Korean Journal of Malacology, Vol. 23(2): 155-164, December 30, 2007

# A New Species of *Arca* L., 1758 (Bivalvia: Arcidae) from New Caledonia, with Comments on the Genus

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## ABSTRACT

A new species, *Arca koumaci* Lutaenko et Maestrati n. sp. (Bivalvia: Arcidae), is described from New Caledonia. The species is characterized by the small size, the convex shell with a strong posterior umbonal ridge covered by spikes, the widely curved ventral margin, and presence of cancellate sculpture and convergent marginal teeth. Presence of spikes on the posterior ridge is a unique morphological feature recorded for the first time in the genus. It is proposed that the only subgenus, namely Pliocene *A.* (*Arcoptera*) Heilprin, 1887, apart from nominative, can be recognized in the genus. Three morphological types are distinguished within the genus based on shell shape and sculpture. Bathymetric analysis shows that representatives of *Arca* inhabit water depths down to 175 m, and more than half of Recent species were found below 50 m. Types of *A. bouvieri* P. Fischer, 1874, *Arca boucardi* Jousseaume, 1894, *Arca avellana* Lamarck, 1819, and *Arca retusa* Lamarck, 1819 are illustrated.

**Keywords:** Arcidae, *Arca*, Taxonomy, Morphological variability, Depth ranges.

## INTRODUCTION

The living bivalves of the genus *Arca* L., 1758 (Arcidae) are not numerous in the number of species, and 16 species are known worldwide. They are typical sessile, byssally attached bivalves occurring mainly in tropical and subtropical seas. The fossil record of the *Arca* seems goes back to the Late Cretaceous (Newell, 1969). Although a majority of the *Arca* species was described in the 18th-19th centuries (Lamy, 1907), still some new species and subspecies were recently recorded from the Arabian Sea and tropical West Africa (Oliver and Cosel, 1992; Oliver and Chesney, 1994).

When sorting a collection of bivalve mollusks taken at two sites in New Caledonia (Koumac and Touho) and in Baie du Santal – Lifou (Loyalty Islands) (Bouchet *et al.,* 2002), we segregated four species of the genus. Three of them are common Indo-Pacific species – *Arca navicularis* Bruguiére, 1789, *Arca ventricosa* Lamarck, 1819 and *Arca avellana* Lamarck, 1819 however, the fourth species with some unusual morphological features appeared to be a new species. Below is given a description of this species along with some comments on the morphological diversity of the genus *Arca.*

**Abbreviations**

MNHN: Muséum National d'Histoire Naturelle, Paris; ZMFUL: Zoological Museum, Far East National University, Vladivostok.

## SYSTEMATICS

Family Arcidae Lamarck, 1809

Subfamily Arcinae Lamarck, 1809

Genus *Arca* Linne, 1758

Type species. - *Arca noae* Linnaeus, 1758 (SD Schmidt, 1818; ICZN Opinion 189, 1944).

Received September 30, 2007; Accepted November 8, 2007
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1225-3480/23201

***Arca* (*Arca*) *koumaci* Lutaenko et Maestrati n. sp.**
(Fig. 1A-G)

**Type material**. - Holotype: New Caledonia, Secteur de Koumac, Grand Récif de Koumac, 20° 40'-40.6'S, 164° 11.2'-164° 12.1'E, depth 55-57 m, sta. 1331, expedition Montrouzier, October 1993, length 6.1 mm, height 3.0 mm, width 3.3 mm (MNHN); paratypes: same locality (8 MNHN).

**Other material examined**. - Iles Loyaute, Lifou, Baie

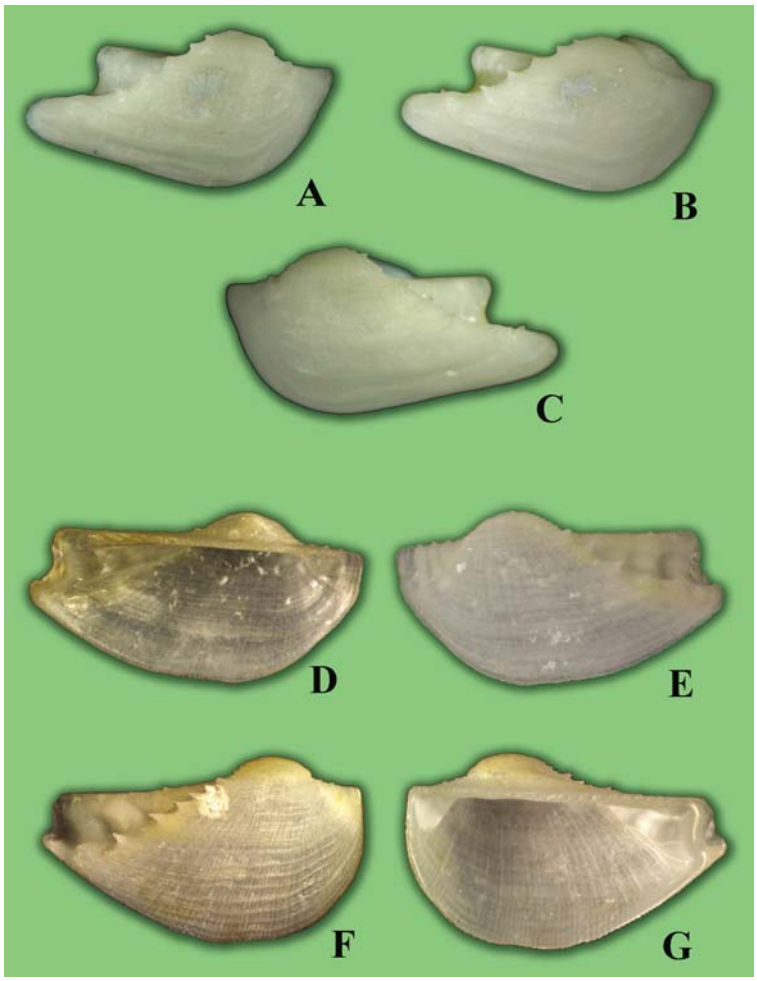


**Fig. 1. A-C.** *Arca* (*Arca*) *koumaci* Lutaenko et Maestrati n. sp. **Holotype**. New Caledonia, secteur de Koumac, Grand Récif de Koumac, 20º 40'-40.6' S, 164º 11.2' - 164º 12.1' E, depth 55-57 m. External views of the shell; Fig. 1A and Fig. 1B are differently turned shell images to show spikes on the postero-ventral ridge. Length 6.1 mm. MNHN. **D**, **E**. *Arca* (*Arca*) *koumaci* Lutaenko et Maestrati n. sp. **Paratype.** New Caledonia, secteur de Koumac, Grand Récif de Koumac, 20º40'-40.6' S, 164º 11.2' - 164º 12.1' E, depth 55-57 m. Internal (D) and external (E) views of the same valve. Length 6.5 mm. MNHN. *Arca* (*Arca*) *koumaci* Lutaenko et Maestrati n. sp. **F**, **G**. **Paratype.** New Caledonia, secteur de Koumac, Grand Récif de Koumac, 20º 40'-40.6' S, 164º 11.2' - 164º 12.1' E, depth 55-57 m. External (F) and internal (G) views of the same valve. Length 4.3 mm. MNHN.

du Santal, 20° 50.8'S-167° 09.7'E, depth 10-12 m, sta. 1445, atelier Lifou, November 16, 2000 (2 MNHN); Iles Loyaute, Lifou, Baie du Santal, au nord du Cap Aimé Martin [=Acadro], 20° 45.8' S - 167° 01.65'E, depth 20 m, sta. 1448, atelier Lifou, November 17, 2000 (2 MNHN); Iles Loyaute, Lifou, Baie du Santal:

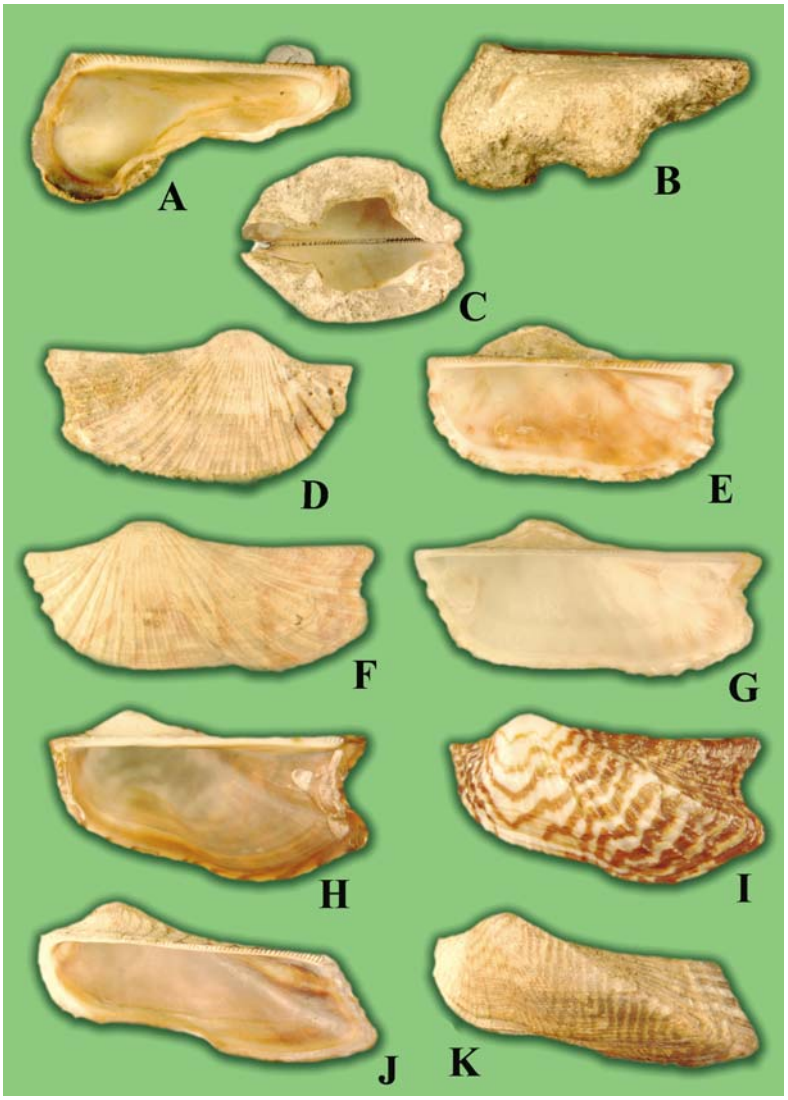


**Fig. 2.** **A**-**C**. *Arca* (*Arca*) *angulata* King et Broderip, 1831. Juan Fernandez. Length 47.3 mm. Internal (A), external (B) and ventral (C) views of the same shell. MNHN. **D**, **E**. *Arca* (*Arca*) *navicularis* Bruguière, 1789. Djibouti. Length 36.8 (D), length 36.1 mm (E). External (D) and internal (E) views. MNHN (coll. E. Lamy). **F**, **G**. *Arca* (*Arca*) *navicularis* Bruguière, 1789 (as *Arca linter* Jonas, 1845 in label). China. Length 63.7 mm. External (F) and internal (G) views of the same shell. MNHN (coll. E. Lamy). **H**, **I**. *Arca* (*Arca*) *pacifica* (G.B. Sowerby I, 1833). St. Elena. Length 43.1 mm. Internal (H) and external (I) views of the same shell. MNHN (coll. E. Lamy). **J**, **K**. *Arca* (*Arca*) *truncata* (G.B. Sowerby I, 1833). Galápagos Islands. Length 58.1 mm. Internal (G) and external (K) views of the same shell. MNHN.

devant Peng tombant, 20° 53.8' S – 167° 07.3' E, depth 48-52 m, sta. 1443, atelier Lifou, November 14, 2000 (1 MNHN).

**Type locality**. New Caledonia, Secteur de Koumac.

Etymology. - The species name derives from Koumac, a locality in New Caledonia.

**Distribution**. The species is known New Caledonia and neighboring Loyalty Islands.

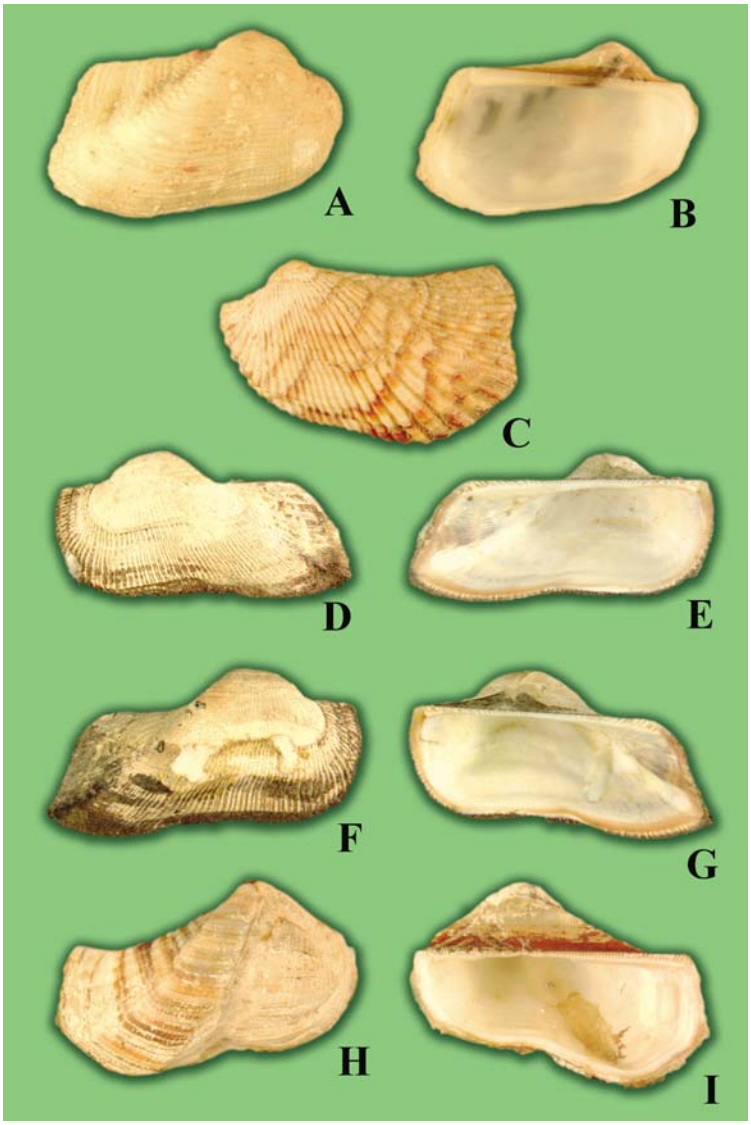


**Fig. 4. A**, **B**. *Arca* (*Arca*) *avellana* Lamarck, 1819. Indo-China. External (A) and internal (B) views of the same valve. Length 27.8 mm. MNHN (coll. E. Lamy). **C**. *Arca* (*Arca*) *bouvieri* P. Fischer, 1874. **Paratype** (according to Oliver and Cosel, 1992, p. 297). "Côtes de Guinée" on the original label. External view of the left valve. Length 43.8 mm. MNHN. **D**-**G**. *Arca* (*Arca*) *boucardi* Jousseaume, 1894. **Syntype**.External (D, F) and internal (E, G) views of the same shell. Length 58.1 mm. MNHN. **H**, **I**. *Arca* (*Arca*) *imbricata* Bruguière, 1789. Martinique. External (H) and internal (I) views of the same valve. Length 44.8 mm. MNHN.

**Diagnosis.** Small size, convex, with a strong posterior umbonal flexure (ridge) covered by spikes, widely curved ventral margin, cancellate surface sculpture, convergent marginal teeth.

**Description.** Shell small, convex, moderately thick, angular-ovate, inaequilateral, with extended posterior margin white, sometimes yellowish, especially in near-umbonal area. Anterior margin curved and

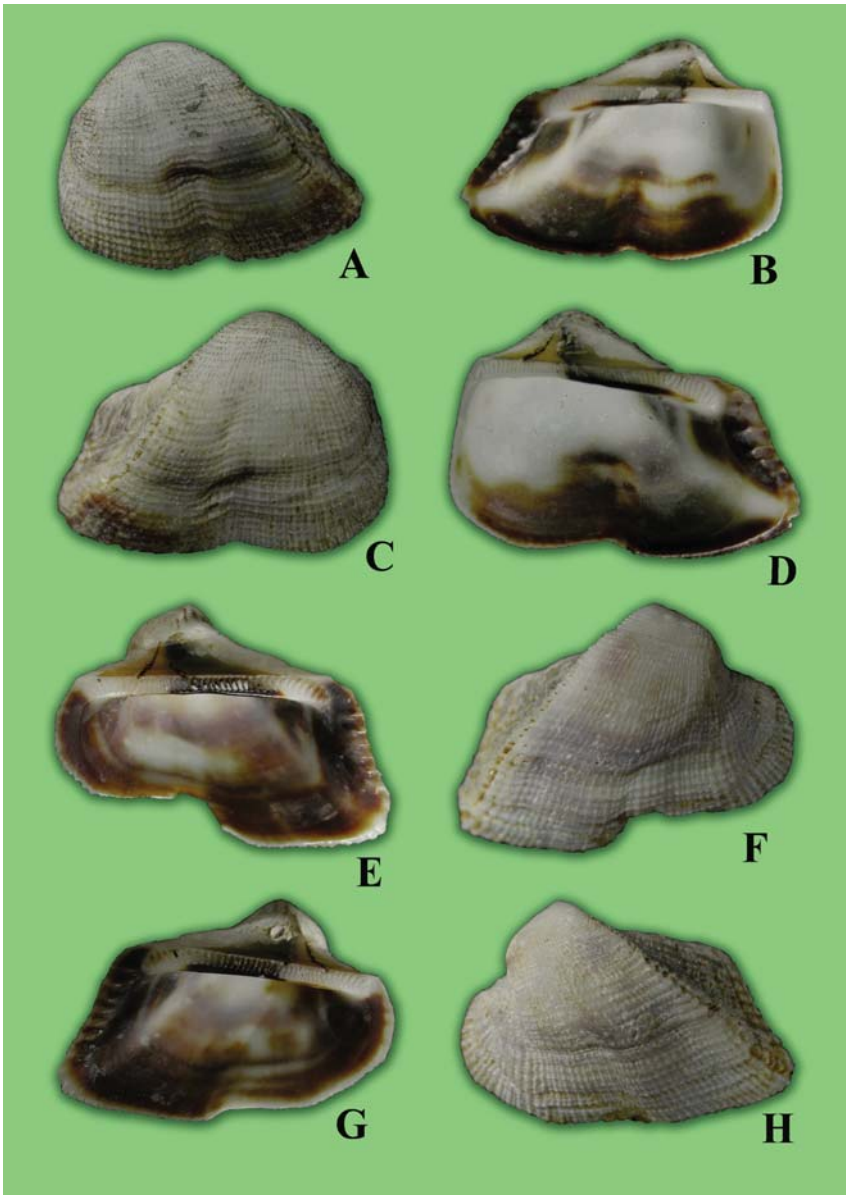


**Fig. 5. A-D**. *Arca* (*Arca*) *avellana* Lamarck, 1819. **Syntype**. "Iles St. Pierre et St. François" [on the cardboard to which shells were originally glued]. External (A, C) and internal (B, D) views of the same shell. Fig. 5B, C were first published by Lamy (1904, pl. 5, figs. 1, 2). MNHN. **E-H**. *Arca* (*Arca*) *avellana* Lamarck, 1819. **Syntype**. "Iles St. Pierre et St. François" [on the cardboard to which shells were originally glued]. Internal (E, G) and external (F, H) views of the same shell. Length 17.7 mm. MNHN.

smoothly passing into ventral margin, but meets straight hinge line at a nearly 90º angle. Ventral margin widely curved, sometimes nearly straight and subparallel to dorsal margin. Posterior margin with a depressed area (sulcus) corresponding to posterior umbonal flexure. Beaks high, inclined anteriorly. Shell

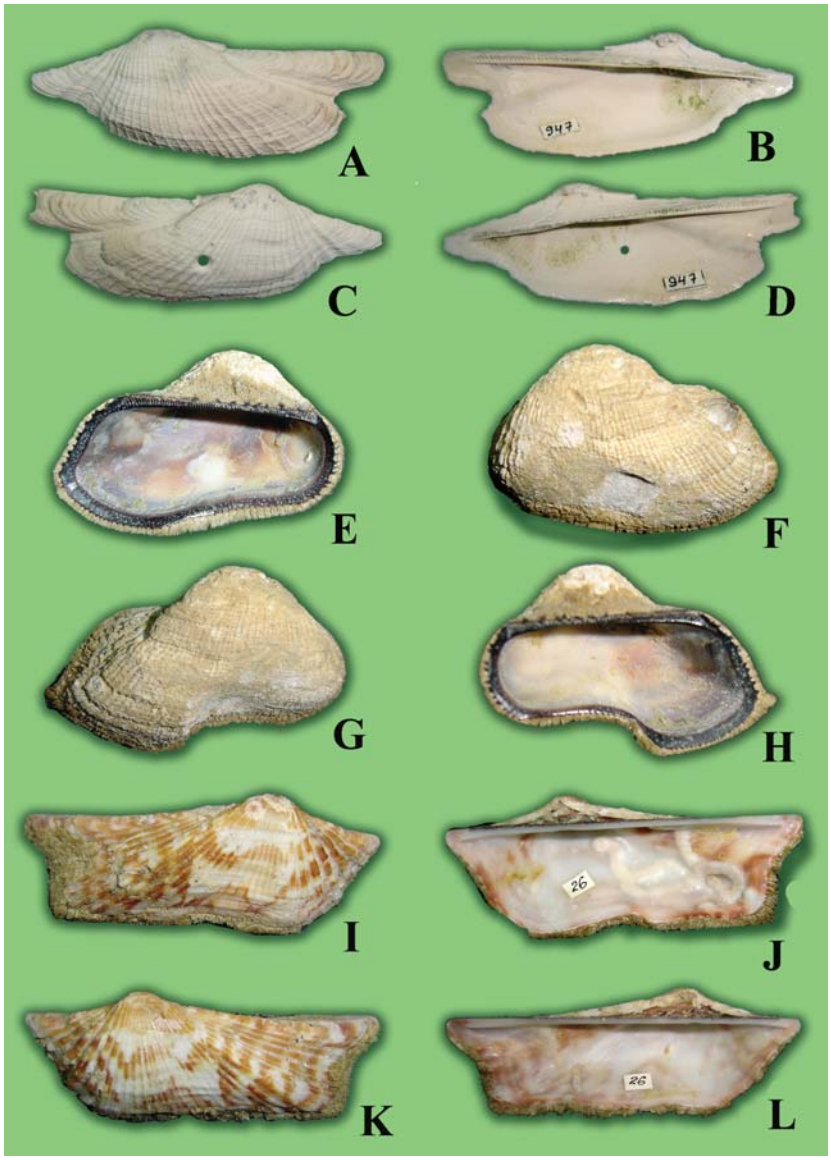


**Fig. 3. A**-**D**. *Arca* (*Arcoptera*) *wagneriana* Dall, 1898. USA, south Florida, between Tampa and St.-Petersburg, Sarasota rock pits, Calloosahatchee Formation. External (A, C) and internal (B, D) views of the same shell. Length 60.4 mm. ZMFU no. 10680/Bv-947. **E**-**H**. *Arca* (*Arca*) *mutabilis* (G.B. Sowerby III, 1833). West Central America, Costa Rica – El Salvador area. External (F, G) and internal (E, H) views of the same shell. Length 36.1 mm. ZMFU no. 12331/Bv-1583. **I-L**. *Arca* (*Arca*) *navicularis* Bruguière, 1789. Cambodia, Gulf of Thailand, Kampong Bay, 10º 51' N, 103º 09' E. External (I, K) and internal (J, L) views of the same shell. Length 61.7 mm. ZMFU no. 8925/Bv-26.

surface covered with numerous riblets giving in combination with commarginal lines cancellate sculpture. Growth lines gross. A series of spikes (5-7) located on posterior ridge. Interiorly, radial lines clearly corresponding to outer riblets. Inner margin smooth or with weak crenulations. Ligamental area wide, assymetrical and triangular in shape, smooth, without grooves or shevrons; widest behind the beaks. Based on ligament fragments, the ligament does not cover the ligamental area completely, but only its anterior part. Teeth transverse in middle part, but clearly convergent at margins, especially posteriorly. Maximum length up to 12-13 mm.

**Remarks.** This species is clearly differentiated from all known species of the genus by its small size, presence of spikes on posterior ridge, and lack of ventral sulcus. In shell shape, it is somewhat close to some varieties of *A. navicularis* (Fig. 2F, G). Some specimens of *A. koumaci* are similar in shell shape to European/West African *Arca tetragona* Poli, 1795 and north-western Pacific *Arca boucardi* Jousseaume, 1894.

## DISCUSSION

Recent representatives of the genus *Arca* show significant morphological variability within a single species. This fact and presence of sibling species were the reasons why so many species names were introduced in the 19th century and thus led to a complicated synonymy (Lamy, 1907). Most likely, there are 17 Recent species and subspecies of *Arca* (some are shown in Fig. 2-6): four in eastern Atlantic (*A. noae* L., 1758, *A. bouvieri* P. Fischer, 1874, *A. avellana turbatrix* Oliver et Cosel, 1992, and *A. tetragona* Poli, 1795), two in Western Atlantic [*A. zebra* (Swainson, 1833), and *A. imbricata* Bruguière, 1789], four in Eastern Pacific [*A. mutabilis* (G.B. Sowerby I, 1833), *A. pacifica* (G.B. Sowerby I, 1833), *A. truncata* (G.B. Sowerby I, 1833), and *A. angulata* King et Broderip, 1831)], and seven are known in Indo-Pacific and Western Pacific (*A. navicularis, A. avellana avellana, A. ventricosa, A. symphenacis* Oliver et Chesney, 1994, *A. boucardi* Jousseaume, 1894, *A. acuminata acuminata* Krauss, 1848, *A. acuminata dayi* Oliver et Chesney, 1994, and *A. koumaci)*; thus, in total, 16 species. Despite intraspecific variability, attempts to subdivide the genus into subgenera were not successful due to uniformity of the most important arcine features. Newell (1969) recognized, except for nominal subgenus *Arca* (*Arca*), Jurassic *Arca* (*Eonavicula*) Arkell, 1929 (type species – *Arca quadrisulcata* J.C. Sowerby, 1824) on the basis that its median teeth are more elongate than in *Arca* (*Arca*) converging strongly downward toward a point below beaks. In an earlier classification of arcids by Reinhart (1935), there are four subgenera: *A.* (*Arca*), *A.* (*Litharca*) Gray, 1842, *A.* (*Arcoptera*) Heilprin, 1887, and *A.* (*Eonavicula*). Monotypic *Litharca* is now recognized as a separate genus within Arcinae representing a case of unusual adaptation to the rock-boring mode of life (Nicol and Jones, 1986); Frizzel (1946) even erected a subfamily, Litharcinae for *Litharca lithodomus* (G.B. Sowerby I, 1833) although this did not find wide acceptance. Reihart (1935) noted that some species are gradational between *Arca* s.s. and *Eonavicula,* and that some Tertiary species unquestionably belonging to *Arca* s.s. also have inclined teeth. So, the status of *Eonavocula* is not clear. Although in various true *Arca* the posterodorsal "wing" is extended to varying degrees, the extremely developed wing and unusual attenuation of the anterior end of the shell of *Arcoptera* (Fig. 3A-D) make this taxon sufficiently distinct morphologically from *Arca* s.s. and it should be taken as a subgenus of the latter. According to L. Campbell (e-mail, Dec. 3, 2005), *Arcoptera* developed in the Lower Pliocene of southern Florida, was common in the Middle and Upper Pliocene of southern Florida, was very rare in the Upper Pliocene of north and south Carolina, and became extinct by 1.6 million years before present. Nothing in its niche suggests adaptive value for its peculiar form. Finally, *Tetrarca* Nordsieck, 1969 (type species – *Arca tetragona* Poli, 1795) is an obvious synonym of *Arca* although Oliver and Chesney (1994) used it at the subgeneric level for *A. acuminata.* Thus, probably, *Arcopterais* the only good subgenus of *Arca.*

Nevertheless, morphological variability of the *Arca*

might be summarized as below although functional significance of used characters needs special investigation. Some species (e.g. *A. angulata, A. bouvieri*) can be regarded as intermediate between Types 1 and 2.

**Type 1.** Species without postero-dorsal "wing" and

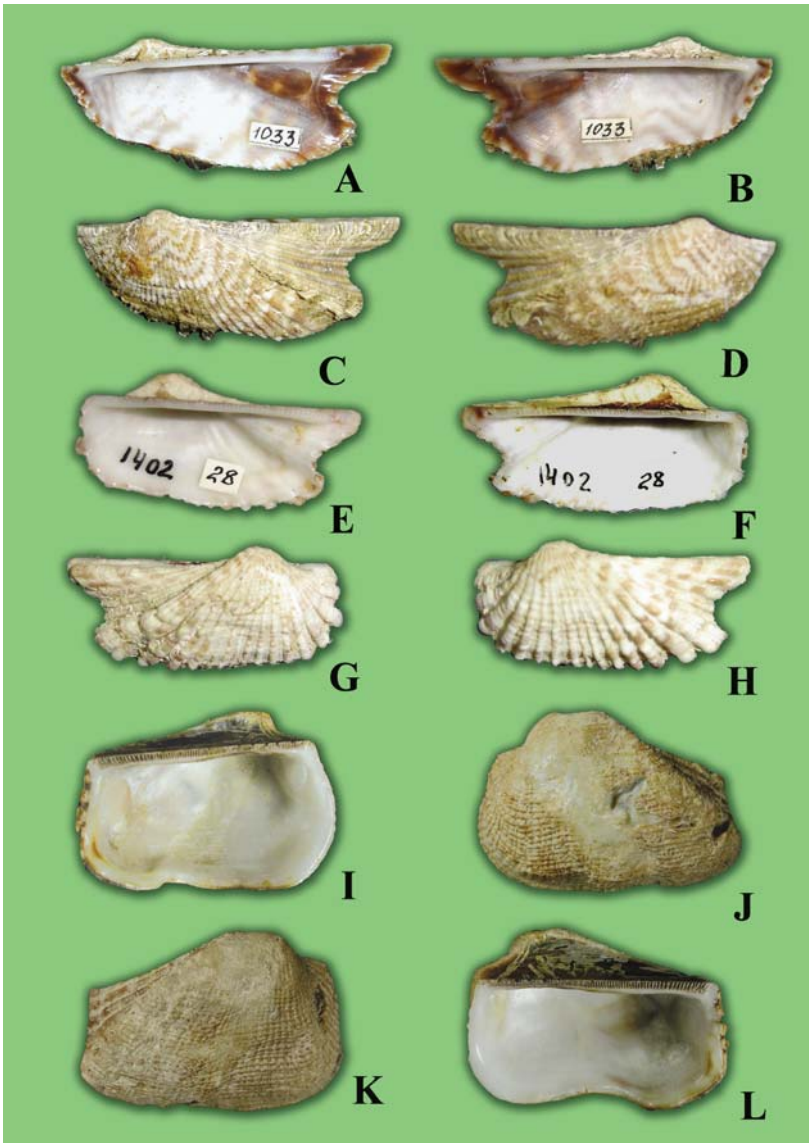


**Fig. 6. A-D**. *Arca* (*Arca*) *zebra* (Swainson, 1833). USA, Florida, Key Largo, depth 30 m. External (C, D) and internal (A, B) views of the same shell. Length 43.1 mm. ZMFU no. 10788/Bv-1033. **E**-H. *Arca* (*Arca*) cf. *navicularis* Bruguière, 1789. Australia. External (G, H) and internal (E, F) views of the same shell. Length 29.9mm. ZMFU no. 8927/Bv-28. **I-L**. *Arca* (*Arca*) *avellana* Lamarck, 1819. **Syntype** of *Arca retusa* Lamarck, 1819. "Mèditerranèe" [on the cardboard to which shell was originally glued]. Internal (I, L) and external (J, K) views of the same shell. Length 38.4 mm. Fig. 6K was first published by Lamy (1904, pl. 5, fig. 12). MNHN.

without posterior sulcus, but with ventral sulcus. Anterior margin is more or less rounded. Sculpture consists of riblets rather than ribs. Postero-ventral point is more prominent as compared to postero-dorsal point. Examples: *A. avellana, A. boucardi, A. mutabilis, A. truncata, A. imbricata, A. tetragona* (Fig. 2-6).

**Type 2.** Species with a well-expressed protruded postero-dorsal "wing". As a rule, anterior margin is acute. Sulcus in the posterior area is always well-marked. Ventral sulcus is present. The "wing" is either longer than lower prominence of the sulcus or both are equal in length. Sculpture with usually gross, clearly seen ribs rather than riblets. The most extreme example is *A. wagneriana. Other examples: A. navicularis, A. pacifica, A. zebra* (Fig. 2, 3, 6).

**Type 3.** Species with an expressed postero-dorsal "wing" and a posterior sulcus, but with a widely curved or nearly straight ventral margin and without ventral sulcus. Clearly convergent teeth at margins and presence of spikes on the posterior ridge also differentiate this type from Types 1-2. The only known example is *A. koumaci.*

Oliver and Holmes (2006) developed another classification of morphotypes within the genus *Arca* highlighting overlooked characters such as presence of a myophoric flange (in *A. tetragona*), degree of coverage of ligament, *etc.* They (l.c.) proposed to distinguish three morphotypes: *A. noae* group, *A. avellana* group and *A. tetragona* group, but above authors did not define precisely the groups and did not include into the consideration such strange fossil arcines as *Arcoptera.*

An interesting morphological feature of *Arca koumaci,* i.e., presence of spikes on the posterior ridge, requires further observations of animals in nature to be explained in terms of habit and functional morphology. Usually, arcoids are characterized by simple surface patterns, lacking divaricate sculpture, spines and other specialized structures (Thomas, 1978). Many of them (e.g., anadarines) have strong radial ribs, whilst nestling species (*Arca, Barbatia*) possess finer ribs which increase friction between the shell and the crevice the mollusk occupies (l.c.). However, nestling species do not show any examples of complicated sculpture of the shell.

*Arca koumaci* was found at a depth of 10-57 m although it is generally believed that representatives of the genus are shallow-water bivalves often living in the intertidal zone (Tatishvili, 1966). However, compilation of available literature data on bathymetric ranges for 10 species of *Arca* (*A. avellana, A. boucardi, A. bouvieri, A. mutabilis, A. navicularis, A. noae, A. pacifica, A. tetragona, A. tetragona, A. zebra*) occurring in different geographic areas (Rost, 1955; Kuroda *et al.,* 1971; Keen, 1971; Rios, 1985; Oliver and Cosel, 1992; Poppe and Goto, 1993; Kubo and Kurozumi, 1995; Hrs-Brenko and Legac, 1996; Lamprell and Healy, 1998; Higo *et al.,* 1999; Lutaenko, 1999; Peharda *et al.,* 2002; Robba *et al.,* 2002; Li, 2004 Krylova, 2006) surprisingly revealed that many of them are rather "deep-water" mollusks: nine species live below 50 m and at least five species were found below 100 m with maximum known depth of 175 m in the Pacific Ocean (*A. boucardi* in Sagami Bay, Japan) and even 1557 m in the Atlantic Ocean (*A. tetragona* near the Azores). Actually, some of these records represent empty shells which can be easily moved downslope due to wave and current actions and precise taphonomic analysis of shallow-water environments is needed to prove such bathymetric distribution of *Arca* however, these data show general trend of wide depth ranges for species of the genus. Thus, *A. koumaci* is not a unique example with regard to its bathymetric distribution.

## ACKNOWLEDGEMENTS

We express our appreciation to Prof. Ph. Bouchet (MNHN) for consultations and comments on the manuscript, and to V. Hèros and D. Brabant for their invaluable help. We are grateful to E.V. Coan (California Academy of Sciences, San Francisco) and L. Campbell (University of South Carolina, Spartanburg) for their comments on the genus Arca. Digital plates were prepared by K.S. Sundukov, English text was improved by T.N. Koznova.

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