more definitely and more deeply denticulate.

Comparing fresh shells of *A. andresi* and *A. fischeriana* of the same locality (such as Ibiza) we have found that the colour of *A. fischeriana* is lighter than that of *A. andresi* which has a central area with a yellow honey-like colour.

The presence of strong ribs is a shared character with *A. rota*, which is distinguished clearly because it has a different protoconch with a single narrow groove and a SWR with a little more than a quarter-whorl.

Ammonicera nodulosa spec. nov. (Figures 4I-J, 21A-I, 22A-P, 26F)

(non) *Ammonicera rota* (Forbes & Hanley, 1850) – GAGLINI & CURINI GALLETTI (1978); AARTSEN et al. (1984: 108, fig. 61); PALAZZI (1988: 107-110, fig. 9, 17); OLIVER, TEMPLADO & KERSTING (2012: 75, fig. 80-81).

(non) *Ammonicera fischeriana* (Monterosato, 1869) – OLIVER BALDOVÍ (2007: 45, fig. 5).

Type material: Holotype in MNCN (15.05/60145H) (Fig. 21A). Paratypes in the following: MNCN (15.05/60145P, 14 s) (Figs. 21C-D, 21F-G), MHNS (100697, 10 s) and in MNHN (IM-2012-36207, 10 s).

Other material studied: (+157 s and spms): Eastern Spain: Columbretes Islands: 22 s (whitish shells) from type locality (MNCN); 5 s, Escalera de España, Columbrete Grande (39°53.7'N, 00°41.0'E, 32 m) (CJDO-JT/MNCN). Valencia: 37 s, Cullera (39°10.9'N, 00°12.9'W, 0-10 m) (CJDO-JT/MNCN). Balearic Islands: Menorca: 3 s, Cap de Cavalleria (40°04.9'N, 4°05.8'E, 20-25 m) (CJDO-JT/MNCN); 25 s (typical form), Fornells (40°03.8'N, 04°07.8'E, 16 m) (CJDO-JT/MNCN); 10 s, Illes des Porros (40°05.5'N, 04°04.4'E, 30 m). Mallorca: 11 s, Pollença (39°56.1'N, 3°11.9'E, 32 m, FAUNA III 190B8) (CJDO-JT/MNCN). Ibiza: 5 s, Bleda Mayor (38°58.3'N, 01°09.9'E, 45 m, FAUNA III 258B1) (CJDO-

JT/MNCN); 25 s, Punta Galera, Espardell island (38°47.7', 01°28.3'E, 35 m FAUNA III 240B4) (MNCN); 6 s, west islets, Togomago (39°02.3', 01°38.7'E, 40 m, FAUNA III 236B) (CJDO-JT/MNCN). Southeastern Spain: 2 s, Almuñécar, Granada (CJDO-JT/MNCN); 2 s, Hormigas islands, Murcia (37°39.4'N, 00°38.9'W, 22 m, FAUNA IV 299B) (CJDO-JT/MNCN); 3 s, Alborán Island (35°56.2'N, 03°01.8'W, 12 m) (CJDO-JT/MNCN). Southern France: 1 s, Grand Congloue (43°10.6'N, 05°24.2'E, 33 m) (MNHN).

Type locality: Columbretes Islands, East side of Fidalgo Bank (39°52.1'N, 00°40.0'E, 40 m, FAUNA IV campaign, sample 277B).

Etymology: The specific name alludes to its ribs often broadened on the upper and the lower cords, forming nodules.

Description: The shell is planispiral, amphiconcave, reaching 0.50 mm in diameter with 2.25 whorls.

The peripheral band is always clearly demarcated from the adapical and abapical areas (Figs. 21H, 22F, 22H, 22N, 22O). The axial sculpture consists of ribs which are clearly narrower than their interspaces, regularly spaced. The ribs are clearly seen to override the cords, especially in juvenile shells, and the grooves between spiral cords. Growth lines that cut the spiral cords are also conspicuous. The ribs stand out in the profile of the spire, giving it a wavy appearance, and are often broadened on the upper and the lower cords, forming nodules. For this reason the suture is also somewhat wavy.

The ribs are incised by the grooves which are separating the spiral cords, resulting in that the nodules of a rib may be slightly offset (Fig. 22F). The relevance of these nodules and their presence or not in the peripheral cords are variable. The appearance of the shell in abapical view does not differ significantly from the apical view. In lateral view, the aperture generally appears rounded but may be somewhat angular at the termination of the spiral cords.

Protoconch and transition zone: As in other species of *Ammonicera* the transition of protoconch to teleoconch is unclear. Around 0.75 whorl and with 150 μ m in diameter, some specimens have a faint scar (Fig. 22D). The first scar of the teleoconch occurs in the first whorl with 195 μ m in diameter (Figs. 21B, 22D).

The nucleus of the protoconch looks smooth but is rough under high magnification (Fig. 22E) and, in apical view,

bears two narrow grooves of similar width. One of the grooves is nearly central, whereas the other is closer to the suture and occasionally concealed (Figs. 21B, 22B, 22D). The two grooves are delimiting the upper cord of the spire, which is wider than in other species because the grooves are so narrow. In lateral view, the internal groove is situated higher than the external groove, so that the surface of the cord forms a convex ramp from one to the other. At higher magnification there are two other weak spiral grooves that give the ramp a somewhat stepped appearance (Fig. 21I).

Inside the outer groove can be seen incisions (Figs. 21B, 21E). The smooth space from the nucleus to the appearance of the first rib (SWR) in this species is approximately $\frac{1}{2}$ whorl. The ribs start a little after the first half whorl. There are about five ribs before the first scar, regularly spaced and which form clear nodules on the upper cord (Fig. 24G). This sculpture will continue in the teleoconch.

Colour: The shell is transparent (Figs. 4I-J), pearl white to yellow with very slight reddish lines on the upper, peripheral and lower cords. Some shells from Ibiza were fully transparent while in others the reddish line is limited to the peripheral cord.

Habitat: The shells from Cullera (Valencia) were collected in detrital bottoms (thick sand) at about 15 m depth.

Distribution: (Fig. 26F) This species has been confused with *A. rota* by van AARTSEN ET AL. (1984) and PALAZZI (1988). Both authors presented photographs of Italian shells so that this

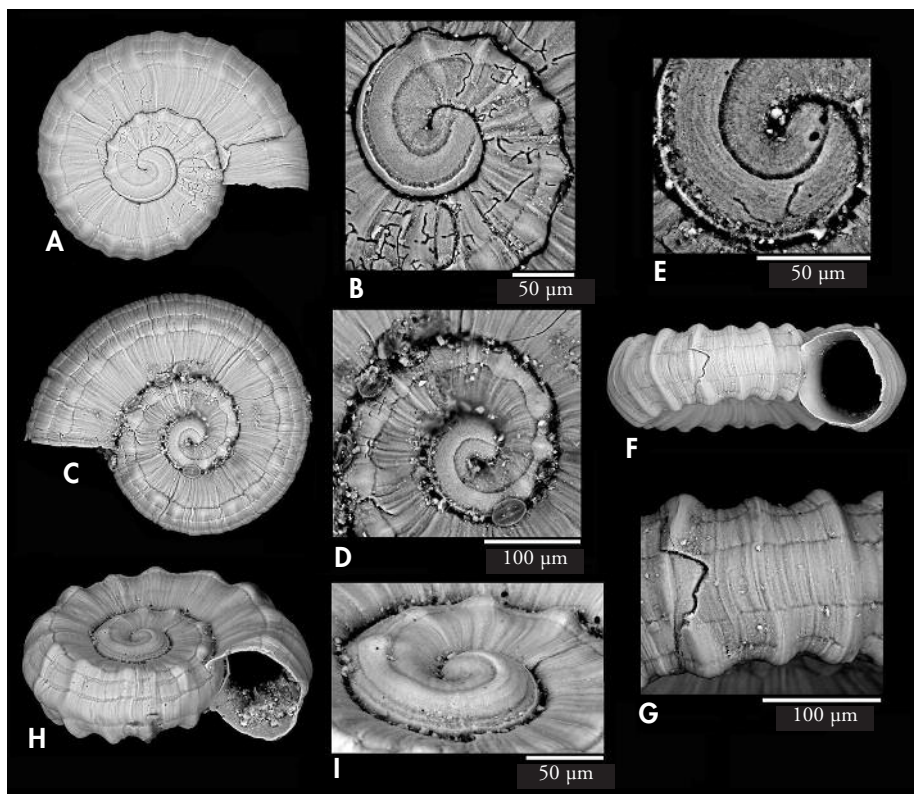


Figure 21. *Ammonicera nodulosa* spec. nov., Columbretes Islands. A-B: holotype, 0.5 mm and its protoconch-teleoconch transition area (MNCN); C, D: paratype, 0.61 mm (MNCN) and its protoconch-teleoconch transition area; E: detail of the microsculpture of the protoconch; F, G: paratype, 0.56 mm and detail of the microsculpture of the teleoconch (MNCN); H, I: shell, 0.42 mm and lateral view of its protoconch-teleoconch transition area (CJDO-JT/MNCN).

Figura 21. Ammonicera nodulosa spec. nov., Islas Columbretes; A, B: holotipo, 0,5 mm y zona de transición protoconcha-teleoconcha (MNCN); C, D: paratipo, 0,61 mm (MNCN) y zona de transición protoconcha-teleoconcha; E: detalle de la microescultura de una protoconcha; F, G: paratipo, 0,56 mm y detalle de la microescultura de la teleoconcha (MNCN); H, I: concha, 0,42 mm y vista lateral de su zona de transición protoconcha-teleoconcha (CJDO-JT/MNCN).

country should be included in the distribution.

In the places where it was collected it may live sympatrically with *A. fischeriana*, *A. columbretensis* spec. nov., *A. andresi* spec. nov., *A. superstriata* spec. nov. and *A. arrondoi* spec. nov.

Remarks: This species has some degree of variability in its colour and in the number and relevance of the ribs. For example, there are shells with about 20 slightly marked ribs on the last whorl

(Figs. 21C and 22M) and others with little more than a dozen of higher ribs (Fig. 22A). This could indicate that we can be in front of more than one cryptic species. In fact, among the studied shells from the Balears, there are some very sculptured and transparent shells that contrast with others, more similar to the holotype, less sculptured and of a white pearl colour with clear reddish lines (compare holotype Fig. 21A with Fig. 22A). However we have preferred to

keep them as a single species until more evidence is gathered.

A. nodulosa is smaller than *A. rota* and *A. fischeriana*. The larger shells of *A. nodulosa* hardly exceed half millimetre in diameter, compared to diameters greater than 0.8 mm in *A. rota* and *A. fischeriana*. The protoconchs of *A. rota* and *A. fischeriana* are also unequivocally different, that of *A. rota* having a single groove and that of *A. fischeriana* having two grooves, but distinctly unequal. In addition, under the stereomicroscope, the slightly wavy

outline of the suture of the shell of *A. nodulosa* in apical view and the undulating profile in lateral view clearly distinguish it from *A. fischeriana*.

From *A. andresi*, it is distinguished by its colour, which in *A. andresi* is yellowish gold while in *A. nodulosa* is pearly white, and by lacking the radial sculpture in form of roulette slots typical of *A. andresi*.

The most similar species is without a doubt *A. arrondoi* (see this species for differences).

Ammonicera superstriata spec. nov. (Figures 4K-L, 23A-I, 26G)

Type material: Holotype in MNCN (15.05/60146H) (Fig. 23A). Paratypes from the same sample in the following: MNCN (15.05/60146P, 16 s, Figs. 23C and 23F); MNHN (IM-2012-36208, 2 s); MHNS (100696, 2 s).

Other material examined: (+154 s and spms): Balears: Ibiza: 90 s and spms from the type locality (CJDO-JT/MNCN). Menorca: 8 s, Cap de Cavallería (40°04.9'N, 4°05.8'E, 20-25 m); 50 s and spms, from ille des Porros, near Cap de Cavallería (40°05.5'N, 04°04.4'E, 30 m) (CJDO-JT/MNCN); 5 s, Punta na Gall (39°55.9'N, 3°55.9'E, 14 m) (CJDO-JT/MNCN); Mallorca: 1 s, Cabo del Pinar (39°53.0'N, 3°11.8'E, 23 m, FAUNA III 191B1) (CJDO-JT/MNCN).

Type locality: Punta Galera, E of the Espardel, Ibiza, Balears (38°47.7', 01°28.3'E, 35 m, FAUNA III campaign, sample 240B4).

Etymology: The name alludes to the strong spiral striation of the shell.

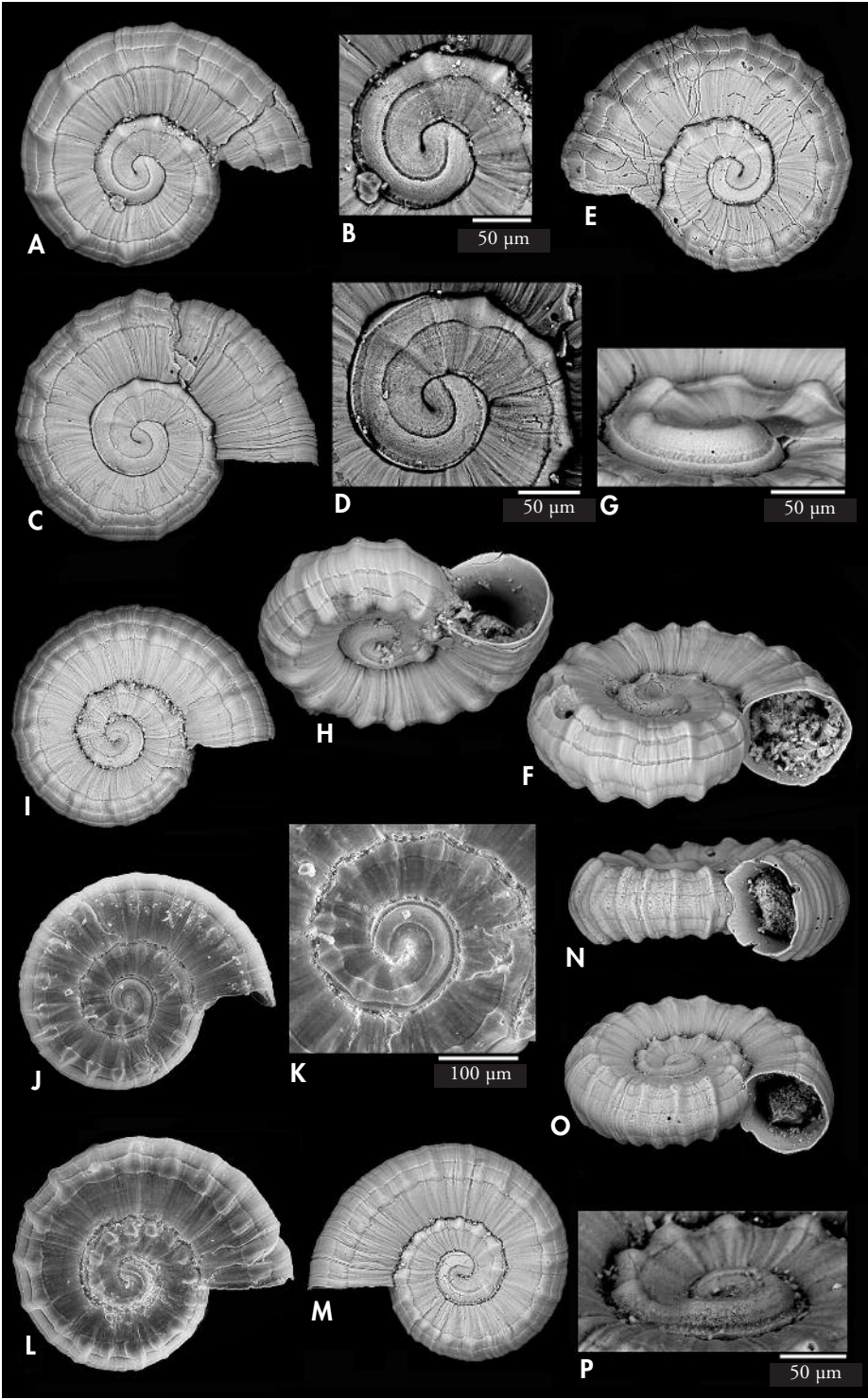
Description: The shell is planispiral, amphiconcave, reaching 0.62 mm in diameter with 2.2 whorls.

There are well-developed spiral striae over all the shell (Fig. 23E), present also on the upper, peripheral and lower cords which tend to form

keels. The shell presents axial ribs (about twenty in the last whorl) which are more prominent on the peripheral band than on the adapical and abapical areas. The ribs slightly override the peripheral cord and therefore its outline is somewhat wavy in apical

(Right page) Figure 22. *Ammonicera nodulosa* spec. nov. A-H. Ibiza (CJDO-JT/MNCN). A, B: shell, 0.46 mm, apical view, and its protoconch-teleoconch transition zone; C, D: shell, 0.50 mm, and its protoconch-teleoconch transition zone; E: shell, 0.48 mm, abapical view; F, G: shell, 0.48 mm, upper lateral view, and lateral view of its protoconch-teleoconch transition zone; H: shell, 0.41 mm, lower lateral view. I. Marseille, Grand Congloue (MNHN), shell of white colour, 0.61 mm. J-P. Cullera (CJDO-JT/MNCN). J, K: shell, 0.68 mm and its protoconch-teleoconch transition zone; L-N: shells in several positions: 0.54 mm, 0.60 mm, 0.54 mm; O, P: shell, 0.57 mm and lateral view of its protoconch-teleoconch transition zone.

(Página derecha) Figura 22. *Ammonicera nodulosa* spec. nov. A-H. Ibiza (CJDO-JT/MNCN). A, B: concha, 0,46 mm, vista apical y su zona de transición protoconcha-teleoconcha; C, D: concha, 0,50 mm y su zona de transición protoconcha-teleoconcha; E: concha, 0,48 mm, vista abapical; F, G: concha, 0,48 mm, vista lateral superior y vista lateral de su zona de transición protoconcha-teleoconcha; H: concha, 0,41 mm, vista lateral inferior. I. Marseille, Grand Congloue (MNHN), concha de color blanco, 0,61 mm. J-P. Cullera (CJDO-JT/MNCN). J, K: concha, 0,68 mm y su zona de transición protoconcha-teleoconcha; L-N: conchas en diversas posiciones: 0,54 mm, 0,60 mm, 0,54 mm; O, P: concha, 0,57 mm y vista lateral de su zona de transición protoconcha-teleoconcha.



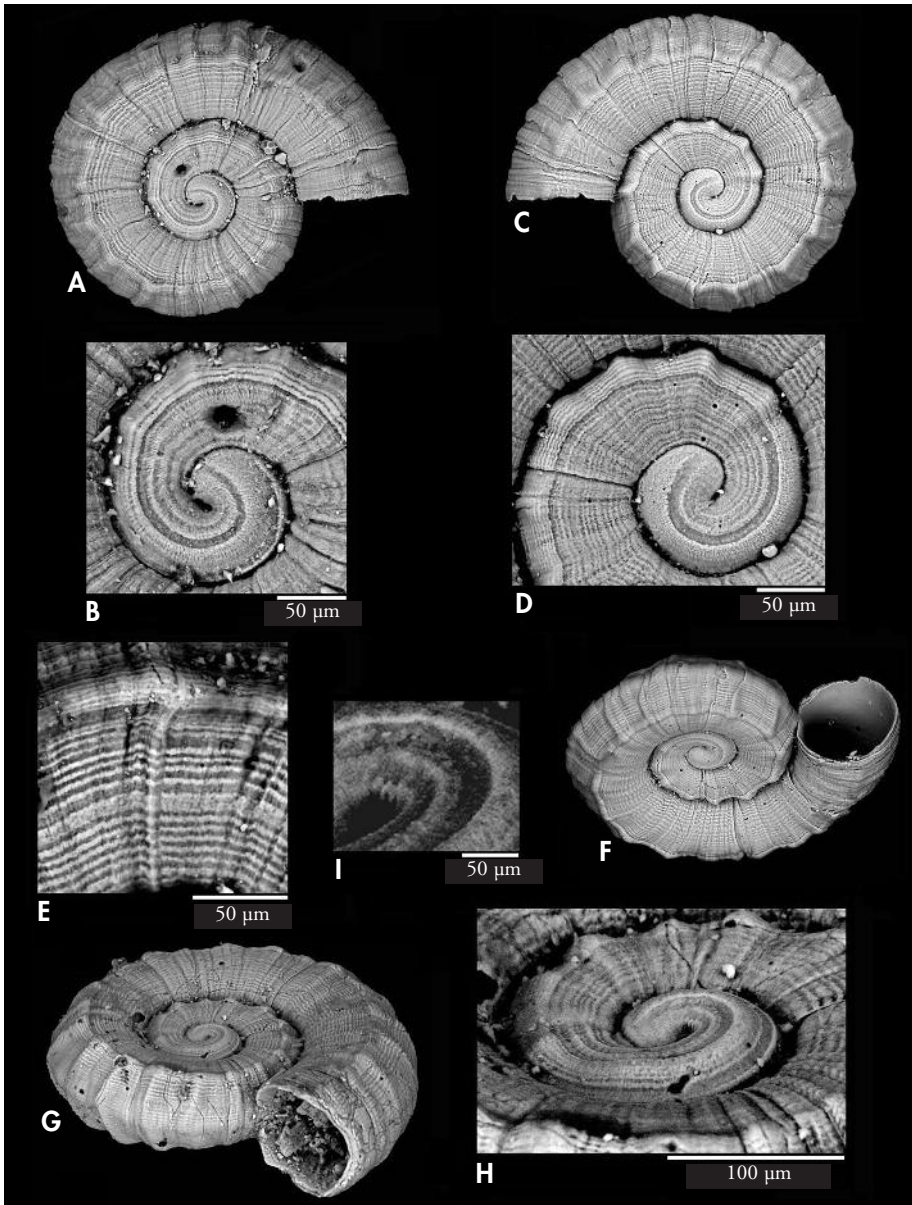


Figure 23. *Ammonicera superstriata* spec. nov., Ibiza. A, B: holotype, 0.6 mm (MNCN) and its protoconch-teleoconch transition area; C, D: paratype, 0.58 mm (MNCN) and its protoconch-teleoconch transition area; E: detail of the microsculpture; F: paratype, lower lateral view, 0.42 mm (MNCN); G: shell, upper lateral view, 0.6 mm; H, I: lateral view of its protoconch-teleoconch transition area, and detail of the inner groove and of a secondary groove in the protoconch.

Figura 23. *Ammonicera superstriata* spec. nov., Ibiza. A, B: holotipo, 0,6 mm (MNCN) y zona de transición protoconcha-teleoconcha; C, D: paratipo, 0,58 mm (MNCN) y zona de transición protoconcha-teleoconcha; E: detalle de la microescultura; F: paratipo, vista lateral inferior, 0,42 mm (MNCN); G: concha, vista lateral superior, 0,6 mm; H, I: vista lateral de la zona de transición protoconcha-teleoconcha y detalle del surco superior y de un surco secundario de la protoconcha.

view. On the upper and lower cord the ribs form nodules, mainly on the juvenile teleoconch. There are two conspicuous furrows delimiting the upper cord. The aspect of the shell in apical view is similar to the abapical view (Fig. 23C).

Protoconch and transition zone: As in other *Ammonicera*, the end of the protoconch is not clear in all the examined shells. In some shells it is possible to see something like a scar (but weak) between 0.5 and 0.7 whorl (with 150 μ m in diameter), just before the first nodules on the cords.

The nucleus of the protoconch has about 50 μ m in width and, in apical view, bears two narrow grooves of similar width. The protoconch is more rugose than in other species (Fig. 23D). The internal groove is slightly wider than the external one which is quickly concealed by the growth of the spire. Between the internal groove and the suture there are other secondary grooves (Figs. 23B, 23I). As the shell grows, some cordlets are formed, separated by secondary spiral grooves (most evident in the adapical area). There is an area without ribs (SWR) from the nucleus to $\frac{3}{4}$ of whorl. A cordlet appears inside the internal groove towards the end of this area without ribs.

Towards the end of the protoconch-teleoconch transition, small striae appear on the inner cord (Figs. 23B, 23D), and these will persist on the whole teleoconch. This cord is undulating after the first half whorl due to the intersection of ribs in the juvenile teleoconch, and will continue undulated on the teleoconch. There are about three nodules on the cord before the first scar,

which appears around one whorl, with a diameter about 210 μ m.

As it is often the case in other *Ammonicera*, the aspect of the protoconch in abapical view is quite similar to that presented in apical view, although there only one of the grooves can be seen, the other one being concealed by the growth of the shell.

Colour: Brown tending to gold with the peristome lighter (Figs. 4K-L). The nodules are usually whitish.

Habitat: Most of the studied shells come from detrital sediments collected between 20-40 m depth near rocky shores.

Distribution: Known only from Balears (Ibiza, Menorca and Mallorca) (Fig. 26G)

Remarks: With the stereomicroscope, because of its reddish brown colour with lighter aperture, *A. superstriata* may be confused with *A. columbretensis*. With some practice and fresh shells, it is possible to see that *A. superstriata* tends to have white ribs and *A. columbretensis* not. The most significant difference is that both species have clearly distinct protoconchs with a single and narrow groove in *A. columbretensis*. In addition, with SEM, more differentiating features can be seen, as *A. columbretensis* lacks spiral striation and has only $\frac{1}{4}$ whorl of SWR.

Although its colour is clearly different, the most similar species, from the sculptural point of view, is *A. fischeriana*, mainly forms of the Atlantic and those more sculptured ones from the Chafarinas Islands. However both the shell and the protoconch sculpture of *A. superstriata* are much more accused (presence of secondary grooves in the upper area of the protoconch) than in this species.

Ammonicera arrondoi spec. nov. (Figs. 4M-N, 24A-H, 26H)

Type material: Holotype in MNCN (15.05/60143H, Fig. 24A). Paratypes in the following: MNCN (15.05/60143P, 10 s); MNHN (IM-2012-36209, 1 s); MHNS (100695, 2 s, Figs. 4M-N); AD (1 s).

Other material studied (36 s): Mallorca: 1 s, Cabo del Pinar, N Mallorca (39°53.0'N, 3°11.8'E, 23 m, FAUNA III 191B1) (CJDO-JT/MNCN). Menorca: 3 s, Cap de Cavallería (40°04.9'N, 4°05.8'E, 20-25 m) (CJDO-JT/MNCN); 5 s, from Porros Island, near Cavallería Cape (40°05.5'N, 04°04.4'E, 30 m) (CJDO-JT/MNCN); 2 s, Punta na Gall (39°55.9'N, 3°55.9'E, 14 m) (CJDO-JT/MNCN). Ibiza:

25 s, Punta Galera, E of Espardell Island (38°47.7', 01°28.3'E, 35 m, FAUNA III 240B4) (CJDO-JT/MNCN).

Type locality: Punta Galera, E of Espardell Island, Ibiza, Balearic islands (38°47.7', 01°28.3'E, 35 m, FAUNA III campaign, sample 240B4).

Etymology: The specific name is after Ernesto Arrondo Odriozola, malacologist from Donostia, by his contribution to Malacology.

Description: The shell is planispiral, amphiconcave, reaching 0.52 mm in diameter with two whorls.

The peripheral band is clearly demarcated from adapical and abapical area. Under high magnification, it shows a fine spiral sculpture and growth lines. There are clearly marked grooves, which can even be distinguished under the stereomicroscope, separating broad, flat upper and lower cords. The axial sculpture is weak but undulates slightly both the lower and upper cords as can be seen in lateral view (Fig. 24H).

Protoconch and transition zone: A faint scar can be seen sometimes around $\frac{3}{4}$ of whorl, corresponding to a diameter of about 155 μm , but it is difficult to determine compared to other *Ammonicera*. Around 1 whorl, with 200 μm in diameter, appears a scar and there can be some additional ones.

The nucleus is about 50 μm in width, more apparent in abapical than in apical position since it seems slightly asymmetrical contrary to other *Ammonicera*. The area without axial sculpture following the nucleus (SWR) is $\frac{3}{4}$ of whorl.

There are two subequal grooves which delimit a cord, forming a ramp from the internal down to the external groove. The external groove is a little more opened, shallow and clearly micropartitioned and runs very close to the suture, becoming concealed by the growth of the shell at the end of the zone. At this level of $\frac{3}{4}$ of whorl, the internal micropartitioning of the external cord (Fig. 24B) is discontinued.

The cord delimited by the grooves has a rough surface and a faint spiral microsculpture but after $\frac{3}{4}$ of a whorl, it

becomes smoother and slightly wavy due to the very weak incipient nodules which will be continued on the teleoconch.

Colour: The studied shells are golden yellowish (Figs. 4M-N) with somewhat darker lines on upper, peripheral and lower cords.

Habitat: Most of the studied shells come from detrital sediments collected between 20-40 m.

Distribution: (Fig. 26H) Only known from the Balears where it lives sympatrically with *Ammonicera fischeriana*, *A. andresi*, *A. nodulosa* and *A. superstriata*.

Remarks: This species has certain similarities with those shells we have called the intermediate form of *A. fischeriana*, and with *A. nodulosa*.

Ammonicera fischeriana can be distinguished by being clearly larger and having a different protoconch (*A. fischeriana* has a wider internal groove and the cord that is delimited by the grooves has a more irregular surface (compare Figs. 12B-C with Figs. 24B-D)). This detail is important to distinguish this species from juveniles of *A. fischeriana*, intermediate form.

From *A. nodulosa*, it may be distinguished by its colour, golden yellow while *A. nodulosa* is more transparent and has a pearly white colour. In addition *A. nodulosa* presents a clear axial sculpture. In some shells of this latter species with a weaker axial sculpture, separation can be based on the width of the grooves of the protoconch which are slightly wider in *A. arrondoi* (especially the external one) while, in *A. nodulosa*, the grooves are narrower and without septation. Above all, the upper and lower zones are proportionately narrower in *A. arrondoi* than in *A. nodulosa*.

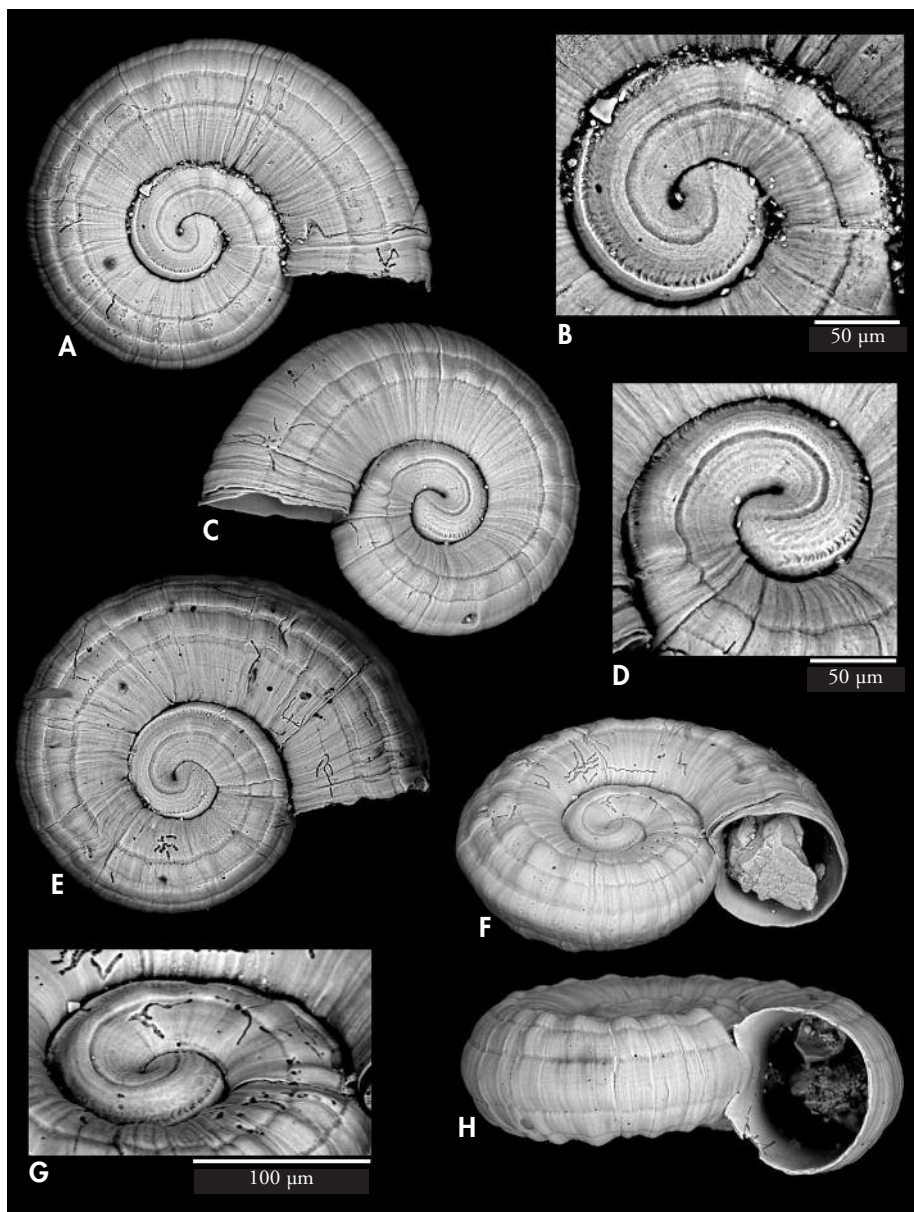


Figure 24. *Ammonicera arrondoi* spec. nov., Ibiza. A, B: holotype, 0.452 mm (MNCN) and its protoconch-teleoconch transition area; C, D: shell, 0.45 mm (CJDO-JT/MNCN) and its protoconch-teleoconch transition area; E: shell, apical view, 0.52 mm (CJDO-JT/MNCN); F, G: shell, upper lateral view, 0.53 mm (CJDO-JT/MNCN) and lateral view of its protoconch-teleoconch transition area; H: shell, lateral view, 0.49 mm (CJDO-JT/MNCN).

Figura 24. *Ammonicera arrondoi* spec. nov., Ibiza. A, B: holotipo, 0,452 mm (MNCN) y zona de transición protoconcha-teleoconcha; C, D: concha, 0,45 mm (CJDO-JT/MNCN) y zona de transición protoconcha-teleoconcha; E: concha, vista apical, 0,52 mm (CJDO-JT/MNCN); F, G: concha, vista lateral superior, 0,53 mm (CJDO-JT/MNCN) y vista lateral de su zona de transición protoconcha-teleoconcha; H: concha, vista lateral, 0,49 mm (CJDO-JT/MNCN).

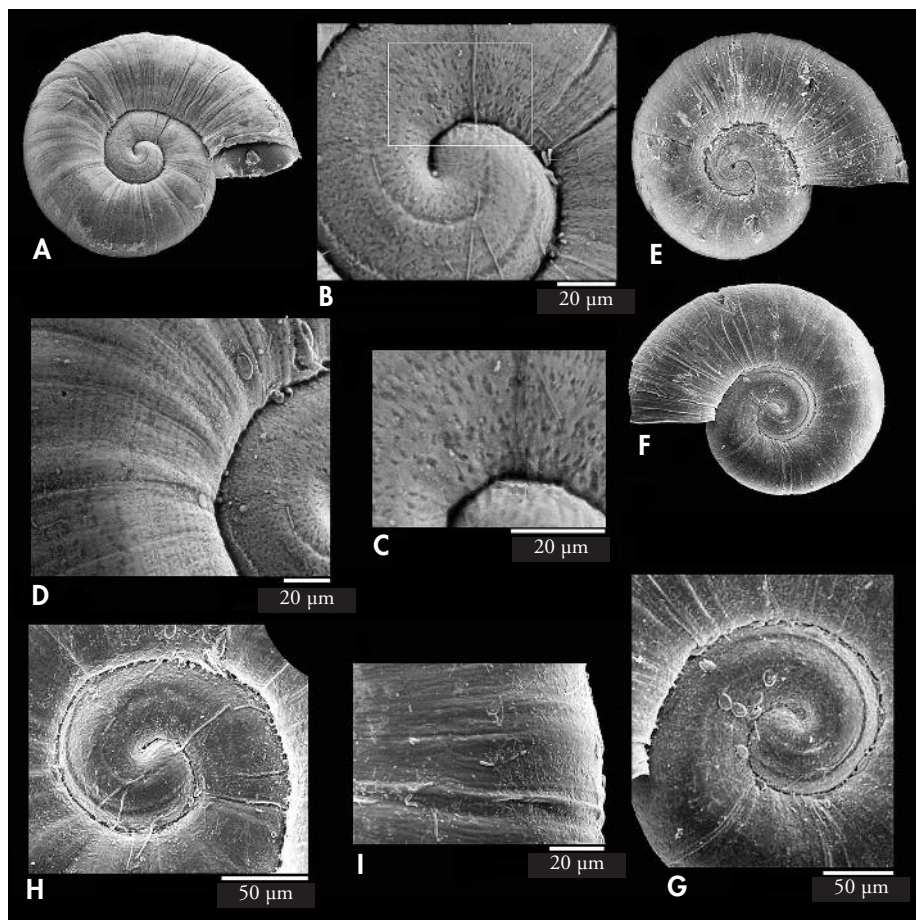


Figure 25. *Ammonicera galaica* spec. nov., Cape Silleiro, Baiona. A: holotype, 0.46 mm (MNCN); B, C: protoconch of the holotype and detail of the microsculpture; D: detail of the microsculpture of the holotype; E: paratype, 0.46 mm (MHNS); F, G: paratype, 0.43 mm, and protoconch (MNHN); H: protoconch of the holotype; I: detail of the microsculpture.

Figura 25. Ammonicera galaica spec. nov., Cabo Silleiro, Baiona. A: holotipo, 0,46 mm (MNCN); B, C: protoconcha del holotipo y detalle de la microescultura; D: detalle de la microescultura del holotipo; E: paratipo, 0,46 mm (MHNS); F, G: paratipo, 0,43 mm y protoconcha (MNHN); H: protoconcha del holotipo; I: detalle de la microescultura.

Ammonicera galaica spec. nov. (Figs. 40, 25A-I, 26I)

Type material: Holotype in MNCN (15.05/60147, Fig. 25A). Paratypes in the following: MNHN (IM-2012-36210, 1 s, Fig. 25C), MHNS (100694, 1 s, Fig. 25B, 40).

Type locality: Cape Silleiro (42°06.4'N, 08°54.3'W), Baiona, Pontevedra, Spain.

Etymology: The specific name alludes to Galicia, Spanish region where the species was collected.

Description: The holotype reaches 0.46 µm of diameter with about 2 whorls, and the paratypes are similar in size.

There is no relevant axial sculpture, neither on the protoconch nor on the teleoconch. A few growth lines, slightly irre-

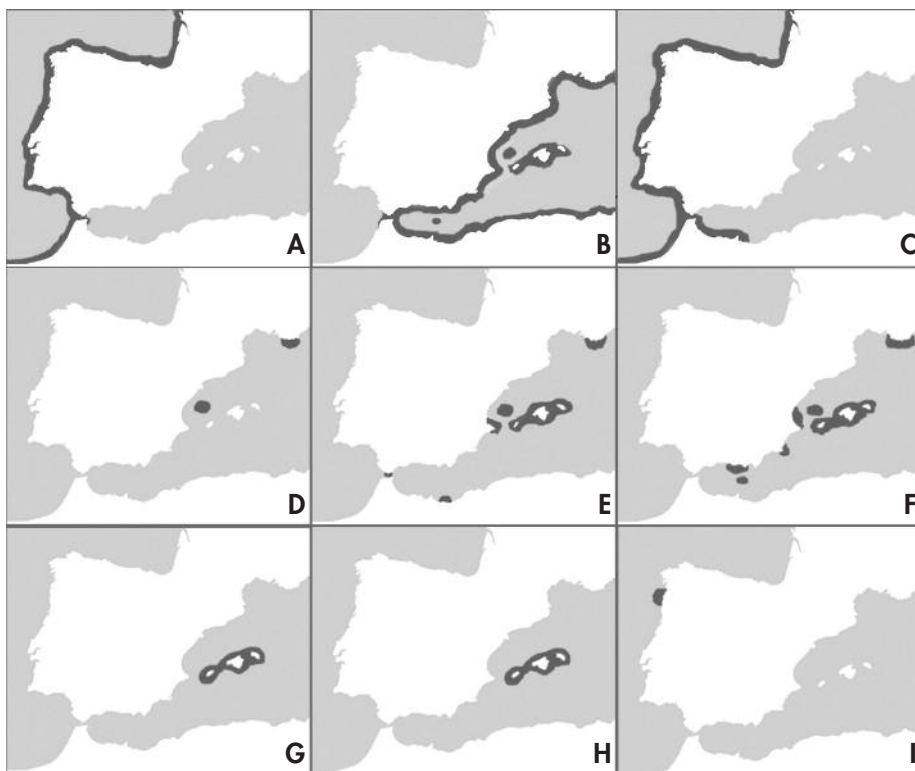


Figure 26. Distribution of the species. A: *Ammonicera rota* (Forbes & Hanley, 1850); B: *Ammonicera fischeriana* (Monterosato, 1869) (Mediterranean form); C: *Ammonicera fischeriana* (Monterosato, 1869) (Atlantic form); D: *Ammonicera columbreensis* spec. nov.; E: *Ammonicera andresi* spec. nov.; F: *Ammonicera nodulosa* spec. nov.; G: *Ammonicera superstriata* spec. nov.; H: *Ammonicera arrondoi* spec. nov.; I: *Ammonicera galaica* spec. nov.

Figura 26. Área de distribución de las especies. A: *Ammonicera rota* (Forbes & Hanley, 1850); B: *Ammonicera fischeriana* (Monterosato, 1869) (forma mediterránea); C: *Ammonicera fischeriana* (Monterosato, 1869) (forma atlántica); D: *Ammonicera columbreensis* spec. nov.; E: *Ammonicera andresi* spec. nov.; F: *Ammonicera nodulosa* spec. nov.; G: *Ammonicera superstriata* spec. nov.; H: *Ammonicera arrondoi* spec. nov.; I: *Ammonicera galaica* spec. nov.

gular and, at times, slightly elevated, can be seen under the SEM. The aperture is rounded with a thin edge. With high magnification, a very spiral fine striation can be detected on the teleoconch (Fig. 25D).

Protoconch and transition zone: The protoconch seems to have a rather precise limit, in a space between 0.8 and 1 whorl with about 150 μm in diameter. A rather clear scar is observed which could be the end of the protoconch. Another scar in the teleoconch is seen at 1.2 whorls and is similar to the previous one.

The sculpture of the protoconch is formed by two narrow and shallow grooves, of which the outer one is more evident than the internal, this last fading out after the first half whorl, while the external one is concealed by the suture after $\frac{3}{4}$ of whorl. This feature is best observed in apical view, while abapically the outer groove remains visible somewhat longer. Between both grooves of the protoconch, an irregular and somewhat spirally oriented microsculpture is seen in some areas.

Table I. Summary of the characters of the shell and protoconch for the species of *Ammonicera* in the Iberian Peninsula.

PROTOCONCH	<i>A. rota</i>	<i>A. fischeriana</i> Mediterranean	<i>A. fischeriana</i> Atlantic	<i>A. columbretensis</i>
Grooves on protoconch	1	2	2	1
Width of the grooves (Internal-external) (W: wide, N: narrow)	N	W - N	W - N	N
Space without ribs (SWR)	1/4 wh.	3/4 wh.	3/4 wh.	1/4 wh.
Microsculpture on protoconch	cells	rough, grooves insinuated	secondary spiral grooves	cells
Striae on the protoconch	no	variable+	yes++	no
Area between grooves	-	slightly elevated, no cordlets	elevated, with cordlets	-
Inside of grooves micropartitioned	Yes	Yes	No	Yes
TELEOCONCH				
Colouration	whitish red spiral lines	yellowish brown lines	yellowish golden	dark brown, whitish aperture
Spiral striation	None	Variable	Constant	No
Nodules on upper and lower cords	Hardly any	None, or very small	Small, variable in number	Very evident

Colour: The shell is transparent, almost colourless with a very light, pale yellow or brown hue (Fig. 4O)

Habitat: The material collected was found in the intertidal, and in first metres of subtidal in sandy sediments.

Distribution: (Fig. 26I) This species is only known from the type material. It is probable that its distribution range be extended from Galicia and others areas actually not well sampled.

Remarks: The lack of sculpture of the shell of this species makes it resemble species of the genus *Omalogyra*, with which it can be easily confused, but its protoconch clearly shows that it belongs to the genus *Ammonicera* (although this sculpture can only be recognized with the SEM).

CONCLUSIONS

For this work more than 2800 specimens and shells of *Ammonicera* have been studied; 2305 have been mentioned

The two narrow and inconspicuous grooves distinguish this species from those of other groups having a single groove (*A. rota*, *A. columbretensis*) and those which have two grooves, but one of them is thicker (*A. fischeriana*, *A. andresi*, *A. superstriata*). In addition, *A. andresi* has a strong sculpture and the SWR is very short and *A. superstriata* has a marked spiral striation on the whole shell.

From the other species with two narrower grooves (only *A. nodulosa* and *A. arrondoi*), it differs in being smaller; furthermore *A. nodulosa* has very marked sculpture on the protoconch and teleoconch; *A. arrondoi* has a clear spiral sculpture and the outer groove is somewhat wider.

in the types (108) and other material examined in this work. Given the difficulty to observe simply under the stere-

Tabla I. Resumen de los caracteres de la concha y protoconcha en las especies de *Ammonicera* de la Península Ibérica.

<i>A. andresi</i>	<i>A. nodulosa</i>	<i>A. superstriata</i>	<i>A. arrondoi</i>	<i>A. galaica</i>
2	2	2	2	2
W - N	N - N	W - N	N - W	N - N
1/2 wh.	3/4 wh.	3/4 wh.	3/4 wh.	1 whorl
micropits	micropits; spiral grooves	grooves very evident	Grooves evident	Irregular sculpture
no	no	yes+++	yes++	no
Internal border with rim	Little elevated No cordlets	Little elevated No cordlets	Little elevated No cordlets	Not elevate No cordlets
No	No	No	Yes	No
Yellowish Brown lines	Whitish red spiral lines	Brown with whitish nodules	Yellowish Brown lines	Uniform, Light brown
Yes	None or very slight	Very marked	None or very slight	Very slight
Acute	Small	Small	Small	None

omicroscope the characters of so small shells, the SEM studies had to be intensive. There were about 300 SEM micrographs taken, from which only 175 illustrate this work; additionally, hundreds of observations were made under the SEM albeit without taking pictures.

The number of species in this genus was hitherto underestimated, since few studies had been conducted and since there were few SEM photographs which had not been properly compared. In addition, the number of specimens studied so far had been very low.

Characters that have been found most important in the separation of species are those relating with the protoconch, assumed to be characters with little environmental variability and controlled genetically. The number of grooves, their width, the microsculpture of the cords that surround them, the inner septation of the grooves and the space without sculpture until the appearance of the first rib (SWR) have been found the most important.

The main protoconch characters and of some additional teleoconch characters are summarized in Table I to facilitate comparisons. Among the latter, the colour of shells was found useful (empirically found rather constant), and so were the spiral striation and the presence of nodules. Already in previous studies, the colour patterns had been the basis of separation of some species both of *Omalogyra* and *Ammonicera* (ROLÁN, 1992a, 1992b).

We concluded that the two species previously known in Europe were valid, were present in the Iberian Peninsula and had a certain degree of variability which we have tried to show. In addition, we have distinguished morphologically six more species which are described as new and documented with numerous SEM images.

Based on our current knowledge, the geographical distribution of the species studied, summarized on Figure 26, is the following:

1. In the Iberian Atlantic coast there are three species: the long well known *A. rota*, *A. fischeriana* (with a broad range of distribution) and, so far restricted to a particular area of Galicia, *A. galaica*.

2. In the Strait of Gibraltar (which includes the Southern part of Spain, Gibraltar and Northern Morocco), were found the already known *A. rota*, *A. fischeriana* Atlantic and Mediterranean form, and one of the new species *A. andresi*.

In some localities the Atlantic form seems to live together with the Mediterranean one.

3. The area where the greatest number of species is the Balearic archipelago (admittedly also where more samples have been taken), where *A. fischeriana* and four newly described species: *A. andresi*, *A. nodulosa*, *A. superstriata* and *A. arrondoi* were collected.

4. In the Iberian Mediterranean coast, only *A. fischeriana* is found in the entire coast. To this species may be added in Granada *A. nodulosa*; and in Levante the latter species and *A. andresi*. It must be kept in mind that large areas in the Mediterranean have been scarcely

sampled and material from there never compared with SEM. For this reason, the actual range of the new species may be wider than recorded here.

5. In the Columbretes Islands, not far away from the Spanish mainland coast, in addition to the common and extended *A. fischeriana*, *A. nodulosa*, *A. andresi* and *A. columbretensis* have been collected.

6. Finally, in the Chafarinas Islands, very close to the North African coast near easternmost Morocco, *A. fischeriana*, *A. pseudofischeriana* and *A. andresi* have been collected.

7- In the surroundings of Alborán island, *A. fischeriana* and *A. nodulosa* have been collected.

A key is here presented to facilitate the separation using the most important comparative characters. Due the small size of the shells, the structural details can only be observed with SEM. The following key is based on the appearance of the shell in apical view, a tempting to indicate, when possible, details observable with a stereomicroscope. The teleoconch characters are highly variable and therefore are more difficult to use as a basis for differentiation.

- 1 - Only one groove visible on the protoconch 2
 - Two grooves visible on the protoconch 3
- 2 - Colour of the shell golden yellowish or pearly whitish *A. rota*
 - Shell dark brown, with a whitish area near the aperture *A. columbretensis*
- 3 - Protoconch with one groove wider than the other 4
 - Protoconch with two equally narrow grooves 8
- 4 - The wider groove is in internal position 5
 - The wider groove is in external position *A. arrondoi*
- 5 - The apical area of the protoconch, besides the main grooves, has very evident secondary grooves *A. superstriata*
 - The apical area of the protoconch without evident grooves 6
- 6 - The space without ribs (SWR) after the nucleus of the protoconch is no more than ½ of whorl *A. andresi*
 - The space without ribs (SWR) is of ¾ of whorl after the nucleus 7
- 7 - Apical area of the protoconch with regularly aligned micropits in spiral direction *A. fischeriana* (Atlantic)
 - Apical area of the protoconch without micropits, or aligned irregularly *A. fischeriana* (Mediterranean)
- 8 - Shell strongly sculptured *A. nodulosa*
 - Shell practically smooth with only very fine spiral striation *A. galaica*

ACKNOWLEDGEMENTS

The authors thank the persons and institutions that have collaborated to make this work possible: MNCN, MNHN and MHNS for the loan of material for study; José Templado of the MNCN for allowing the examination of samples in the Museum and for his critical review of the manuscript; Javier de Andrés for his kindness and diligence to provide material from the MNCN; Serge Gofas for facilitating the loan of the MNHN material for study and the detailed revision of the work. For information about the types, to Andreia Salvador of the National History Museum United Kingdom and Massimo Appolloni, of the Museo Civico di Zoologia, Roma.

The photographs of the shells at SEM were made in several places:

- Scanning Electron Microscopy (SEM) FEI INSPECT y FEI QUANTA (5350 NE Dawson Creek Drive Hillsboro Oregon 97124 (USA) of the MNCN, by Laura Tormo, Marta Furió and Alberto Jorge.

- Scanning Electron Microscopy (SEM) XL30 and QUANTA 200 Centro de Apoyo Científico y Tecnológico a la Investigación (CACTI), University of Vigo, by Jesús Méndez and Inés Pazos.

- Centro de Apoyo Científico y Tecnológico, University of Santiago de Compostela (CACTUS), by Ramiro Barreiro and Raquel Antón Segurado.

For sampling collaborated: Antonio A. Monteiro, Mónica Albuquerque, Fernando Pires from Portugal; Marta Calvo and José Templado for providing material from the Chafarinas, Columbretes and Menorca Islands; Juan Carlos Sotelo Solana, Antonio Saa Pena and José Antonio Álvarez Clavero, for the collecting of samples in Galicia by diving; Frank Swinnen of Lommel, Belgium, for the loan of material from his collection; Ernesto Arrondo and Julián Martínez of S. C. INSUB, Donostia for the loan of sedimentary material.

We are also grateful to Marian Ramos, head of the Fauna Ibérica project, and to Secretaría General del Mar (especially Silvia Revenga) for the permissions and facilities for sampling in the Marine Reserves of Columbretes and Alborán Islands, and to Organismo Autónomo de Parques Nacionales, Ministerio de Medio Ambiente (especially Javier Zapata), for the facilities in Chafarinas Islands.

BIBLIOGRAPHY

- AARTSEN J.J. VAN, MENKHORST H.P.M.G. & GITTENBERGER E. 1984. The marine Mollusca of the Bay of Algeciras, Spain, with general notes on *Mitrella*, *Marginellidae* and *Turridae*. *Basteria*, suppl. 2: 1-135.
- BACKELJAU R.T., MEYER M. DE, JANSSENS L., PROESMANS R. & VADER W. 1984. *Ammonicera rota* in Norway (Mollusca, Gastropoda: Omalogyridae). *Fauna Norvegica* Ser. A, 5: 6-8.
- BIELER R. & MIKKELSEN P.M. 1998. *Ammonicera* in Florida: Notes on the smallest living gastropod in the United States and comments on other species of Omalogyridae (Heterobranchia). *The Nautilus*, 111 (1): 1-12.
- BOUCHET P. & ROCROI J.P. 2005. Classification and Nomenclator of Gastropod families. *Malacologia*, 47 (1-2): 1-397.
- CHERNYSHEV A.V. 2003. Three new species of the genus *Ammonicera* Vayssièrè, 1893 (Gastropoda, Omalogyridae) from the Japan Sea [In Russian]. *Ruthenica*, 13 (2): 107-112.
- DAUTZENBERG P. & FISCHER P.H. 1925. Les Mollusques marins du Finistère et en particulier de la région de Roscoff. *Travaux de la Station Biologique de Roscoff*, 3: 1-180.
- FORBES E. & HANLEY S.C. 1848-1853. A history of British Mollusca and their shells. Vol. 1: 1-486 (1848), Vol. 2: 1-480 (1 dec. 1849) 481-557 (1850), Vol. 3: 1-320 (1850) 321-616 (1851), Vol. 4: 1-300 (1852). Introduction. Plates I-LXXX [1853].
- FRANC A. 1948. Notes sur deux Homalogyridés: *H. Fischeriana* et *H. Atomus* et sur leur développement. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord*, 39 (7-8): 142-145.
- FRETTER V. & GRAHAM A. 1962. *British Prosobranch Molluscs*. Ray Society, London. 755 pp.
- FRETTER V. & GRAHAM A. 1978. The prosobranch molluscs of Britain and Denmark. Part 4: Marine Rissoacea. *Journal of Molluscan Studies*. Supplement 6: 153-241.

- GAGLINI A. & CURINI GALLETTI M. 1978. Alcune considerazioni sulla Fam. Omalogyridae. *Conchiglie*, 14 (11-12): 207-214.
- GOFAS S., MORENO D. & SALAS C. 2011. *Moluscos marinos de Andalucía, vol. II*. Universidad de Málaga, Servicio de Publicaciones. pp. i-xii, 344-798.
- GRAHAM A. 1988. *Molluscs: Prosobranch and Pyramidellid Gastropods*. The Linnean Society of London. Brill & Backhuys. 662 pp.
- HABE T. 1972. The Japan's smallest Gastropod, *Ammonicera japonica* sp. nov. *Venus*, 31 (3): 115-116.
- HIDALGO J.G. 1917. Fauna malacológica de España, Portugal y las Baleares. Moluscos testáceos marinos. Fauna Malacologica de España, Portugal y las Baleares. *Trabajos del Museo Nacional de Ciencias Naturales, Zoología*. 30: 1-752.
- HØISÆTER T. 1968. *Skenea nitens*, *Ammonicera rota*, *Odostomia lukisi* and *Eulimella nitidissima*, small marine gastropods new to the Norwegian Fauna. *Sarsia*, 31: 25-33.
- HØISÆTER T. 2009. Distribution of marine, benthic, shell bearing gastropods along the Norwegian coast. *Fauna norvegica*, 28: 5-106.
- JEFFREYS J.G. 1867. *British Conchology*. Vol. 1: CXIV + 341 pp. [1862]; Vol. 2: 479 pp. [1864]; Vol. 3: 394 pp. [1865]; Vol. 4: 487 pp. [1867]; Vol. 5: 259 pp. [1869]. London, van Voorst.
- KNUDSEN J. 1995. Observations on reproductive strategy and zoogeography of some marine prosobranch gastropods (Mollusca) from the Azores. *Açoreana, Supplement* 1995: 135-158.
- MACEDO M.C.C., MACEDO M.I.C. & BORGES J.P. 1999. *Conchas marinhas de Portugal*. Verbo, Lisboa. 516 pp.
- MONTEROSATO T. A. DI 1869. Description d'espèces nouvelles de la Méditerranée. *Journal de Conchyliologie*, 17 (3): 274-277, pl. 13, figs. 1-3.
- NOBRE A. 1940. *Moluscos marinhos e das águas salobras*. Editora do Minho, Porto. 806 pp, 87 pls.
- NORDSIECK F. 1968. *Die europäischen Meeres-Gehäuseschnecken*. Gustav Fischer, Stuttgart, 273 pp.
- OLIVER BALDOVÍ J.D. 2007. Catálogo de los Gasterópodos testáceos marinos de la parte Sur del golfo de Valencia (España). *Iberus*, 25 (2): 29-61.
- OLIVER J.D., TEMPLADO J. & KERSTING D.K. 2012. Gasterópodos marinos de las islas Columbretes (Mediterráneo occidental). *Iberus*, 30 (2): 49-87.
- PALAZZI S. 1988. Note sugli Omalogyridae mediterranei e maderensi. *Bollettino Malacologico*, 24 (5-8): 101-111.
- PALAZZI S. 1992. Note sugli Omalogyridae mediterranei e maderensi. Aggiunte. *Bollettino Malacologico*, 28 (5-12): 139-144.
- PALAZZI S. & GAGLINI A. 1979. Taxonomic notes on the Rissoidae and related families. II. The genus *Ammonicera* O.G. Costa, 1861. *Notiziario C.I.S.M.A.*, 1 (1): 29-37.
- PARENZAN, P. 1970. *Carta d'identità delle conchiglie del Mediterraneo*. vol. I. Bios Taras, Taranto, 283 pp.
- PEÑAS A., ROLÁN E., LUQUE A.A., TEMPLADO J., MORENO D., RUBIO F., SALAS C., SIERRA A. & GOFAS S. 2006. Moluscos marinos de la isla de Alborán, *Iberus*, 24 (1): 23-151.
- POPPE G.T. & GOTO Y. 1991. *European Seashells*. vol 1. Christa Hemmen, Wiesbaden. 352 pp.
- RODRÍGUEZ-BABIO C. & THIRIOT-QUIÉVREUX C. 1974. Gastéropodes de la région de Roscoff. Etude particulière de la protoconque. *Cahiers de Biologie Marine*, 15: 531-549.
- ROLÁN E. 1983. Moluscos de la Ría de Vigo 1. Gasterópodos. *Thalassas*, 1 (1) supl. 1: 1-383.
- ROLÁN E. 1992a. ("1991"). La familia Omalogyridae G.O. Sars, 1878 (Mollusca, Gastropoda) en el Archipiélago de Cabo Verde. *Graellsia*, 47: 105-116.
- ROLÁN E. 1992b. The family Omalogyridae G. O. Sars, 1878 (Mollusca, Gastropoda) in Cuba with description of eight new species. *Apex*, 7 (2): 35-46.
- ROLÁN E., LUQUE A.A. & PEÑAS A. 2009. Three new species of minute Heterobranchs (Gastropoda: Heterobranchia: Omalogyridae and Rissoellidae) from Namibia. *Gloria Maris*, 48 (6): 132-145.
- ROLÁN E. & OTERO SCHMITT J. 1996. *Guía dos moluscos de Galicia*. Ediciones Galaxia, Vigo, 318 pp.
- SABELLI B., GIANNUZZI-SAVELLI R. & BEDULLI D. 1990. *Catalogo Annotato dei Molluschi Marini del Mediterraneo*. Vol 1. Libreria Naturalista Bolognese. 348 pp.
- SARTORI A.F. & BIELER R. 2014. Three new species of *Ammonicera* from the Eastern Pacific coast of North America, with re-descriptions and comments on other species of Omalogyridae (Gastropoda, Heterobranchia). *Zootaxa*, 3872 (1): 1-21.
- SIMONE L.R.L. 1997. A new species of *Ammonicera* (Omalogyridae, Allogastropoda) from Brazil. *Journal of Conchology*, 36 (1): 43-50.
- SLEURS W. 1983. The marine microgastropods from the northern coasts of Papua New Guinea (Mollusca Gastropoda). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, 55 (2): 1-11.
- SLEURS W. 1985a. Marine microgastropods from the Republic of Maldives 1. Genus *Ammonicera* Vayssière, 1893, with description of four new species (Prosobranchia: Omalogyridae). *Basteria*, 49: 19-27.

- SLEURS W. 1985b. *Ammonicera angulata* sp. nov. from Laing Island, Papua New Guinea, with comments on the genus *Ammonicera* Vayssière, 1893. *Annales de la Société des Royales Zoologique de Belgique*, 115 (2): 177-181.
- VAYSSIÈRE A. 1893. Observations zoologiques et anatomiques sur l'*Ammonicera*, nouveau genre de Gasteropode Prosobranché. *Annales de la Faculté des Sciences de Marseille*, 3: 15-28.
- VERDUIN A. 1976. On the systematics of recent *Rissoa* of the subgenus *Turboella* Gray, 1847, from the Mediterranean and European Atlantic coasts. *Basteria*, 40: 21-73.

