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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

The genus *Granulina* (Mollusca: Gastropoda: Neogastropoda) from the Turkish coasts with taxonomical notes on some Mediterranean species

Akdeniz türleri üzerine bazı taksonomik notlarla birlikte, Türkiye kıyılarındaki *Granulina* (Mollusca: Gastropoda: Neogastropoda) genusunun durumu

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Abstract: In the present study four *Granulina* species we recognized from the Turkish coasts: *G. marginata* (Bivona, 1832), *G. occulta* (Monterosato, 1869), *G. boucheti* Gofas, 1992 and *G. melitensis* Smriglio, Mariottini & Rufini, 1998. The high variability of the shell morphology is studied and «morphologic affinities» are comparatively analized, and two different complex of species are here recognised: the *G. marginata*/*G. boucheti* complex and the *G. occulta*/*G. melitensis* complex. Meanwhile, with our records the number of the species known from the research area has been increased to four with the addtion of *G. boucheti* and *G. melitensis*. The name *Granulina guttula* La Perna, 1999 is restored, being considered as not preoccuped by *Erato guttula* Sowerby, 1832. *Granulina gubbiolii* Smriglio & Mariottini, 1999 is here recognised as a junior synonym of *Granulina minusculina* (Locard, 1897).

***Keywords*:** *Granulina*, Turkish coasts, shell morphology, variability, species complex

Öz: Türkiye kıyılarından dört *Granulina* türü bilinmektedir: *G. marginata* (Bivona, 1832), *G. occulta* (Monterosato, 1869), *G. boucheti* Gofas, 1992 ve *G. melitensis* Smriglio, Mariottini & Rufini, 1998. Bu çalışmada, *G. marginata*/*G. boucheti* ve *G. occulta*/*G. melitensis* grubu olmak üzere, iki «morfolojik benzerlik» çerçevesinde türlerin kabuk morfolojisindeki büyük değişkenlik karşılaştırmalı olarak incelenmiş ve *G. boucheti* ile *G. melitensis* türlerinin de ilave edilmesiyle, araştırma sahasından bilinen tür sayısı dörde yükselmiştir. *Granulina guttula* La Perna, 1999 türünün, *Erato guttula* Sowerby, 1832 den farklı bir tür olduğu belirlenmiş ve ilk türün geçerliliği korunmuştur. *Granulina gubbiolii* Smriglio & Mariottini, 1999 ise *Granulina minusculina* (Locard, 1897)'nın genç sinonimi olarak ele alınmıştır.

Anahtar kelimeler: *Granulina*, Türkiye kıyıları, kabuk morfolojisi, değişkenlik, tür grupları

INTRODUCTION

In his revision of the Mediterranean species of *Granulina*, Gofas (1992) distinguished four previously described species: *G. marginata* (Bivona, 1832) from the infralittoral of the whole Western Basin, Eastern Sicily and Djerba Island (Tunisia); *G. occulta* (Monterosato, 1869) from the circalittoral of the Western Basin; *G. minusculina* (Locard, 1897) from the bathyal of the Alboran Sea; and *G. vanhareni* (van Aartsen, Menkhorst & Gittenberger, 1984) from the infralittoral of the Strait of Gibraltar. He furthermore described two new species from the Mediterranean waters : *G. boucheti* from the upper infralittoral of southeastern Sicily (Acitrezza) and *G. torosa* from the lower infralittoral of the Strait of Gibraltar (Ceuta). The studies carried out by Gofas hushered an era of intensive descriptions of new taxa in the genus *Granulina* for the Mediterranean waters, which was followed by the other studies in which were also described new for the science several taxa, as: *G. gofasi* Smriglio & Mariottini, 1996 from the bathyal of Tyrrhenian Sea (Lazial Coast); *G. melitensis* Smriglio, Mariottini & Rufini, 1998 from the circalittoral of Malta and Eastern Tyrrhenian Sea (Lazial Coast); *G. gubbiolii* Smriglio & Mariottini, 1999 from the bathyal of western Alboran Sea (Estepona); *G. guttula* La Perna, 1999 (later renamed as *G. mediterranea* Landau, La Perna & Marquet, 2006) from the circalittoral of Eastern Tyrrhenian Sea (Ponza Island); *G. pusaterii* Smriglio & Mariottini, 2003 from the circalittoral of Central Tunisia (Sfax); *G. lapernai* Smriglio & Mariottini, 2013 from the upper circalittoral of Scilla and the southeastern Tyrrhenian side of the Messina Strait; *G. zanclea* Bogi, Boyer, Renda & Giacobbe, 2016 from the upper bathyal of Eastern Tyrrhenian Sea (Bagnara Calabra). Hereby, just after only 20 years after the above-mentioned review of Gofas, the number of *Granulina* species known from the Mediterranean waters increased from six to thirteen, all observed from the Western Basin and the far-western part of Central Mediterranean (southeastern Sicily, Malta and Tunisia).

We hereafter propose to restore *Granulina guttula* La Perna, 1999 as valid taxon. When renaming «*G. guttula*» as

«*G. mediterranea*», Landau et al. (2006) considered this former name as preoccuped by «*Granulina guttula* (Sowerby, 1837)». But Sowerby (1832 : 16 and 1837 : pl. VII, fig. 50) described *Erato guttula* in his *Erato* Section. Boyer (2015:12), studying and revising this taxon, proved to be an *Hydroginella* species, not an *Erato* neither a *Granulina*. So the name *Granulina guttula* La Perna, 1999 cannot be considered as preoccuped by *Erato guttula* Sowerby, 1832, both taxa corresponding to perfectly different genera.

Several main morphologic groups seem to occur in this fauna: *G. marginata* and *G. boucheti*, mostly ranging in upper infralittoral depths, are pretty looking similar for the shell features, being sometimes difficult to recognize on this simple ground. They can more easily distinguished on the ground of the animal chromatism; *G. minusculina*, *G. melitensis* and G. *gubbiolii* look to be very similar on the ground of shell features, may be conspecific or corresponding to geographic or bathymetric populations; *G. gofasi* and *G. pusaterii* both presenting possible affinitties with this group but looking as less closely related; *G. occulta*, *G. guttula* and *G. lapernai*, mainly known from the circalittoral of the Tyrrhenian Sea, although they show some similar morphologic features, the mentioned species cannot be considered as closely matching.

Many of these species (geographic or bathymetric forms) seem to be restricted to a rather limited range, but despite the significant progress made over the last 35 years in sampling of materials and field studies of Mediterranean marine mollusca, only in few places the micro-molluscs were seriously studied. So despite the important progress performed recently in the faunistic inventory of *Granulina* in Mediterranean Sea, we must consider that much remains to do, as well concerning the intensive samplings at coastal and circalittoral levels all around the Mediterranean area than concerning more accurate studies about the intraspecific variability, the real specific diversity playing in Mediterranean Sea, and the composition of the species-groups in this area.

As a contribution to such a duty, we propose herein a revision of the *Granulina* fauna collected along the Turkish coasts, on the ground of an original material recently collected along the Aegean and Levantine Coasts. Only two *Granulina* species (*G. marginata* and *G. occulta*) were reported in the recent inventory of the marine molluscs from the Turkish waters (Öztürk *et al*., 2014). The numerous *Granulina* specimens at hand obtained from a wide area allowing to display nowadays a possibility to study the intraspecific disparity at work, and the point of species limits being challenged, the identification key of the referable species will be first checked, before to deal with a study of the morphologic variability playing in the fauna of the Turkish waters and with the specific attributions that may be worked.

MATERIAL AND METHODS

The material utilized for the present study comes principally from the type specimens studied from MCZR, MNHN and MZB, from the collections of MZB, NMR, the University of Messina and the University of Bari, and from some private collections, principally that of Jacques Pelorce, of Attilio Pagli and of the first author. In complement were checked also pictures, reports and revisions found in malacological publications as well as on documented Internet websites. The investigated material comes principally from the collections of the Department of Hydrobiology (Ege University, Faculty of Fisheries), sampled and sorted out during the period 1995-2018. A part of the material from the Turkish Levantine Coast was sampled within the Project 104Y065 financially supported by TUBITAK (The Scientific and Technological Research Council of Turkey). A limited addition of material came from the collections of Kemal Geyran (Istanbul, Turkey) and of the second author.

The *Granulina* material from ESFM was collected from 80 stations grouped along 47 geographic sites (Figure 1) and containing about one thousand shell specimens. Thirty-nine of these geographic sites are located in the Aegean Sea and the Mouth of the Dardanelles Strait, and only eight of these sites are located in the Levantine Sea. About 45% of the samplings were operated from 0,3 m to 30 m, and 55% were operated lower than 30 m (only 3 stations lower than 80 m). The material loaned by K. Geyran is composed of 4 lots containing about 20 specimens of diversified forms, from stations staggered from 50 to 80 m (3 stations from the Aegean Sea and one from the Levantine Sea). The material provided by the second author is composed of a lot of about 20 specimens of *G. marginata* and *G. boucheti* collected at 12 m off Bozcaada Island (Aegean Sea).

It was not possible to obtain data about the live animals ranging in the Turkish waters, specially concerning the chromatism of the soft parts, and the study is only supported by the observation and comparison of shell morphology features. In these conditions, a preliminary focus on the *Granulina* shell morphology patterns and variability known to science for the Mediterranean waters is required. So, in the First Part we are going to check the specific patterns documented from Western and Central Mediterranean, in link with the forms observed along the Turkish coasts, before to devote in the Second Part to the analysis of the morphologic patterns observed along the Turkish coasts.

The specimens worked in the present study were deposited at the Museum of Faculty of Fisheries (ESFM), Ege University, Izmir, Turkey.

Figure 1. Map of sampling stations along the Turkish coasts

Acronyms and abreviations

ESFM : Museum of Faculty of Fisheries, Ege University, Izmir
MCZR : Museo Civico di Zoologia di Roma
MNHN : Muséum national d'Histoire naturelle, Paris
MZB : Museo di Zoologia, Università di Bologna
NMR : Natuurhistorisch Museum Rotterdam
BOC : B. Öztürk Collection (ESFM)
FBC : F. Boyer Collection
LPC : R. La Perna Collection
KGC : K. Geyran Collection
WRC : W. Renda Collection
L : shell length
spm : specimen
sh : shell
stn : station

RESULTS AND DISCUSSION

The investigation of *Granulina* specimens collected along the Turkish Levantine and Aegean coasts yielded four species: *Granulina marginata* (Bivona, 1832), *G. occulta* (Monterosato, 1869), *G. boucheti* Gofas, 1992 and *G. melitensis* Smriglio, Mariottini & Rufini, 1998, of which *G. boucheti* and *G. melitensis* are new records from the area. The high variability of the shell morphology in the identified species is studied from a comparative point of view, in the frame of two complex of «morphologic affinities», and the results are presented and discussed below.

SYSTEMATICS

Family: Granulinidae G. A. Coovert & H. K. Coovert, 1995

Genus : *Granulina* Jousseaume, 1888

Type species : *Marginella pygmaea* Issel, 1869 (non *Marginella pygmaea* Sowerby, 1846) = *Marginella isseli* Nevill & Nevill, 1875 (nom. nov.), by monotypy.

Recognition of the specific patterns documented from Western and Central Mediterranean

Four main shell patterns are observed in the *Granulina* fauna collected along the Turkish coasts, matching closely for the most the current definition of the species *G. marginata*, *G. boucheti*, *G. occulta* and *G. melitensis*. In some case, morphologic affinities are suggested also with other species from Western Mediterranean, the most confusing case being that of *G. minusculina*. So we propose to proceed to the preliminary checking of these five taxa.

Granulina marginata (Bivona, 1832) **(Figure 2, A-P)**.

Volvaria marginata Bivona, 1832 : 24, pl. 3, fig. 5 (Palermo).

Voluta brocchi Scacchi, 1833 : 22 (Napoli).

Type material

Neotype MNHN (Figure 2, A and B), Acitrezza, southeast Sicily, 1-2 m, L= 2.0 mm.

Distribution

Gofas (1992) gave *Granulina marginata* as ranging in whole Western Mediterranean, including Algeria, and

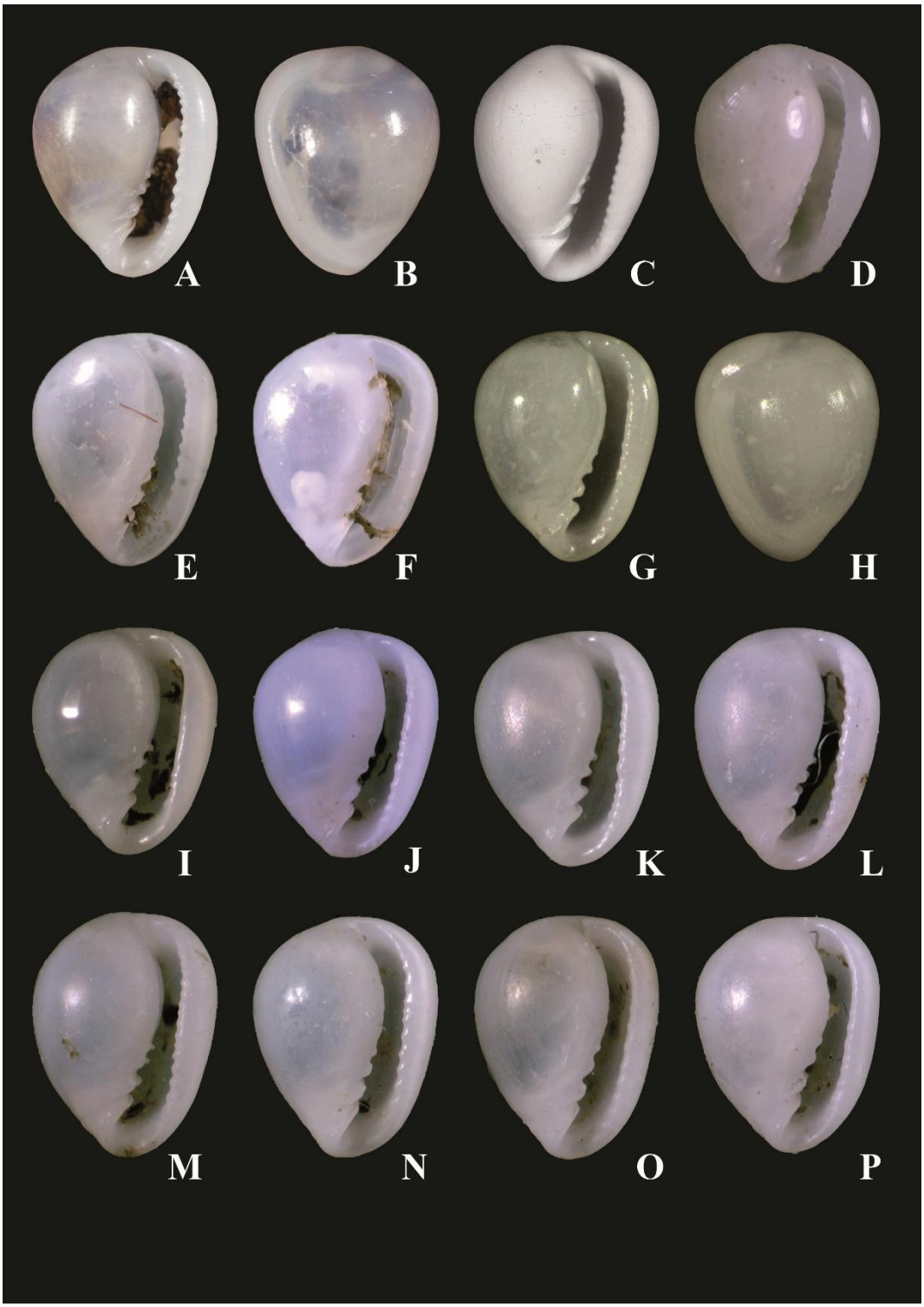

Figure 2. A-P. A, B. *Granulina marginata* (Bivona, 1832), neotype of *Volvaria marginata* Bivona 1832, Port of Acitrezza, Sicily, L = 2.0 mm, MNHN. **C**. *Granulina marginata*, Gioia Tauro Basin, Bagnara Calabra, 335-371 m, L = 1.9 mm. **D**. *G. marginata*, Villaggio Pace, Strait of Messina, 33 m, L = 2.0 mm. **E, F**. *G. marginata*, Capo d'Armi, southern Calabria, 4-6 m, L= 2.5 mm & 2.5 mm. **G, H**. *G. marginata*, Larnaca, Cyprus, NMR 40393, L = 1.9 mm. **I-P**. *G. marginata*, Port du Niel, Presqu'île de Giens, French Riviera, L = 1.8 to 2.2 mm, CFB.

recorded it also from Eastern Sicily (type locality of the neotype), southern Tunisia (Djerba) and Samos Island in Eastern Aegean Sea. Since the Gofas revision, various records have been made from the oriental basin, but often the most without clear illustrations or descriptions allowing us to verify the specific identity, and to check the difference with the similar species *G. boucheti*. The first author had however the opportunity to verify the identity of specimens of *G. marginata* from Malta (Meliella Bay), from Croatia (Crès Island), from Southern Pelopponese (Gulf of Messinias) and from Cyprus (Larnaca) (Figure 2, G-H), on the ground of well-conserved shells. The species is known to range mainly in shallow water but it seems to reach the entire infralittoral and shells are often dredged at deeper levels (Boyer et al., 2017).

Remarks

The stout, thick and heart-shaped shell of *G. marginata* allow easy identification in most cases, but the shell morphology of the species displays a rather wide variability (Figs A-P) and ambiguous cases may occur with shells intercalating more or less with the closely matching species *G. boucheti* (Figure 3, A-P), less common and less abundant but rather often collected in syntopy with *G. marginata*. See below for comparison with *G. boucheti*.

Granulina boucheti Gofas, 1992 **(Figure 3, A-P)**.

Granulina boucheti Gofas, 1992 : 10-11, figs 9-10.

Type material

Holotype MNHN (Figure 3, A and B), Acitrezza, southeast Sicily, 1-3 m, L = 2.1 mm.

Distribution

Gofas (1992) recorded *G. boucheti* from the Tyrrhenian Sea, Sicily, Algeria (Arzew) and Tunisia (Djerba). He did not find it along the French and the Spanish coasts, but he underlined the elusive status of the shallow water populations in *G. boucheti* and suggested that the species may have a wider distribution. Later on, the species was discovered and studied by Boyer *et al.* (2003) from the French Riviera, where it looks to be rather common, even if less abundant than *G. marginata*.

Shells of *G. boucheti* were not recognized by the first author in the samples examined from Malta, Croatia, Pelopponese and Cyprus, but a specimen attributable to *G. boucheti* is recorded from the Baleares in the NMR collection (Figure 3, C and D). The species seems to be restricted to shallow waters.

Remarks

Syntopic populations of *G. marginata* (Figure 2, I-P) and *G. boucheti* (Figure 3, E-P) have been studied by the first author in the Port du Niel, at the southern tip of the Presqu'île de Giens (French Riviera). On the ground of a vast amount of live collected specimens, the morphology of the shells and the chromatism of the animals were systematically compared. As far as the specific status is concerned, very few ambiguous cases were observed in this assemblage, first due to the larger size of the shells of *G. boucheti* in this place (shells of *G. boucheti* generally ranging in size +10% the shell length of *G. marginata*), second due to the subtle but rather constant differences in the detail of the shell morphology, and third due to the evident differences between the respective animal chromatism of the two species. As far as the shell morphology is concerned, the main shell differences observed between the two species are hereafter reported as follows: a thicker shell and the stouter and more triangular outline for *G. marginata*, versus a slightly more slender and pyriform outline in *G. boucheti*; the rather flat top in *G. marginata* versus more arched top in *G. boucheti*; the slightly wider aperture with a well-opened upper part and a low non-overlapping upper labrum in *G. marginata*, versus a less opened aperture, running higher towards the left side, with a slightly higher and more overlapping upper labrum in *G. boucheti*; a rather longer, stronger and sinuous first columellar plait in *G. marginata* versus a slightly shorter, thinner and straighter one in *G. boucheti*. Very few cases of puzzling specimens were observed in this assemblage, like for instance in Figure 2, M and Figure 3, N, but at least one of the shell morphology details allowed to determine the specific distinction, and in each case this attribution was confirmed by the larger size of the shell of the *G. boucheti* specimens in this place, as well as by the distinctive chromatism of the animals (more colorful in *G. boucheti*, with an orange stain ranging ahead of the eye, ligth yellowish inner mantle with light orange stains, and yellowish to orange stains and clouds on the sides of the foot).

Gofas (1992) described exactly the same animal chromatism both in *G. marginata* and in *G. boucheti* from the type locality of Acitrezza, but in this place the shell morpholy of *G. boucheti* (Figure 3, A and B) seems to differ from the morphology observed in Port du Niel, with a more slender and more pyriform outline, and a rather long first columellar plait (however less sinous and thinner than in the sympatric *G. marginata*).

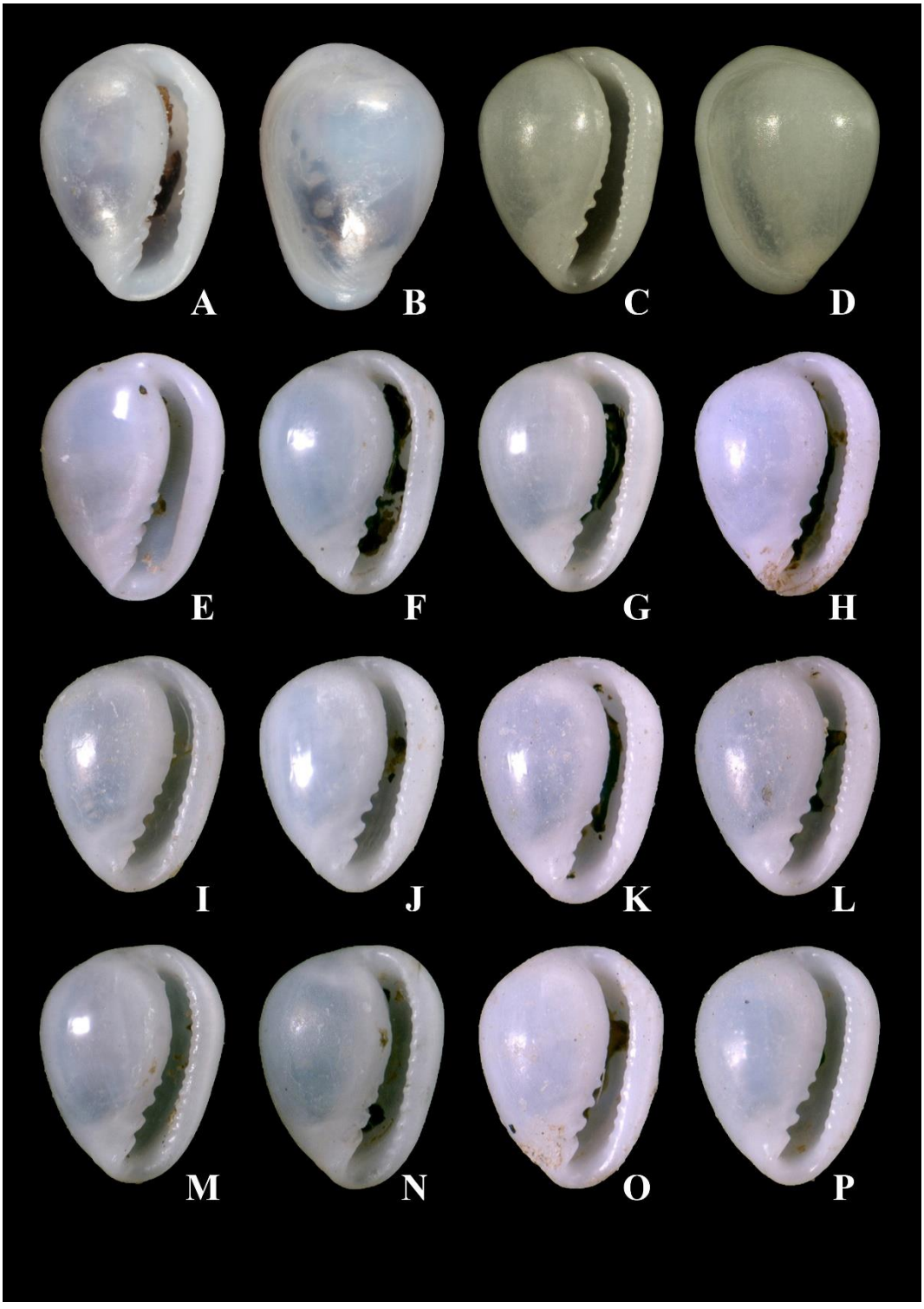

Figure 3. A-P. A, B. *Granulina boucheti* Gofas, 1992, holotype MNHN, Acitrezza, L = 2.1 mm. **C, D**. *G. boucheti*, Formentera, Baleares, NMR 40378, L = 2.3 mm. **E-P**. *G. boucheti*, Port du Niel, Presqu'île de Giens, French Riviera, L = 2.0 to 2.4 mm., CFB

Granulina occulta (Monterosato, 1869) **(Figure 4, A-K)**.

Marginella occulta Monterosato, 1869: 17-18, fig. 10.

Volutella parvulina Locard, 1897: 126-127, pl. 21, figs 3-4.

Type material

Lectotype MNHN, ex-Monterosato coll. (Figure 4, A and B), Sicily, Palermo, L = 2.45 mm.

Distribution

Gofas (1992) reported *G. occulta* from circalittoral levels (one case from a bathyal level) off the French Riviera, Corsica, Capri Island, Palermo, Oran and the Alboran Sea, based on a limited number of specimens. Several specimens were studied by the first author in the collections of Jacques Pelorce and André Hoarau (Fréjus/Saint-Raphael, French Riviera: three stations from 70 to 170 m) and in the collection of Attilio Pagli (Tuscan Archipelago and Eastern Tyrrhenian : three stations from 110 to 300 m), most of these shells being squatter than the lectotype. We did not find reliable records about *G. occulta* from Central and Eastern Mediterranean, including from Eastern Sicily and Malta. Samplings from the Aegean Sea were however subjected in some studies carried out in the past, but without good individual pictures neither reliable identification.

Remarks

In the whole, *G. occulta* looks as a rather elusive species, ranging at circalittoral levels, rarely collected and recorded from Western Mediterranean, and it remains very badly known in the area. For instance the species was not found in the samplings made by the Messina University in southeastern Tyrrhenian and studied by Boyer *et al*. (2017). The type material of *G. occulta* (Figure 4, A, B, E-G) and the syntype of its junior synonym *G. parvulina* (Figure 4, C and D) all prove to be slender shells with sharp upper rostrum, rather different from the stouter shells generally collected off the French Riviera and in the Tyrrhenian Sea. Some specimens attributed to *G. occulta* (Figure 4, H and I) from the Alboran Sea show a tiny and rather cylindrical shell poorly matching the typical concept of the species, although the same type of columellar plaits is present. Some specimens from the Tyrrhenian Sea (Figure 4, J and K) are similar to the recently described species *G. guttula* La Perna, 1999 (Figure 4 L-O), which seems to differ from *G. occulta* principally for a thicker shell, a more pyriform outline, a more rounded top and a more produced upper plait, characters which make them something different from the typical *G. occulta*. On the basis of these specimens we can argue that the morphological traits of this latter species needs more accurate investigations to define its real variability range.

Granulina minusculina (Locard, 1897) **(Figure 5, A-H)**.

Volutella minusculina Locard, 1897: 127-128, pl. 21, figs 6-8.

Granulina gubbiolii Smriglio & Mariottini, 1999: 35-40, figs 1-10.

Type material

Lectotype MNHN (Figure 5, A and B), «Travailleur» 1882, st. 34, Ouest du Maroc, 112 m, L = 2.0 mm.

Distribution

According to Gofas (1992): «distributed in the Ibero-Moroccan Gulf, rare in Mediterranean… the Mediterranean specimens are less rostrated and with a much less thickened labrum». In fact the species shows to be rather common at lower circalittoral levels and at upper bathyal levels in the Alboran Sea (Figure 5, C and D), and specimens attributable to *G. minusculina* are recorded from off Western Sicily and from the Tyrrhenian Sea (Figure 5, E-H).

Remarks

According to us, the description of *G. gubbioli* by Smriglio and Mariottini (1999) seems not to consider for comparison the lectotype selected by Gofas (1992) for *G. minusculina* (Figure 5, A and B), which is a strong inflated shell with an heavy upper rostrum. When characterizing the identity of *G. minusculina*, in fact they based their differences on the poorly descriptive figure of the type specimen by Locard (Smriglio & Mariottini, 1999: fig. 10), and a topotype from the Travailleur Expedition which shows to bear rather more tapered tips (ib.: figs 11-12). In fact all the type specimens of *G. gubbiolii* from the Straight of Gibraltar (ib.: figs 1-5) as well as the specimens illustrated from Estepona (ib.: figs 6-7) match perfectly the morphology displayed by the lectotype of *G. minusculina* and according to us they should be considered as synonyms. Smriglio and Mariottini illustrated also as «*G. gubbiolii*» two specimens collected by the BALGIM Expedition in the Alboran Sea (ib.: figs 8-9) : these two shells are lighter in colour than the lectotype of *G. minusculina* and than the type material of *G. gubbiolii* but they do not differ structurally. Such « lighter in colour shells » are rather common in the population of *G. minusculina* in the Alboran Sea (Figure 5, C and D) and in the Tyrrhenian Sea as well. Whereas the lectotype of *G. minusculina* presents a thick shell, a much globose outline, a widely arched upper labrum, strong subequal labial denticles and four well-distinct decreasing columellar plaits, these features are shown to be variable in the various material referred to *G. gubbiolii* by Smriglio and Marriottini (1999: figs 1-9), the single specimen referred to *G. minusculina* (ib.: figs 11-12) showing itself a moderately globose outline, a well tapered top than arched, and a rather indisctinct fourth columellar plait.

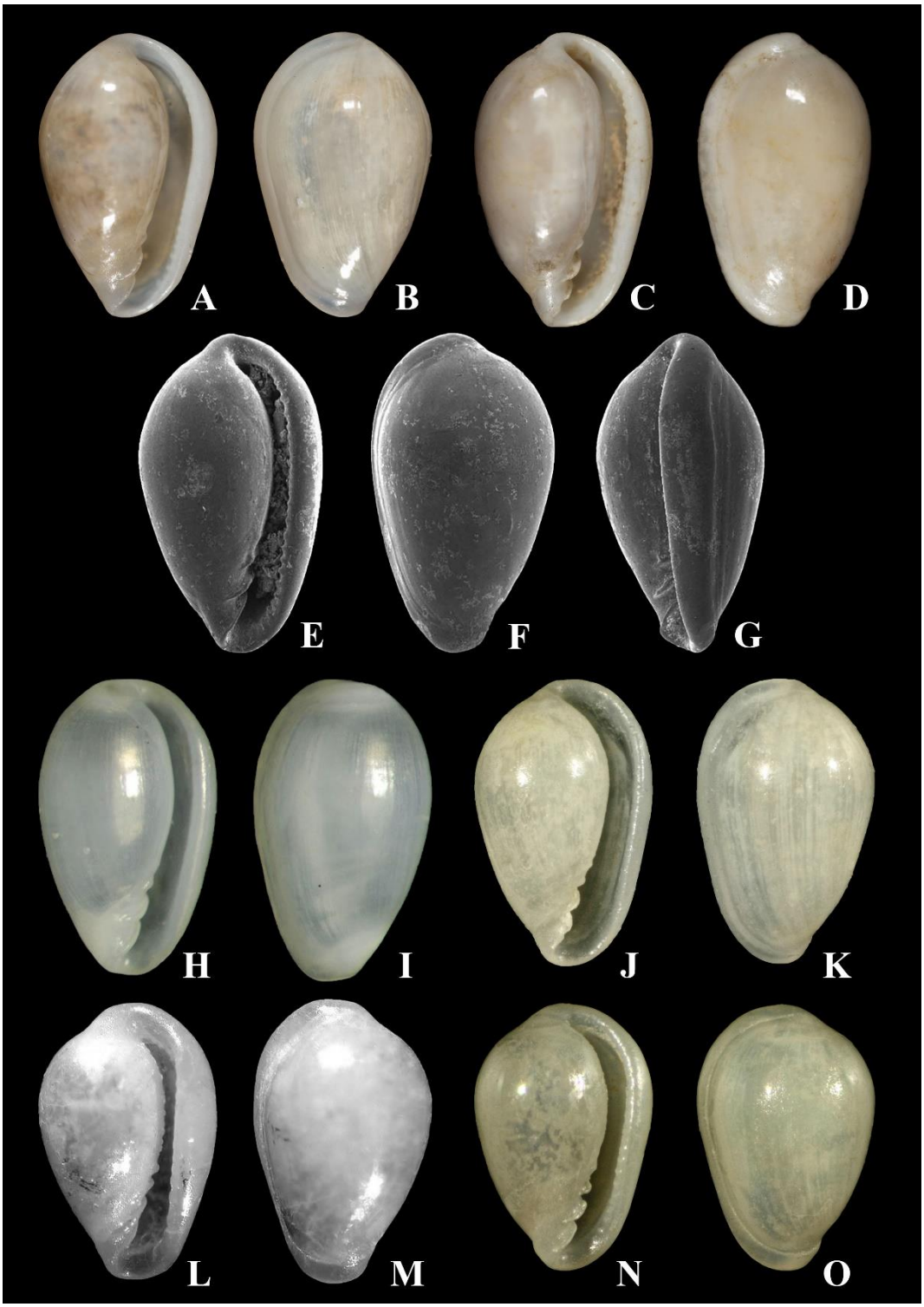

Figure 4. A-O. A, B. *Marginella occulta* Monterosato, 1869, lectotype MNHN (ex-Monterosato), Palermo, L = 2.45 mm. **C, D.** *Volutella parvulina* Locard, 1897, syntype MNHN (ex-Locard, «Travailleur Exp.: nord de l'Espagne, 1.094 m; est de l'Espagne, 322 m»), « Mer d'Alboran » (fide Gofas, 1992: 13), L = 2.45 mm. **E-G**. *Gibberulina occulta* Monterosato, 1869 (ms label), syntype MCZR, Palermo, L = 2.4 mm (from Smriglio & Mariottini, 2013: figs 9 a-c). **H, I**. *Granulina* cf. *occulta*, Barbate, Andalucia, L = 2.0 mm (from Gofas in WoRMS). **J, K**. *G.* cf. *occulta*, Messina, Punta Falcone, NMR 40408, L = 3.0 mm. **L, M**. *G. guttula* La Perna, 1999, holotype University of Bari, Ponza Island, Eastern Tyrrhenian Sea, 84 m, L = 1.9 mm. **N, O**. *G. guttula*, Latina, Sperlonga, 100 m, NMR 40392, L = 2.0 mm.

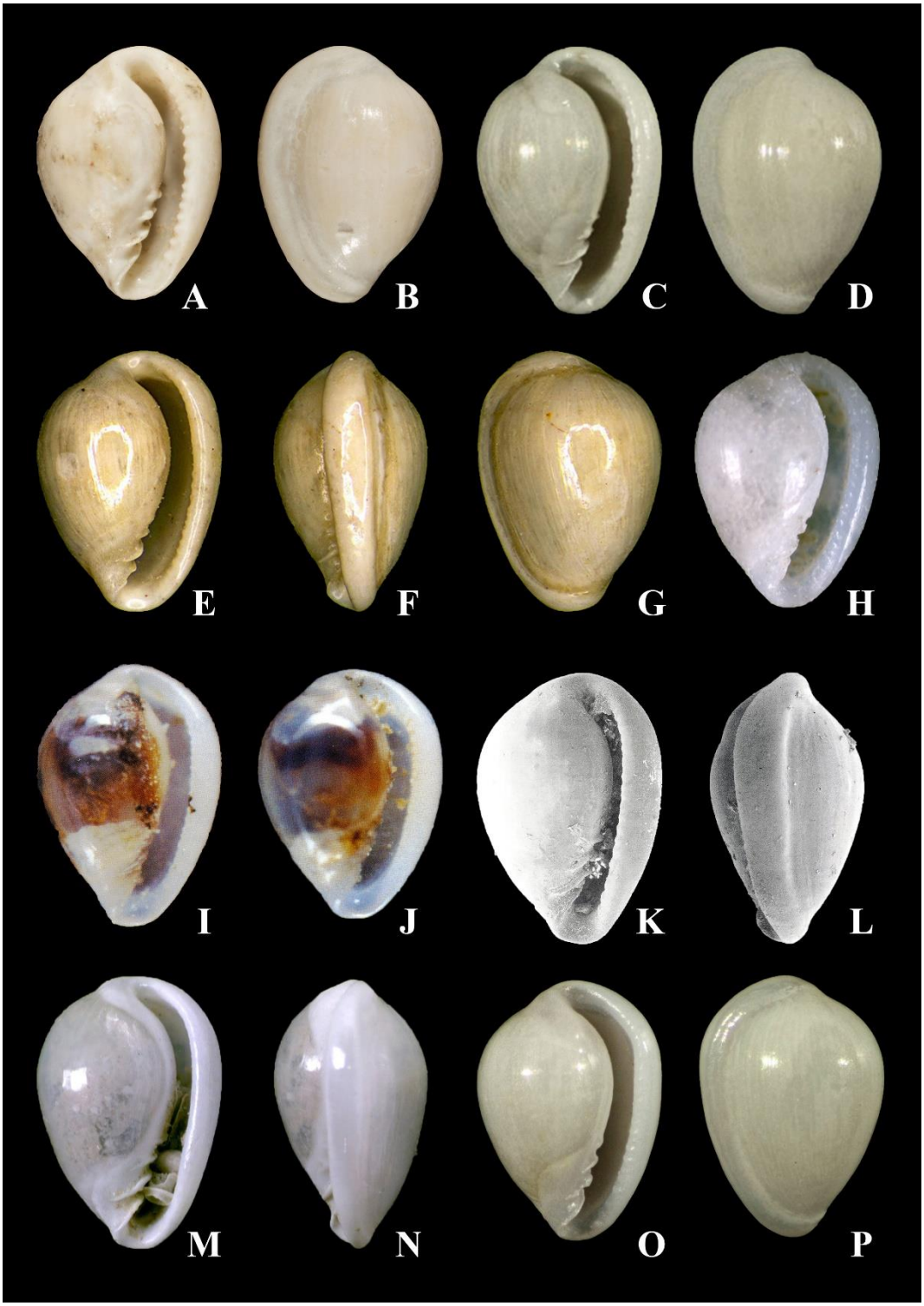

Figure 5. A-P.A, B. *Volutella minusculina* Locard, 1897, lectotype MNHN (ex-Locard, «Talisman Exp.: Maroc Atlantique», L = 2.0 mm. **C, D**. *Granulina minusculina*, Bahia de Cadiz, Spain, 543 m (NIOZ dredgings), NMR 40405, L = 2.4 mm. **E-G**. *G.* cf. *minusculina*, Isole Egadi, Western Sicily, 100 m, detrito, L = 2.3 mm, coll. Ennio Squizzato (www.fotoconchigliemediterraneo.com). **H**. *G.* cf. *minusculina*, Gioia Tauro Basin, Bagnara Calabra, southeastern Tyrrhenian Sea, 371 m, L = 2.25 mm, coll. University of Messina. **I.** *G. melitensis* Smriglio, Mariottini & Rufini, 1998, holotype MZB 12693, Malta, 100-120 m, L = 2.2 mm. **J**. *G. melitensis*, paratype B, coll. Smriglio, Mariottini & Rufini, Malta, 100-120 m, L = 2.1 mm. **K, L**. *G. melitensis*, paratype L, coll. Smriglio, Mariottini & Rufini, Malta, 100-120 m, L = 1.8 mm. **M, N**. *G.* cf. *melitensis*, Lazial Coast, Latium, eastern Tyrrhenian Sea, mud, 250 m, L = 2.1 mm, coll. C. Smriglio. **O, P**. *G. melitensis*, Kyklades Plateau, Greece, 120 m, NMR 40404, L = 2.1 mm.

Some specimens from the Tyrrhenian tentatively attributed to *G. minusculina* (Figure 5, H) show a rather thick shell but a narrower aperture, a moderately globose outline and a less arched upper labrum, looking as morphologic intergrade forms to the more recently described *G. melitensis*.

Granulina melitensis Smriglio, Mariottini & Rufini, 1998 **(Figure 5, I-P; Figure 6, A-P)**

Granulina melitensis Smriglio, Mariottini & Rufini, 1998: 53-56, figs 1-7.

Type material

Holotype MZB (Figure 5, I), Malta, 100-120 m, L = 2.2 mm.

Distribution

Described from Malta at depths between 100-120 m, *G. melitensis* was reported to have been collected also in the Eastern Tyrrhenian Sea, off the Lazial Coasts at 250 m depth. Some of the specimens from the Lazial Coasts attributed to *G. melitensis* by Smriglio *et al.* (1998) (Figure 5, M and N) seem to be rather differing from the type of *G. melitensis*. But numerous specimens matching the type of *G. melitensis* have been later collected in the Tyrrhenian. Although this species seems common in Tyrrhenian, in south-eastern Sicily and in Malta, *G. melitensis* remains very elusive in the rest of Central and Eastern Mediterranean. It has been however recorded from the Aegean Sea (Figure 5, O and P).

Remarks

The description of *G. melitensis* was accompanied by insufficient figure of types (Figure 5, I-L) and it presents in the whole the features of the «lighter form» of *G. minusculina*, with minor variations such as a less globose shell, a slightly less wide aperture, a less denticulate inner labrum and a less arched but slightly «broken» upper labrum (Figure 5, I-O), this last feature being however not constant, even in the type material of *G. melitensis* (Figure 5, K and L). Comparing their new species *G. melitensis* to *G. minusculina*, Smriglio *et al.* (1998: 54) consider that the shell of *G. melitensis* is less globular and less inflated, with a more narrowed base, a narrower aperture and thinner labial denticles. All these characters seem to prove that inside populations from the type locality, this species is almost variable and seem to overlap to those of *G. minusculina* (Figure 5, A-H). The relative thickness of the shells seem to be linked to depth, being the thicker shells typical of higher depths, while lighters ones typical of lower depths. According to Smriglio *et al.* (1998), the most distinctive feature of *G. melitensis* consists in the outer part of the upper margin forming a bent profile, tilting towards the dorsum (Figure 5, L), which is more marked and not tilting in *G. minusculina* (Figure 5, F).

This features was studied on a great number of specimens from the Alboran Sea, from the Tyrrhenian and from Malta: even if a general tendency to a «bent profile of the upper outer margin» is often observed in the populations from Malta, this feature is not constant, few cases are also found in the populations from the Alboran Sea, and the situation prevailing in the Tyrrhenian shows to be the most confusing. Consequently, it seems to be not clear to separate the form «*G. melitensis*» from the form «*G. minusculina*», specially for the populations from the Tyrrhenian where all kinds of intergades are occurring (Figure 5, H). According to us, *G. melitensis* may well represent the «lighter Eastern form» of *G. minusculina*, mostly characterized by a less arched upper labrum, and it might be conspecific. However, in the absence of a complete demonstration about the point, we prefer consider provisionnally *G. melitensis* as a valid species for the Central and Eastern Mediterranean. A good display of the morphologic variability at work in the «typical form» of *G. melitensis* is given by lots collected off south-eastern Sicily (Figure 6, A-P).

B. Analysis of the patterns observed in the Granulina species along the Turkish coasts

The *Granulina* fauna along the Turkish coasts is typified by two couples of species, namely *G. marginata* and *G. boucheti* from one hand, and *G. occulta* and *G. melitensis* from the other hand. In each of these couples, the individual species are easily separated in most cases on the ground of the combination of distinctive morphologic features, but in a rather important number of cases the specific attribution can just be advocated on the ground of one or two features. In a limited number of cases, the specific attribution remains deeply uncertain, especially when the attribution is made on the ground of a single feature showing to have only a «statistic value» (stage of a variation more often combinated within such a morphospecies).

We are going to characterize and identify the *Granulina* specimens collected along the Turkish coasts on the ground of these two «couples of species», as this way to display the problematics seems to be the most demonstrative. The tentative to play a morphometric duty on the ground of selected shell features proved to be unefficient and poorly relevant, so we preferred to deal with a demonstration based on comparative pictures illustrating the divergences/ convergences between individuals, with special focus on series coming from the same station. Most of the geographical sites and depths are used in this demonstration: in the whole, the geographic position and the bathymetry do not seem to be linked to any special kind of variation, and most of the variations are more or less found in each of the samplings, when the samplings are made of numerous specimens. We shall see however that the most «ambiguous cases» (in rate of divergence as well as in number proportion) are better found in the marginal levels (deeper levels for the shallow species and shallow levels for the deep species).

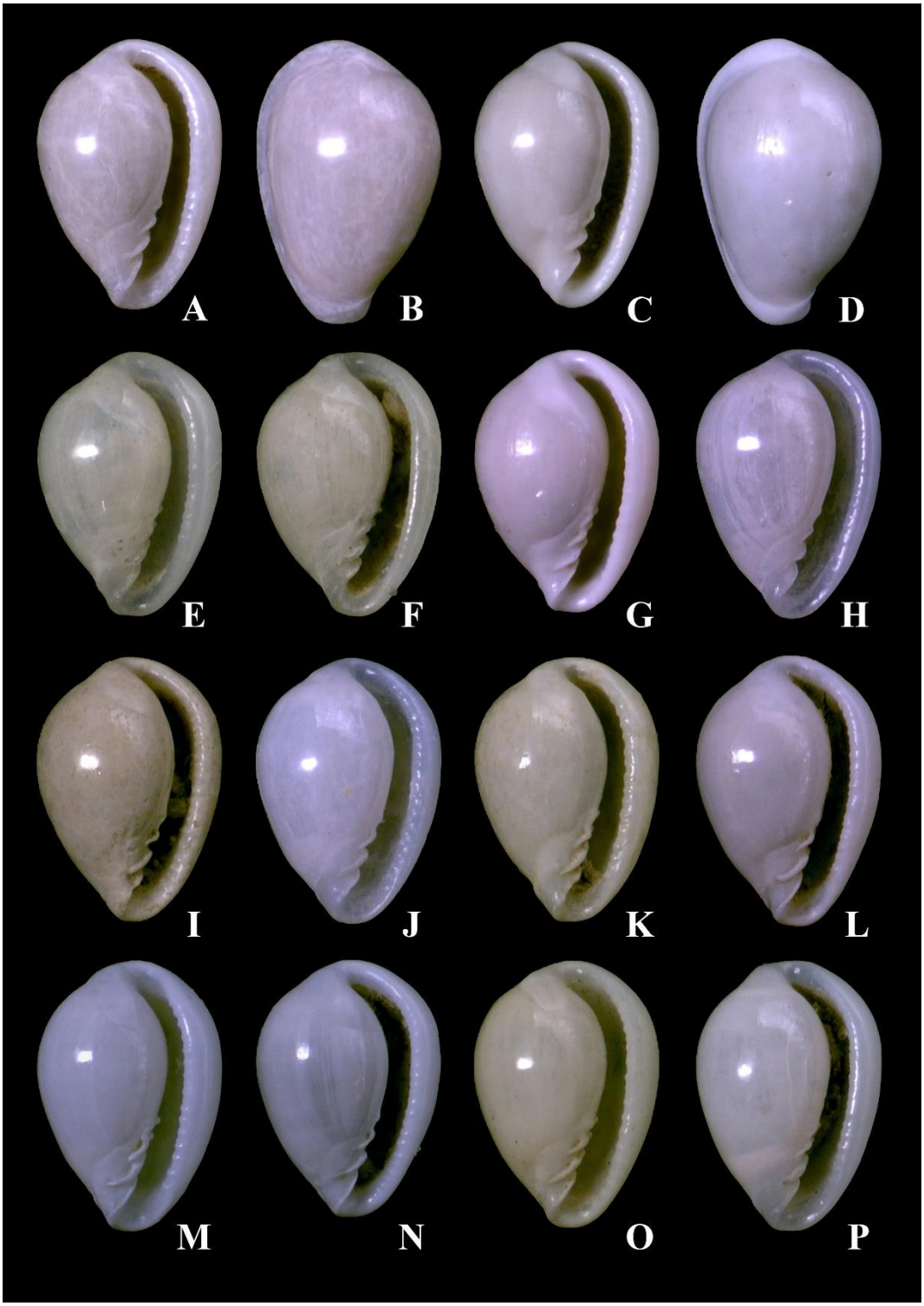

Figure 6. A-P. A-H. *Granulina melitensis*, southeastern Sicily, 200 m (LPC, stn 10P), L = 2.1-2.3 mm. **I**. *G. melitensis*, southeastern Sicily, 120-126 m (LPC, stn PS81-2xB), L = 2.20 mm. **J**. *G. melitensis*, southeastern Sicily, 76 m (LPC, stn PS81-4B), L = 2.22 mm. **K**. *G. melitensis*, southeastern Sicily, 76 m (LPC, stn PS81-4B), L = 2.35 m. **L**. *G. melitensis*, southeastern Sicily, 86 m (LPC, stn PS81-4C), L = 2.2 mm. **M**. *G. melitensis*, southeastern Sicily, 86 m (LPC, stn PS81-4C), L = 2.15 mm. **N**. *G. melitensis*, southeastern Sicily, 86 m (LPC, stn PS81-4C), L = 2.25 mm. **O**. *G. melitensis*, southeastern Sicily, 102 m (LPC, stn PS81-4x), L = 2.16 mm. **P**. *G. melitensis*, southeastern Sicily, 160 m (LPC, stn PS81-5), L = 2.32 mm.

G. marginata*/*G. boucheti

Figure 7, A-H display specimens from the same station (Eski Foça, shallow water) matching perfectly the typical «*G. marginata* concept» such as revised by Gofas (1992) and illustrated by the population from Port du Niel, French Riviera (Figure 2, A-P). Figure 7, I-L display the variability at work in a series of four individuals of *G. marginata* coming from the same station (Dardanelles Entrance, shallow water), Figure 7, K looking as the less «conform to the type», due to its rather oval outline, its poorly sinous first plait : however other important features, such as the aperture well-turned towards the topside, a non-reflected/overlapping upper labrum and rather strong labial denticles, allow to distinguish clearly this individual from the related species *G. boucheti*. Figure 7, M-P display a set of three «ambiguous individuals» coming from the same station (Çandarli Bay, 46 m). They are identified as *G.* cf. *marginata*, despite they all suggest affinities with features more commonly found in the Western Mediterranean forms of *G. boucheti*. Despite its rather slender outline, poorly widening aperture and very thin labial denticles (Figure 7, M and N), display a triangular shape, an attenuated pointing base, an upper aperture well-turned towards the topside and a long and rather sinuous first plait forming a deep oblique gutter at the base of the aperture, all features matching the common form of *G. marginata*. The placement of Figure 7, O in *G. marginata* is less evident, due to the much oval-slender outline, the attenuated pointing base, the much narrowed aperture, the very straight first plait and the smooth inner labrum, but the orientation of the upper part of the apertrure is coherent with the «*G. marginata* concept». Figure 7, P is the most ambiguous individual from the series: its subpyriform outline, its poorly widening aperture and its few tiny denticles all suggest affinities with *G. boucheti*, but the upper aperture is unclear, as it is running deeply to the left and it is slightly overlapped by a faintly reflecting upper labrum, whereas the upper aperture remains mostly turned towards the topside and the first plait looks as long, thick and rather sinuous, forming a rather deep oblique gutter at the base of the aperture. The balance of these elements leads to prefer a provisionnal placement in *G. marginata*, however with formal reservations.

Figure 8, A-L display a set of 12 individuals collected in sympatry (Marmaris, 30 m) and showing a wide range of morphologic disparity: some of the individuals are attributed to *G. marginata* without serious reservations, several individuals are attributed to *G. marginata* with reservations (see the captions of Figure 8), one shell (Figure 8, H) is considered to match *G. boucheti* with evidence, and another one is referred by preference to *G. boucheti* despite its atypical appearence: the subtriangular stout outline and the upper aperture better turner towards the topside suggest better affinities with *G. marginata*, but the rather «brooken profile» of the inner upper labrum and the shape of the short first plait suggests better the belonging to *G. boucheti*.

Figure 8, M-P display a set of four individuals collected off Bozcaada Island (12 m), the first three referrable to *G. marginata* and the last one attributed to *G. boucheti* with no serious reserves.

G.occulta/G. melitensis

The distinction between *G. occulta* and *G. melitensis* along the Turkish coasts looks to be almost difficult in many cases: both species prove to be highly variable by themselves, with many «divergent forms», and beside series more or less easily attributable to one of these two taxa, a good number of specimens look as intergrading them. Few specimens from the Turkish waters really match the «typical pattern» ruled by the types of *G. occulta* and *G. parvulina* (Figure 4, A-G) and by the type material of *G. melitensis* (Figure 5, I-L): even if *G. occulta* shows in the whole a more slender outline, a more attenuated top, a rather long and straigth first plait and a poorly visible fourth plait, versus a more rounded outilne, an arched upper labrum, a more sinuous first plait and a more visible fourth plait in *G. melitensis*, many exceptions are occurring and the specific placement of numerous specimens remains dubious even after deep investigation based on «modular comparisons» (comparison of combinated features).

Figure 9, A-D match the general features of the «typical *G. occulta*», like at a lesser degree Figure 10, A and Figure 11, A, whereas Figure 10, E and Figure 11, I are displaying a slightly more inflated form. The form displayed by Figure 9, E-H look as very similar to the Tyrrhenian species *G. guttula* (Figure 4, J-O), for its general outline as well for details such as the straight central part of the inner labrum. The same general morphology is found in Figure 11, J-K. Such occurrence does not lead directly to suspect the possible presence of *G. guttula* along the Turkish coasts: it better lead to wonder about the real variability at work for *G. occulta* in the Tyrrhenian and the real status of *G. guttula* in this morphologic complex.

Figure 9, I-L display the most common form from Turkey attributable to *G. occulta*, and characterized by a stout oval shell much attenuated at both tips. At a lesser degree, the same pattern is displayed in Figure 10, M and N. Slightly more inflated shells with less tapered tips must be attributed better to *G. melitensis* (Figure 11, D-H).

Figure 9, M-P display a rather puzzling case: despite the oval-narrowed and rather pyriform outline and the strange irregular top, this individual presents several diagnostic features of *G. melitensis*, including the relatively «arched» upper labrum, the heavy and well-defined columellar callus, and the strongly sinuous first columellar plait. Even if not frequently displayed as such, the four prominent rather grouped columellar plaits can be accepted as «secondary diagnostic feature for *G. melitensis*». But the narrowed central aperture with straight inner labrum must be considered as an atypical feature. No further individual from this kind was not observed in the samplings from

Turkey, and in the present state we cannot infer if this specimen is more than a «freak individual» within the *G. melitensis* complex.

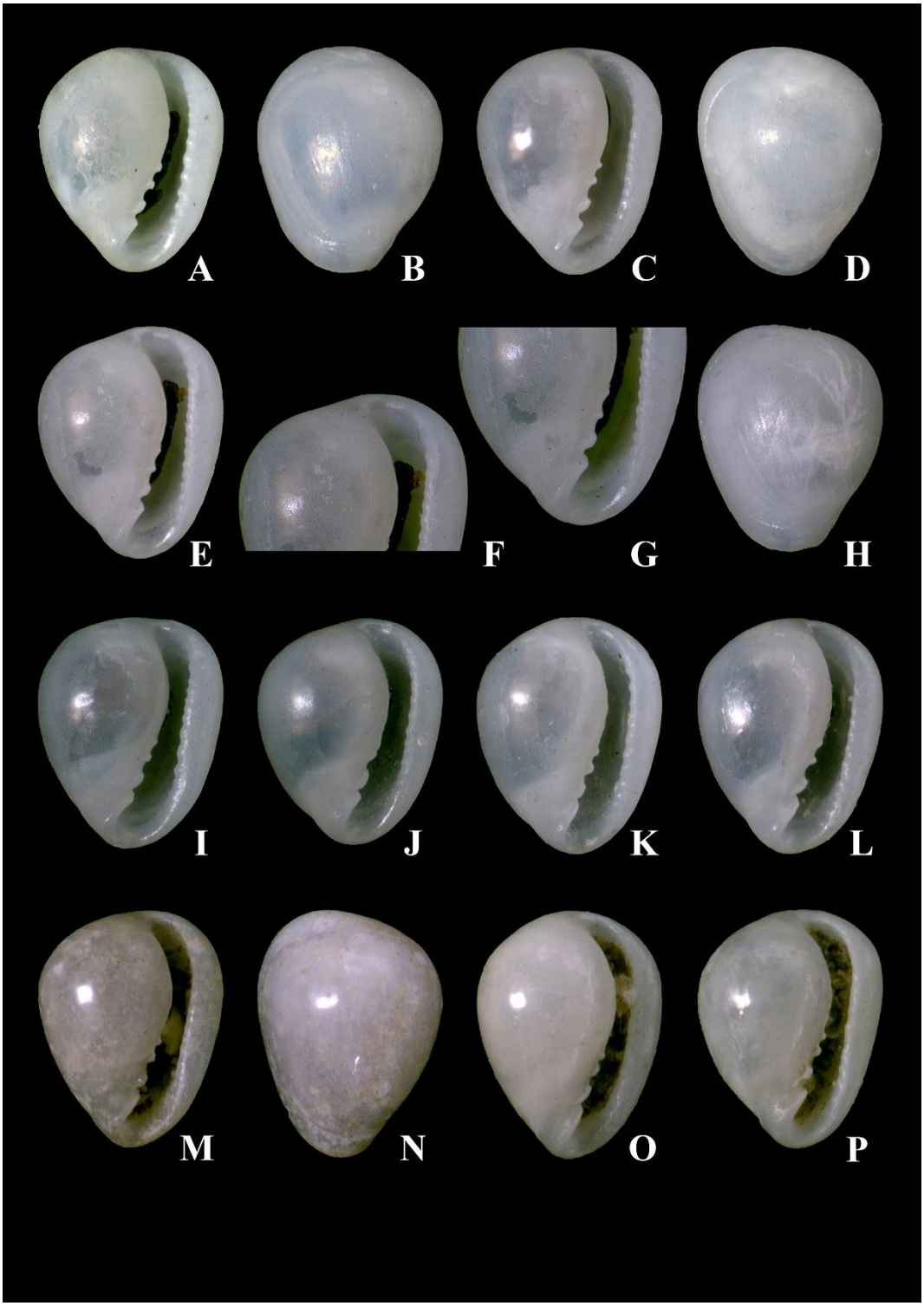

Figure 7. A-P. A, B. *Granulina marginata*, Eski Foça, Aegean Sea, *Cystoseira adriatica*, 1 m, L = 2.05 mm. **C, D**. *G. marginata*, Eski Foça, Aegean Sea, *Cystoseira adriatica*, 1 m, L = 1.90 mm. **E-H**. *G. marginata*, Eski Foça, Aegean Sea, *Cystoseira adriatica*, 1 m, L = 1.95 mm. **I**. *G. marginata*, Dardanelles Entrance, Monument, *Cystoseira adriatica*, 0,5-1 m, L = 1.85 mm. **J**. *G. marginata*, Dardanelles Entrance, Monument, *Cystoseira adriatica*, 0,5-1 m, L = 1.85 mm. **K**. . *marginata*, Dardanelles Entrance, Monument, *Cystoseira adriatica*, 0,5-1 m, L = 1.95 mm. **L**. *G. marginata*, Dardanelles Entrance, Monument, *Cystoseira adriatica*, 0,5-1 m, L = 1.95 mm. **M, N**. *G*. cf. *marginata*, Çandarli Bay, Aegean Sea, 46 m, L = 2.00 mm. **O**. *G*. cf. *marginata*, Çandarli Bay, Aegean Sea, 46 m, L = 1.75 mm. **P**. *G*. cf. *marginata*, Çandarli Bay, Aegean Sea, 46 m, L = 1.80 mm.

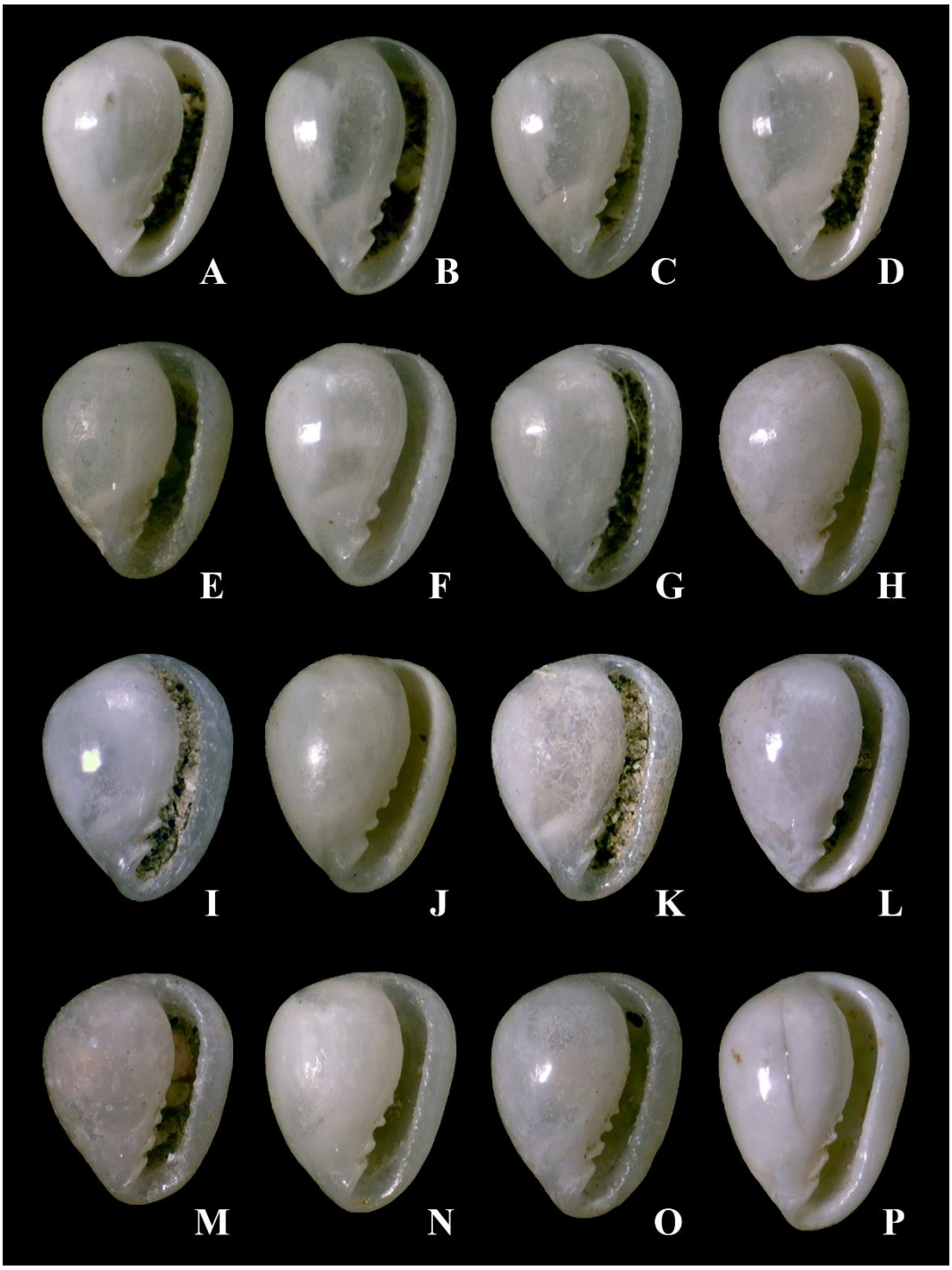

Figure 8. A-P. A. *Granulina marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.70 mm. **B**. *G*. cf. *marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.80 mm. **C**. *G*. cf. *marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.95 mm. **D**. *G*. cf. *marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.90 mm. **E**. *G. marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.50 mm. **F**. *G. marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.50 mm. **G**. *G*. cf. *marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.75 mm. **H**. *G. boucheti*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 2.20 mm. **I**. *G. marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.80 mm. **J**. *G. marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.55 mm. **K**. *G*. cf. *marginata*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.65 mm. **L**. *G*. cf. *boucheti*, Adaköy, Marmaris, Aegean Sea, muddy sand, 30 m, L = 1.90 mm. **M**. *G. marginata*, Bozcaada Island, Aegean Sea, 12 m, WRC, L = 1.90 mm. **N**. *G*. cf. *marginata*, Bozcaada Island, Aegean Sea, 12 m, WRC, L = 1.90 mm. **O**. *G*. cf. *marginata*, Bozcaada Island, Aegean Sea, 12 m, WRC, L = 1.90 mm. **P**. *G. boucheti*, Bozcaada Island, Aegean Sea, 12 m, WRC, L = 2.05 mm.

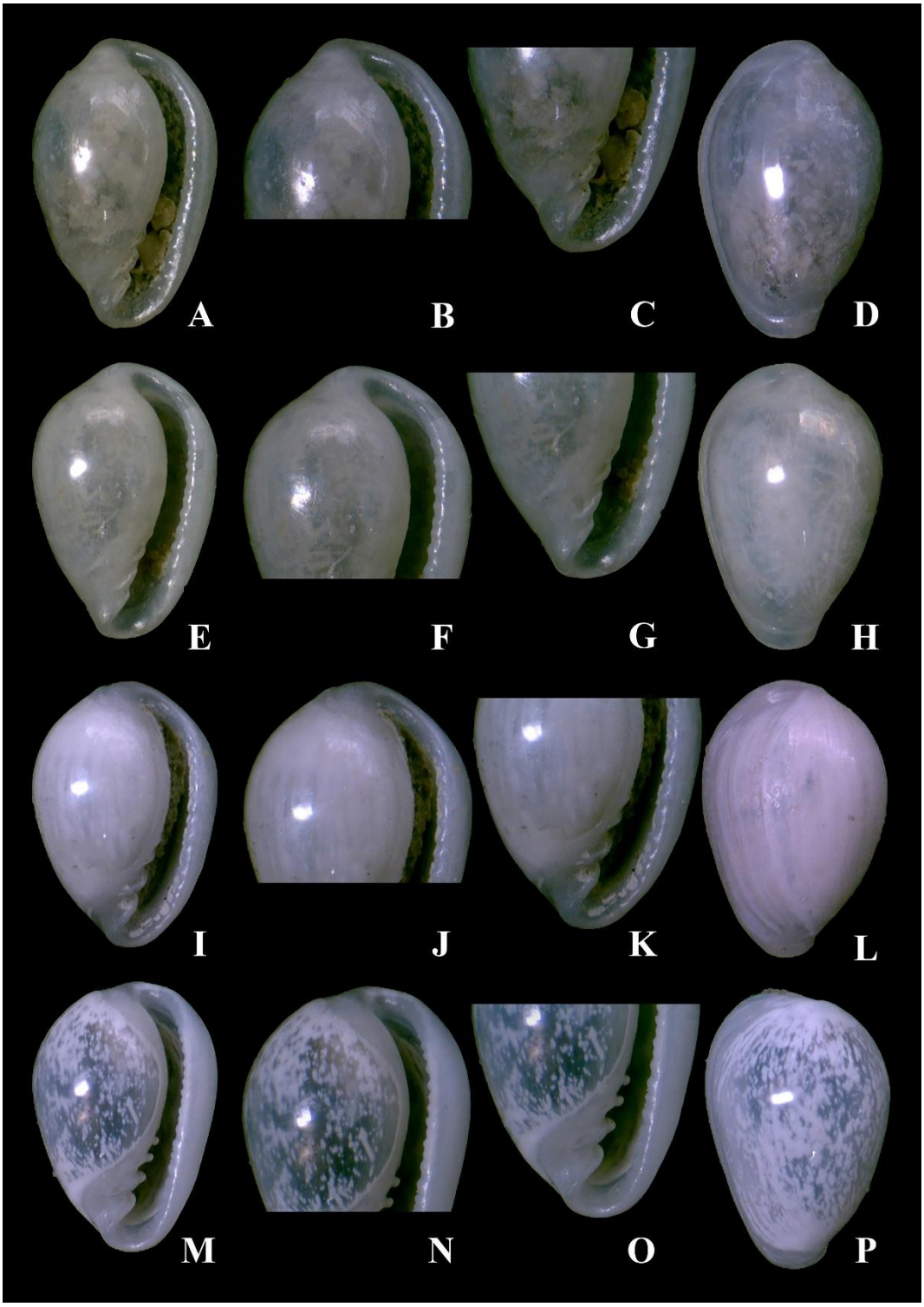

Figure 9. A-P. A-D. *Granulina occulta*, Anamur, Levantine Sea, muddy sand, 50 m, L = 2.00 mm. **E-H**. *G. occulta*, Ildir Bay, Çesme, Aegean Sea, sand, 61 m, L= 1.95 mm. **I-L**. *G.* cf. *occulta*, Erdemli, Mersin Bay, Levantine Sea, sand, 38 m, L = 1.60 mm. **M-P**. *G.* cf. *melitensis*, Çandarli Bay, Aegean Sea, sand, 35 m, L = 2.00 mm.

Figure 10, B-D display the case of a «transitional series» from *G. occulta* to *G. melitensis* (Marmaris, 56 m) : in fact Figure 10, B must be attributed to *G. melitensis* mainly on the ground of its rounded outline and secondary on the ground of the more «grouped» columellar plaits, which are more spread along the columella in *G. occulta* (see in Figure 10, A and E), whereas the other features are unconclusive (upper labrum not arched, fourth plait poorly suggested, aperture narrow). Figure 10, C is more clearly attributable to *G. melitensis*, and Figure 10, D must be considered as a «typical representant of the species», for the well-rounded outline, the wide aperture, the four produced columellar plait and the first strongly sinuous plait.

Figure 10, I-L, Figure 10, O-P, Figure 11, D-H, Figure 11, L-P display various forms occurring for *G. melitensis* in the Turkish waters. Figure 11, C displays an individual which we propose to place in *G. melitensis*, due to its rather arched and thick labrum and its produced columellar plaits (2nd and 3nd being double-folded), whereas all the other features and proportions look as ambiguous.

CONCLUSION

The study of the *Granulina* diversity along the Turkish coasts leads to confirm the occurrence of four representatives, together with few possible cases of sibling species, cryptic species or freak specimens. Overall, numerous cases of «poorly characterized attributions» are noted, leading to consider first that the shell morphology is not always sufficient for a full discrimination duty, and secondly that the high morphologic variability at work in the considered species may hide the occurrence of multi-species groups or the real «limits of the species». From both points of view, the documentation and the comparative study of the live animals, first of all concerning their external chromatism, seem to be a necessary step for the next.

This study leads also to underline the deep affinities playing within this fauna: the case of *G. marginata*/*G. boucheti* as species-group was already known, but the present work suggests also the necessity to investigate respectively *G. occulta*/*G. lapernai* as well as *G. minusculina*/*G. melitensis* as species groups. Moreover, the deep overlapping of the morphologic variability at work in *G. occulta* and in *G. melitensis* leads to advocate a special evaluation of their own relationships.

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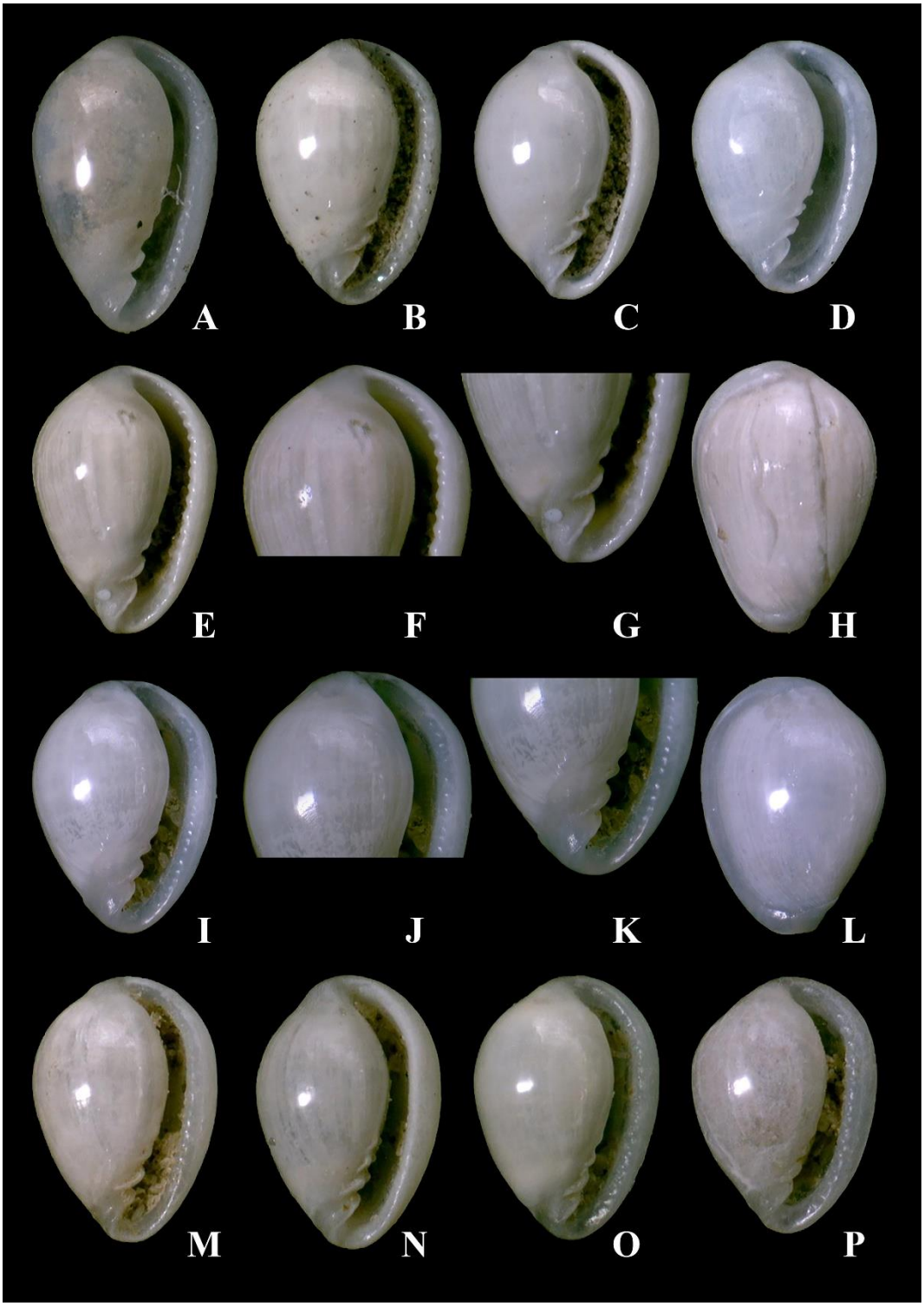

Figure 10. A-P. A. *Granulina occulta*, Bodrum, 100 m, KGC, L = 1.95 mm. **B.** *G*. cf. *melitensis*, Turunç, Marmaris, Aegean Sea, sandy mud, 56 m, L = 1.90 mm. **C**. *G. melitensis*, Turunç, Marmaris, Aegean Sea, sandy mud, 56 m, L = 1.90 mm. **D**. *G. melitensis*, Turunç, Marmaris, Aegean Sea, sandy mud, 56 m, L = 1.95 mm. **E-H**. *G. occulta*, Konacik, Iskenderum Bay, Levantine Sea, sandy mud, 75 m, L = 1.95 mm. **I-L**. *G*. cf. *melitensis*, Güllük Bay, Aegean Sea, sandy mud, 47 m, L = 2.00 mm. **M**. *G. occulta*, Bozcaada Island, Aegean Sea, 80 m, KGC, L = 1.90 mm. **N**. *G. occulta*, Bozcaada Island, Aegean Sea, 80 m, KGC, L = 2.03 mm. **O**. *G*. cf. *occulta*, Bozcaada Island, Aegean Sea, 80 m, KGC, L = 1.95 mm. **P**. *G. melitensis*, Bozcaada Island, Aegean Sea, 80 m, KGC, L = 1.95 mm.

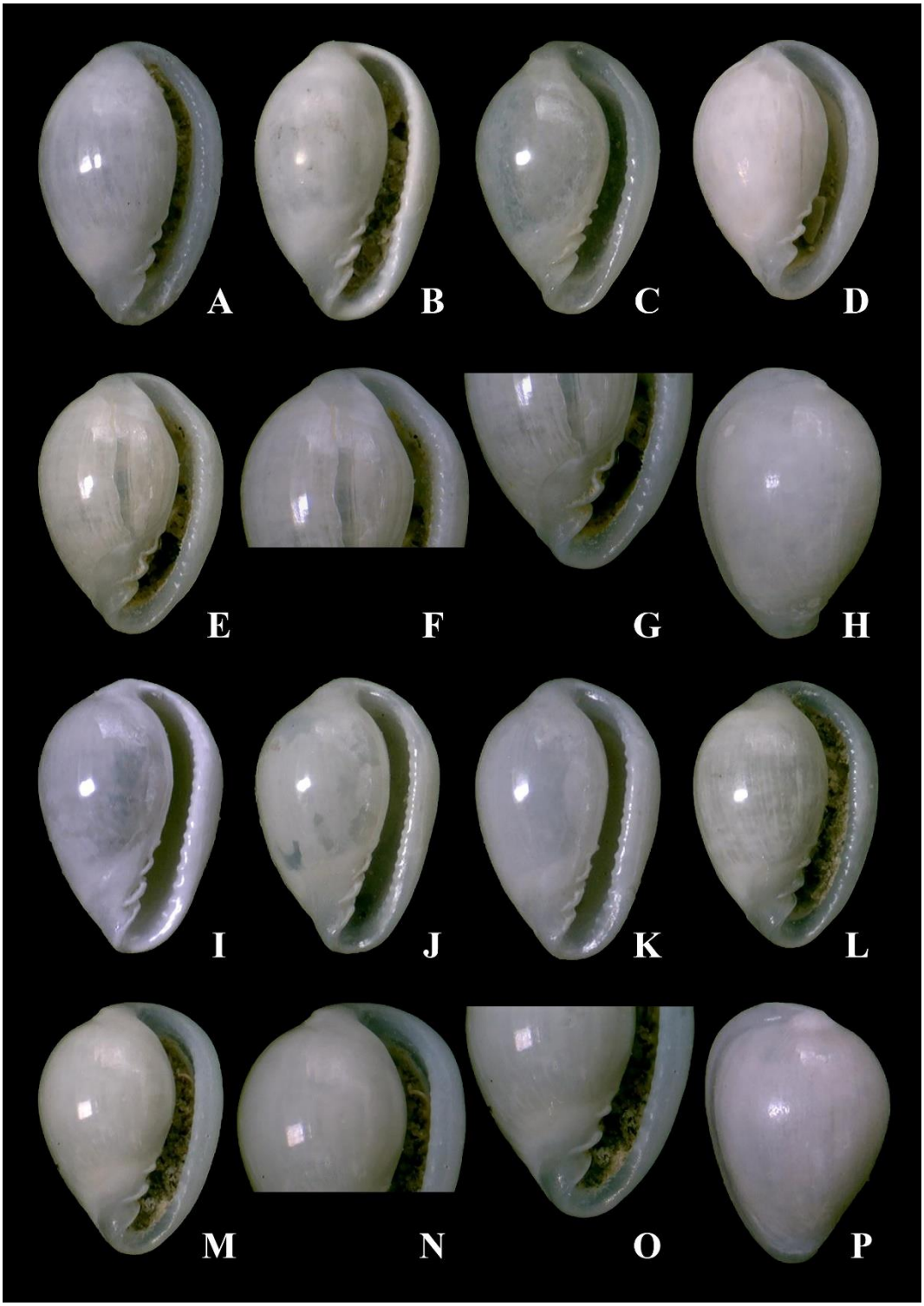

Figure 11. A-P. A. *Granulina occulta*, Güllük Bay, Aegean Sea, sandy mud, 80 m, L = 1.95 mm. **B**. *G*. cf. *occulta*, Izmir Bay, Aegean Sea, mud, 60 m, L = 1.80 mm. **C**. *G*. cf. *occulta*, Izmir Bay, Aegean Sea, mud, 60 m, L = 2.00 mm. **D**. *G. melitensis*, Izmir Bay, Aegean Sea, mud, 60 m, L = 2.05 mm. **E-H**. *G*. cf. *melitensis*, Dalaman, Aegean Sea, sandy mud, 35 m, L = 1.90 mm. **I**. *G. occulta*, Aegean Sea, mud, 27 m, L = 1.85 mm. **J**. *G. occulta*, Aegean Sea, mud, 27 m, L = 1.95 mm. **K**. *G. occulta*, Aegean Sea, mud, 27 m, L = 1.93 mm. **L**. *G*. cf. *melitensis*, Aegean Sea, sandy mud, 47 m, L = 2.05 mm. **M-P**. *G. melitensis*, Turunç, Marmaris, Aegean Sea, mud, 57 m, L = 1.90 mm.

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