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New Deep-Sea Molluscan Records from Mallorca Channel Seamounts (North-Western Mediterranean)

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Abstract: Seamounts are globally important and essential ecosystems for supporting and maintaining marine biodiversity. In the Mallorca Channel, three prominent seamounts are present: Ausias March, Ses Olives and Emile Baudot. Currently, this area is being evaluated for inclusion in the Natura 2000 network. For this objective three surveys were conducted in the seamounts of the Mallorca Channel during July 2018 and July 2020. Samples of macro-invertebrates obtained in the deep sea revealed a rich fauna of Mollusca (68 species belonging to 40 families). New Mollusca occurrences included: four species of Gastropoda: *Colus jeffreysianus*, *Cantrainea peloritana*, *Fusiturris similis*, *Gymnobela abyssorum*, and seven species of Bivalvia: *Pododesmus squama*, *Allogramma formosa*, *Asperarca nodulosa*, *Cetomya neaeroides*, *Spondylus gussonii*, *Haliris granulata* and *Policordia gemma*. Where possible, the identification of these species was confirmed using the DNA barcoding method (sequencing of the cytochrome c oxidase subunit I). This study contributes towards filling the gap in knowledge of deep-sea mollusc fauna of the north-western Mediterranean.

Keywords: benthos; biodiversity; bivalvia; INTEMARES project; gastropoda; LEBA demarcation; Mediterranean; Natura 2000 network; SCI; seamounts

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1. Introduction

In the Mediterranean, over 242 seamounts have been recorded [1,2]. Although seamounts are globally important and deemed essential ecosystems for supporting and maintaining marine biodiversity [3–5], much of these seamounts remain poorly studied or unexplored [6]. This gap needs to be filled in order to discover the potential contribution of these systems to deep Mediterranean biodiversity and/or to identify vulnerable marine ecosystems [7].

This is the case of the Mallorca Channel (Balearic Islands, western Mediterranean), where three prominent seamounts are present, of between 86 and 1005 m in depth: Ses Olives, Ausias March and Emile Baudot. This area is located in the Eastern and Balearic demarcation (LEBA) one of five Spanish marine demarcations of the Marine Strategy Framework Directive (MSFD), 2008/56/EC [8]. There are relatively few studies on these seamounts. Some studies have focused on specifics zoological groups, such as Porifera [9,10] or Cnidaria [11]. The first habitat/faunistic studies were carried out by OCEANA [12,13]. All these studies suggest their high ecological value, as biological hotspots, and for this reason the three seamounts have recently received scientific attention to preserve the deep-sea ecosystem of the Mediterranean.

Currently, these seamounts are being evaluated within the LIFE IP INTEMARES project (https://intemares.es/en/the-project/life-integrated; accessed on 11 September 2022)

for their inclusion in the Natura 2000 Network (proposed Sites of Community Importance, pSCIs) (LIFE IP INTEMARES project). For that, it is necessary to improve the scientific knowledge on the presence of areas of ecological interest that host vulnerable and protected habitats and species. Recent studies have already highlighted the ecological importance of these seamounts, where up to 547 taxa and 29 categories of benthic habitats have been found [14]. Biodiversity studies on unexplored areas, such as seamounts, lead, in most cases, to the discovery of new species for science [15], to new species records [16] or to an increase in species distribution knowledge (geographical and/or bathymetric) [17].

Molluscans are an important component of the seamount macrobenthos, being a large part of the abundance and biomass in any marine assemblage [18,19]. Molluscs are one of the most species-rich phyla inhabiting the Mediterranean waters [20]. In fact, the Mediterranean malacofauna is considered the best known in the world [21], with 2113 species described up to 2010 [22]. Recent studies in Mediterranean seamounts have revealed that these ecosystems can host a high biodiversity of molluscs [14,17,23,24].

In 2017, Gofas et al. [18] published an update of the Spanish marine mollusc master list for compliance with the requirements of the MSFD [25,26]. These valuable and laborious biodiversity updates provide basic knowledge for effective marine conservation. Therefore, this type of work, like future contributions to the list, represents a link between biodiversity studies and conservation, highlighting the important task of understanding regional biodiversity patterns and its ecology, as O'Hara et al. [27] observed, "to conserve marine biodiversity, we must first understand the spatial distribution and status of at-risk biodiversity" and be able to conserve it through effective management programs, or/and award conservation status, such as SCI and Special Areas of Conservation (SAC), within the Natura 2000 Network. The checklist of Gofas et al. [18] highlights the gap in knowledge in the mollusc fauna of the Balearic Islands, as most of the records underlying the 1165 reported species in the LEBA demarcation of the MSFD (East coast of Spain and Balearic Islands) were from the mainland.

The aim of the present study was to improve knowledge of north-western Mediterranean mollusc diversity, by adding information on the Mallorca Channel (Balearic Islands) seamounts, where this Phylum has been poorly characterized. To do so, where possible, identification of species was performed through both morphological characterization and molecular analyses.

2. Materials and Methods

2.1. Study Area

The Mallorca Channel corresponds to a seaway between the Ibiza and Mallorca islands, at the central sector of the Balearic Promontory. This promontory, of structural origin, is located in the middle of the western Mediterranean (Figure 1). It is characterized by the presence of a variety of morphological features namely seamounts, scarps and depressions [28,29]. Three seamounts called Ses Olives, Ausias March and Emile Baudot, are located between 86 and 1005 m depth. They are 375, 264, 600 m high, respectively, 10 to 17 km long and up to 77° of slope. They have tabular summits and irregular basal geometry, remarkably elongated in NE-SW trends [30]. While Ses Olives and Ausias March are of continental origin, the Emile Baudot is of volcanic origin [31].

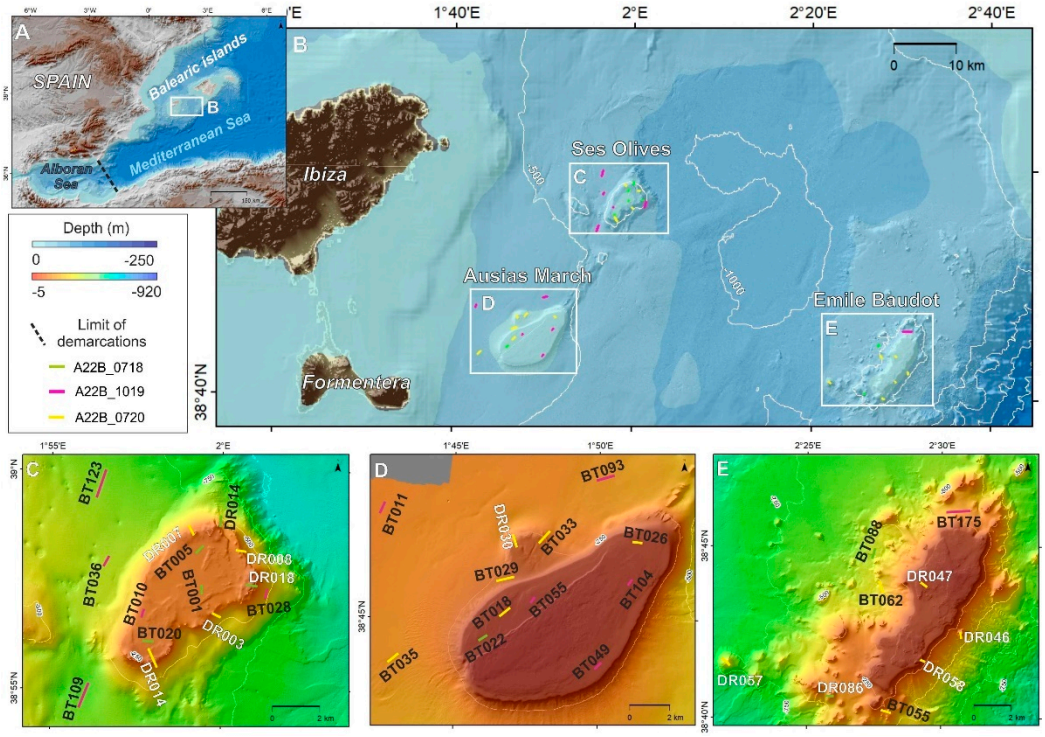

Figure 1. Maps showing: (**A**) western Mediterranean, with the two Mediterranean Spanish demarcations of the MSFD: Straits and Alborán demarcation (ESAL) and Eastern and Balearic demarcation (LEBA), separated with dashed line; (**B**) general view of the total area of study, Mallorca Channel (Balearic Islands); (**C**) Ses Olives; (**D**) Ausias March; and (**E**) Emile Baudot seamounts. Maps C–E show the codes of the sampling stations with new occurrences of molluscans, developed during the INTEMARES surveys. The serial reference is shown above the track: (BT) beam trawl and (DR) rock dredge.

2.2. Sample Collection

Specimens of deep-sea molluscs were obtained during the sampling operations of the INTEMARES project. The project aimed to improve the scientific knowledge on habitats, species, and human activities to include these seamounts in the European network of marine Natura 2000 sites. For this objective, three INTEMARES surveys were conducted in the seamounts of the Mallorca Channel in July 2018, October 2019 and July 2020 on board the R/V *Ángeles Alvariño*. Sampling gears included a Jennings type beam trawl (BT) of 2 and 0.5 m horizontal and vertical openings, respectively, equipped with a 5 mm mesh size cod-end, and a rock dredge (DR) with 0.77 and 0.35 m horizontal and vertical openings with a 6 cm mesh size code-end. A total of 85 samples between 99 and 764 m depth, and 55 samples between 89 and 1191 m depth, were collected using BT and DR, respectively. Samples were taken during daytime and had 5–15 min duration at around 2 knots for BT and 1 knot for DR (Table 1) [14]. All samples were sorted and identified as species or to the lowest possible taxonomic category. Molluscs with uncertain identification on board were preserved in absolute ethanol for further analyses in the laboratory.

Table 1. Information on the stations where new records of Mollusca were found in the seamounts of the Mallorca Channel (Balearic Islands, western Mediterranean): Ses Olives (SO), Ausias March (AM) and Emile Baudot (EB). Samples were collected with beam-trawl (BT), rock dredge (DR) during the INTEMARES surveys developed between 2018 and 2020. Depth range and mean depth for DR and BT stations, respectively are also shown.

			Setting		Hauling				
Survey	**Sampling Method**	**Sample Code**	**Latitude (N)**	**Longitude (E)**	**Latitude (N)**	**Longitude (E)**	**Depth (m)**	**Area**	**Habitat**
A22B_0718	BT	BT001	38°56.800′	001°58.540′	38°57.380′	38°57.3800′	290	SO	Fine sand
		BT005	38°58.620′	001°59.880′	38°58.120′	001°59.240′	259	SO	Fine sand
		BT020	38°56.100′	001°58.520′	38°56.100′	001°57.730′	275	SO	Fine sand
		BT022	38°44.570′	001°46.250′	38°44.420′	001°45.890′	105	AM	Coarse sand
		BT088	38°45.480′	002°27.750′	38°44.740′	002°27.440′	574	EB	Coarse silt
	DR	DR014	38°58.970′	001°59.970′	38°58.740′	001°59.980′	479–278	SO	Fine sand
		DR018	38°57.360′	002°01.090′	38°57.410′	002°00.830′	263–235	SO	Rocky outcrops with medium sand
A22B_1019	BT	BT010	38°56.790′	001°57.710′	38°56.670′	001°57.650′	288	SO	Fine sand
		BT028	38◦56.750′	002◦01.160′	38◦57.290′	002◦01.320′	449	SO	Coarse sand
		BT036	38°57.190′	001°56.110′	38°57.990′	001°56.670′	619	SO	Medium silt
		BT049	38°43.330′	001°49.370′	38°43.330′	001°49.370′	124	AM	Medium sand
		BT055	38°45.440′	001°47.560′	38°45.560′	001°47.780′	114	AM	Medium sand
		BT093	38°48.400′	001°48.030′	38°48.890′	001°50.450′	376	AM	Very fine sand
		BT101	38°48.700′	001°42.880′	38°47.830′	001°42.400′	320	AM	Coarse silt
		BT104	38°45.620′	001°50.770′	38° 46.090′	001°51.140′	116	AM	Coarse sand
		BT109	38°53.670′	001°55.370′	38°55.120′	001°56.120′	715	SO	Coarse silt
		BT123	38°58.270′	001°55.850′	38°59.970′	001°56.560′	675	SO	Medium silt
		BT175	38°46.070′	002°30.150′	38°46.053′	002°31.100′	412	EB	Fine sand
A22B_0720	BT	BT018	38°45.050′	001°46.550′	38°45.270′	001°46.900′	113	SO	Coarse sand
		BT026	38°47.160′	001°50.760′	38°47.100′	001°51.440′	127	AM	Very fine silt
		BT029	38°46.240′	001°47.570′	38°46.030′	001°46.520′	195	AM	Fine sand
		BT033	38°46.730′	001°47.670′	38°46.730′	001°47.670′	225	AM	Coarse sand
		BT035	38°44.420′	001°43.790′	38°43.800′	001°42.750′	352	AM	Fine to medium sand
		BT055	38°39.980′	002°28.990′	38°40.240′	002°27.810′	473	EB	Volcanic rock with fine sand
		BT062	38°43.250′	002°27.820′	38°44.000′	002°27.680′	508	EB	Fine sand

		DR003	38°56.670′	001°59.940′	38°56.740′	001°59.770′	455–288	SO	Rocky outcrops with fine sand
		DR007	38°58.760′	001°59.010′	38°58.560′	001°59.140′	384–255	SO	Rocky outcrops with coarse silt
		DR008	38°58.165′	002°00.670′	38°58.200′	002°00.430′	355–295	SO	Rocky outcrops
	DR	DR014	38°55.510′	001°58.130′	38°55.910′	001°57.880′	395–270	SO	Rocky outcrops with fine sand
		DR030	38°47.310′	001°47.010′	38°46.970′	001°47.130′	276–204	AM	Rocky outcrops
		DR046	38°42.310′	002°30.750′	38°42.520′	002°30.710′	367–235	EB	Volcanic rocky outcrops
		DR047	38°43.840′	002°29.400′	38°43.940′	002°29.280′	127	EB	Rhodoliths
		DR057	38°41.720′	002°21.880′	38°41.560′	002°22.100′	665–488	EB	Fine sand
		DR058	38°40.700′	002°35.370′	38°40.940′	002°35.270′	1191–1066	EB	Volcanic rocky outcrops

2.3. Sedimentological Analysis

Samples of surface sediments, collected using Shipek and Box–Corer grabs during the above-mentioned INTEMARES surveys, were also analyzed [14]. The sedimentological analysis for grain size distribution was carried out on 10–15 g of sediment pre-treated with 10% H_2O_2 to remove organic matter and sodium hexametaphosphate as a dispersing agent. Samples were wet sieved to separate the coarse fraction (gravel) using a 2 mm mesh size sieve. Particles <2 mm (sand, silt, and clay) were determined by using a laser diffraction analyzer (Mastersizer 3000, Malvern® Panalytical, Centro Oceanográfico de Málaga, IEO-CSIC). The textural classification of the sediments was based on Folk [32] ternary diagrams and also the organic matter was obtained [33].

2.4. Morphological Identification

Only live-taken specimens are considered. Individuals were analyzed under a stereomicroscope Leica M165C equipped with a camera Leica MC170. Identification was done using specific taxonomic guides [34–37]. The taxonomic names of the species were checked in MolluscaBase database [38]. The specimens were deposited in the Biological Reference Collections (CBMR) at the Institut de Ciències del Mar (ICM-CSIC) under serial code shown in the description of the examined material.

2.5. Molecular Identification

Genomic DNA was extracted from a small piece of tissue using the DNeasy Blood and Tissue Extraction kit (Qiagen, West Sussex, United Kingdom). Polymerase chain reaction (PCR) was used to amplify the mitochondrial DNA barcoding fragment (cytochrome c oxidase subunit I, COI) with the universal primers LCO1490/HCO2198 proposed by Folmer et al. [39].

PCR was performed in 25 μL volume (17.2 μL ddH2O, 2.5 μL Mangobuffer (Bioline), 1 μL DNTPs, 1.75 MgCl2, 0.5 μL BSA, 0.5 μL each primer (each 10 pmol), 0.05 μL TAQ (Bioline) and 1 μL DNA). The PCR thermal profile was: initial stage of 96 °C for 5 min; then 35 cycles at 94 °C for 60 s, 50 °C for 60 s and 72 °C for 60 s, followed by a final extension at 72 °C for 10 min. PCR products were purified using the QIAquickR PCR Purification Kit (QIAGEN). Both heavy and light strands were sequenced on an ABI 3130 sequencer (Applied Biosystems).

Sequences were imported into BioEdit 7.0.5.2. [40] and checked for quality and accuracy with nucleotide base assignment. The DNA sequences obtained were deposited in the GenBank database (http://www.ncbi.nlm.nih.gov/genbank/; accessed on 2 February 2021).

Sequences were validated using the BLAST function from the GenBank database (https://blast.ncbi.nlm.nih.gov/Blast.cgi; accessed on 15 March 2021 [41]) as well as the IDENTIFICATION function from the Barcode of Life Data System BOLD system (https://www.boldsystems.org; accessed 21 March 2021 [42]).

3. Results

3.1. Mollusca Biodiversity

A total of 2509 individual molluscs were collected during the INTEMARES surveys in the seamounts of the Mallorca Channel. These individuals belonged to 68 species, of which 34 species were bivalves and 34 species were gastropods (Table 2). Up to 15 of these species were present in all three seamounts. In Ses Olives seamount, 27 species were identified, 46 species were identified in Ausias March seamount, and 43 species in the Emile Baudot seamount. Figure 2 shows photographs of some of the species that form part of the mollusc community of the seamounts of the Mallorca Channel.

Table 2. List of live collected molluscs specimens in the Mallorca Channel (Balearic Islands, western Mediterranean) seamounts: Ses Olives (SO), Ausias March (AM) and Emile Baudot (EB). Information on the presence (x) and no presence (0) of the species by seamount is also provided. New records shown in bold.

Class	Subclass	Order	Family	Species	SO	AM	EB	Depht (m)
GASTROPODA	Caenogastropoda	Littorinimorpha	Aporrhaidae	*Aporrhais serresiana* (Michaud, 1828)	x	x	x	319–640
			Capulidae	*Capulus ungaricus* (Linnaeus, 1758)	0	x	x	127–150
			Cymatiidae	*Monolex corrugatus* (Lamarck, 1816)	0	0	x	116
			Naticidae	*Euspira fusca* (Blainville, 1825)	x	x	x	281–474
				Tectonatica rizzae (Philippi, 1844)	x	x	0	105–445
			Ranellidae	*Ranella olearium* (Linnaeus, 1758)	0	0	x	137–410
			Xenophoridae	*Xenophora crispa* (König, 1825)	0	x	x	122–297
		Neogastropoda	Clathurellidae	*Comarmondia gracilis* (Montagu, 1803)	0	0	x	127
			Colidae	***Colus jeffreysianus* (P. Fischer, 1868)**	**0**	**0**	**x**	**503–574**
			Columbellidae	*Mitrella gervillii* (Payraudeau, 1826)	0	0	x	665–488
			Fasciolariidae	*Aptyxis syracusana* (Linnaeus, 1758)	0	x	0	118
				Fusinus pulchellus (Philippi, 1840)	0	x	x	105–395
				Gracilipurpura rostrata (Olivi, 1792)	0	x	x	127–483
			Fusiturridae	***Fusiturris similis* (Bivona And., 1838)**	**0**	**x**	**0**	**116–376**
			Muricidae	*Murexsul aradasii* (Monterosato, 1883)	0	0	x	123–126
				Orania fusulus (Brocchi, 1814)	0	0	x	123–131
				Ocenebra erinaceus (Linnaeus, 1758)	0	x	0	225
				Pagodula echinata (Kiener, 1839)	x	x	x	259–680
				Trophonopsis muricata (Montagu, 1803)	0	x	0	319
			Raphitomidae	***Gymnobela abyssorum* (Locard, 1897)**	**x**	**x**	**x**	**259–574**
		-	Epitoniidae	*Epitonium celesti* (Aradas, 1854)	0	0	x	147–410
	Heterobranchia	Cephalaspidea	Philinidae	*Philine monterosati* Monterosato, 1874	x	x	x	98–410
				Philine sp.	x	x	x	111–740
			Gastropteridae	*Gastropteron rubrum* (Rafinesque, 1814)	0	x	0	105–242
		Pteropoda	Cymbuliidae	*Cymbulia peronii* Blainville, 1818	x	x	x	111–680
			Acteonidae	*Japonactaeon pusillus* (Forbes, 1844)	x	0	0	482–586
	Vetigastropoda	Lepetellida	Addisoniidae	*Addisonia excentrica* (Tiberi, 1855)	0	x	0	118
		Seguenziida	Chilodontaidae	*Danilia tinei* (Calcara, 1839)	0	x	x	127–150
		Trochida	Calliostomatidae	*Calliostoma conulus* (Linnaeus, 1758)	0	0	x	302

				Calliostoma granulatum (Born, 1778)	x	x	x	118–405
				Calliostoma zizyphinum (Linnaeus, 1758)	0	x	x	225–483
			Colloniidae	***Cantrainea peloritana* (Cantraine, 1835)**	**0**	**0**	**x**	**503–574**
			Trochidae	*Callumbonella suturalis* (Philippi, 1836)	0	x	x	169–365
				Clelamdella miliaris (Brocchi, 1814)	x	x	0	135–474
BIVALVIA	Autobranchia	Arcida	Arcidae	*Anadara corbuloides* (Monterosato, 1881)	0	x	0	111–112
				***Asperarca nodulosa* (O. F. Müller, 1776)**	**x**	**0**	**x**	**260–665**
				Bathyarca philippiana (Nyst, 1848)	x	x	x	152–759
				Tetrarca tetragona (Poli, 1795)	0	x	0	99
		Cardiida	Tellinidae	*Arcopella balaustina* (Linnaeus, 1758)	0	x	0	122–195
			Semelidae	*Abra longicallus* (Scacchi, 1835)	x	x	x	195–740
		Limida	Limidae	*Lima lima* (Linnaeus, 1758)	0	x	0	105
				Limaria tuberculata (Olivi, 1792)	0	x	0	267
		Pectinida	Anomiidae	*Anomia ephippium* Linnaeus, 1758	0	0	x	274
			Pectinidae	*Pododesmus patelliformis* (Linnaeus, 1761)	0	x	0	105–122
				***Pododesmus squama* (Gmelin, 1791)**	**0**	**x**	**0**	**105–124**
				Delectopecten vitreus (Gmelin, 1791)	x	0	x	640–674
				Karnekampia sulcata (O. F. Müller, 1776)	0	x	x	122–348
				Mimachlamys varia (Linnaeus, 1758)	x	0	0	255–384
				Palliolum incomparabile (Risso, 1826)	x	x	x	169–503
				Parvamussium fenestratum (Forbes, 1844)	x	x	x	127–674
				Pseudamussium clavatum (Poli, 1795)	0	x	x	105–352
				Similipecten similis (Laskey, 1811)	x	x	x	105–298
				Aequipecten commutatus (Monterosato, 1875)	0	0	x	410
			Spondylidae	***Spondylus gussonii* O. G. Costa, 1830**	**0**	**0**	**x**	**127**
		Venerida	Mactridae	*Spisula subtruncata* (da Costa, 1778)	x	0	0	259
			Veneridae	*Timoclea ovata* (Pennant, 1777)	0	0	x	127
		-	Cuspidariidae	*Cardiomya costellata* (Deshayes, 1835)	x	x	0	118–607
		-		*Cuspidaria cuspidata* (Olivi, 1792)	x	x	x	127–474
		-		*Cuspidaria rostrata* (Spengler, 1793)	x	x	x	122–759
		-		*Tropidomya abbreviata* (Forbes, 1843)	x	x	x	122–523
		-	Lyonsiidae	***Allogramma formosa* (Jeffreys, 1882)**	**x**	**0**	**0**	**619–675**
				***Policordia gemma* (A. E. Verrill, 1880)**	**0**	**x**	**0**	**124**

	-	Poromyidae	*Poromya granulata* (Nyst & Westendorp, 1839)	0	x	x	122–352
			***Cetomya neaeroides* (Seguenza, 1877)**	**x**	**0**	**0**	**235–449**
	-	Verticordiidae	***Haliris granulata* (Seguenza, 1860)**	**0**	**x**	**x**	**127–412**
Protobranchia	Nuculanida	Nuculanidae	*Ledella messanensis* (Jeffreys, 1870)	x	0	0	523–715
	Nuculida	Nuculidae	*Nucula nitidosa* Winckworth, 1930	0	x	0	320–365
			Nucula sulcata Bronn, 1831	0	x	0	376

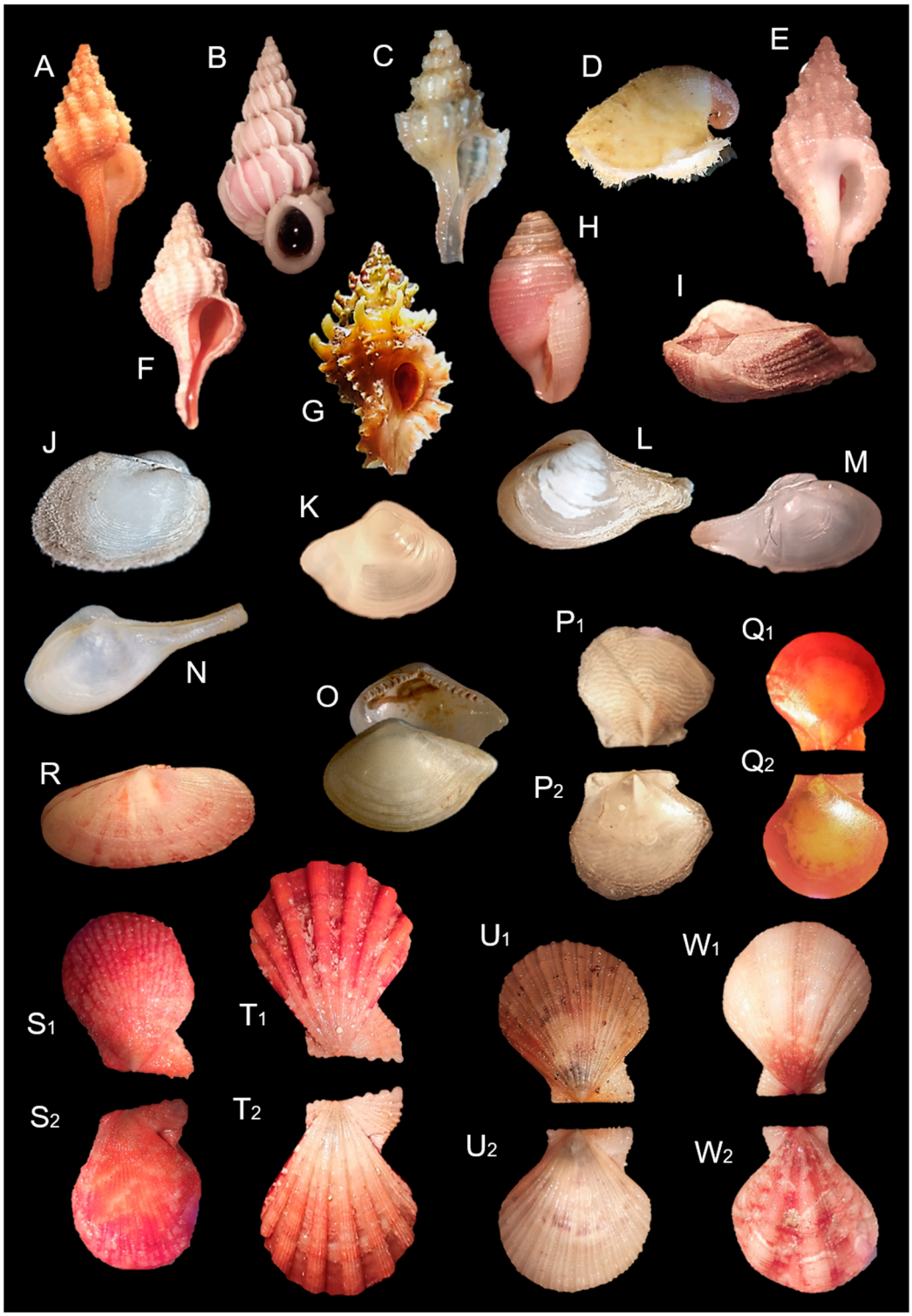

Figure 2. Some molluscans species collected from Ses Olives, Ausias March and Emile Baudot seamounts in the Mallorca Channel (Balearic Islands): (**A**) *Fusinus pulchellus*; (**B**) *Epitonium celesti*; (**C**) *Pagodula echinata*; (**D**) *Capulus ungaricus*; (**E**) *Orania fusulus*; (**F**) *Trophonopsis muricata*; (**G**) *Murexul aradasii*; (**H**) *Japonacteon pusillus*; (**I**) *Tetrarca tetragona*; (**J**) *Bathyarca philippiana*; (**K**) *Tropydomia abbreviata*; (**L**) *Cuspidaria cuspidata*; (**M**) *Cardiomya costellata;* (**N**) *Cuspidaria rostrata*; (**O**) *Ledella messanensis*; (**P**) *Similipecten similis*; (**Q**$_1$,**Q**$_2$) *Palliolum incomparabile*; (**R**) *Gari costellata*; (**S**$_1$,**S**$_2$) *Tolochlamys multistriata*; (**T**$_1$,**T**$_2$) *Manupecten pesfelis*; (**U**$_1$,**U**$_2$) *Karnekampia sulcata*; and (**W**$_1$-**W**$_2$) *Pseudamussium clavatum*. Images not to scale.

3.2. New Occurrence from Mallorca Channel Seamount

Up to 11 species of Phylum Mollusca constitute new records that improve the scientific knowledge on Mallorca Channel seamounts in the western Mediterranean; 4 species belong to the Class Gastropoda and 7 species to the Class Bivalvia (Table 2; Figure 3).

Figure 3. New deep-see molluscans records from Ses Olives, Ausias March and Emile Baudot seamounts in the Mallorca Channel (Balearic Islands): (**A**) *Colus jeffreysianus*; (**B**$_1$,**B**$_2$) *Cantrainea peloritana*; (**C**) *Fusiturris similis*; (**D**,**D**$_2$) *Gymnobela abyssorum;* (**E**$_1$,**E**$_2$) *Pododesmus squama*; (**F**$_1$,**F**$_2$) *Spondylus gussonii*; (**G**) *Allogramma formosa*; (**H**$_1$,**H**$_2$) *Asperarca nodulosa;* (**I**) *Cetomya neaeroides*; (**J**$_1$,**J**$_2$) *Haliris granulata*; and (**K**$_1$,**K**$_2$) *Policordia gemma*. Images not to scale.

3.3. Systematic Account

Phyllum Mollusca Linnaeus, 1758
Class Gastropoda Cuvier, 1797
Family Colidae Gray, 1857
Colus jeffreysianus (P. Fischer, 1868)
(Figure 3A)

Material examined: R/V Ángeles Alvariño; St. BT088, 38°45.480′ N 002°27.750′ E, Emile Baudot seamount, 574 m depth, A22B_0718, 1 specimen. Deposited under the serial code ICMCBR000393.

External morphology: Shell large with sculpture attenuated, consisting only of fine spiral grooves and protoconch of more than 2 whorls, with a small nucleus. Within the genus *Colus*, protoconch morphology, such as the number of whorls and the way they are whorled, may be regarded as being specific.

Distribution: *Colus jeffreysianus* lives in deep water from 400 to 2100 m from South Iceland and Norway, the Shetland Islands and the Faroes, the Kattegat and SW Skagerrak and off the British Isles. Further southwards it is found on the continental shelf of the Bay of Biscay, the Iberian Peninsula and the western Mediterranean Sea [43]. It is not common anywhere, but less common in the east English Channel and southern North Sea than elsewhere [44].

Remarks: Records have been reported in the north-western Mediterranean was probably based on fossil specimens according to Gofas et al**.** [18]. We provide a live specimen, in which the operculum was preserved (Figure 3A), collected on coarse slit in Emile Baudot seamount at 574 m depth. Identification has been based on another two specimens whose protoconch were preserved and had more than 2 whorls. The present record is the first record for the Balearic Islands.

Genetics: PCR amplification of *C. jeffreysianus* did not work.

Family Colloniidae Cossmann, 1917
Cantrainea peloritana (Cantraine, 1835)
(Figure 3B$_1$-B$_2$)

Material examined: R/V Ángeles Alvariño; St. BT088, 38°45.480′ N 002°27.750′ E, A22B_0718, Emile Baudot seamount, 574 m depth, 07/2018, 1 specimen. Deposited under the serial code ICMCBR000443.

External morphology: This species is remarkable for the uniform white colour, the concavity at the upper part of the whorls, the median angle or carination, and the two or three keels upon the last whorl. Mediterranean shape is smaller.

Distribution: *C. peloritana* species was collected in northern Spain and western Portugal, cited by Nobre [45] and Locard [46] at depths ranging from 135 to 512 m. In the Atlantic Ocean it has been documented in Canary Islands [47] at 470–485 depth, Azores at 454 m depth [48] and in the northern part of the Bay of Biscay, at 630–650 m depth [49]. In the Mediterranean, this species has been reported on deep-sea coral banks in Sardinia (Capo Carbonara) and Central Tyrrhenian Sea (coast of Latium), at 300-600 m depth [48]. The few specimens reported in the Mediterranean classify this species as rare in this area [38].

Remarks: Two individuals were collected at the Emile Baudot seamount at 574 and 508 m depth on fine sand and coarse silt. The presence of *C. peloritana* in the western Mediterranean is confirmed. The present record also represents the first record of the species in the north-western Mediterranean.

Genetics: PCR amplification of *C. peloritana* did not work.

Family Fusiturridae Abdelkrim, Aznar-Cormano, Fedosov, Kantor, Lozouet, Phuong, Zaharias & Puillandre, 2018
Fusiturris similis (Bivona Ant. in Bivona And., 1838)
(Figure 3C)

Material examined: R/V Ángeles Alvariño; St. BT093, 38°48.400′ N 001°48.030′ E, Ausias March, 376 m depth, A22B_1019, 1 specimen; St. BT101, 38°48.700′ N 001°42.880′

E, Ausias March, 320 m depth, A22B_1019, 1 specimen; St. BT104, 38°45.620′ N 001°50.770′ E, Ausias March, 116 m depth, A22B_1019, 2 specimens. Deposited under the serial code ICMCBR000450.

External morphology: Shell elongated and fusiform shape, up to 50 mm. Very narrow and turriculate with numerous narrow axial ribs with three reddish-brown bands.

Distribution: *F. similis* can be found characterizing deep rubble on the Alborán shelf [24,50] as well as in bathyal muds and sediment-covered rocky bottoms of the Seco de los Olivos seamount [13]. Gofas and Zenetos [51] considered *F. similis* a tropical or subtropical species, distributed from the Ibero-maroccan Atlantic coasts, the Sahara and Morocco to the Alborán Sea, and Algeria and Tunisian coasts in the south-west Mediterranean. This species has been also collected in Amanay seamount in the Canary Islands (Atlantic Ocean) [52].

Remarks: Four specimens were collected at the Ausias March seamount between 120-370 m depth on sand or coarse silt. The present record extends the distribution of the species to the north-western Mediterranean.

Genetics: A fragment of 594 base pairs (bp) of the COI fragment was sequenced and deposited in GenBank under the accession number: OP329214. High similarity values (98.82%) were detected in both genetic databases, GenBank and BOLD system, from sequences of *F. similis* published by Cunha et al. [53]. Therefore, this result supported the morphological identification of *F. similis*.

Family Raphitomidae Bellardi, 1875

Gymnobela abyssorum (Locard, 1897)

(Figure 3D-D$_1$)

Material examined: R/V Ángeles Alvariño; St. BT005, 38°58.620′ N 001°59.880′ E, Ses Olives seamount, 259 m depth, A22B_0718, 1 specimen; St. BT020, 38°56.100′ N 001°58.520′ E, Ses Olives seamount, 275 m depth, A22B_0718, 1 specimen; St. BT088, 38°45.480′ N 002°27.750′ E, Emile Baudot seamount, 574 m depth, A22B_0718, 1 specimen. Deposited under the serials code ICMCBR000385, ICMCBR000446, ICMCBR000453, respectively.

External morphology: Shell light brown-brownish white. The sculpture consists of short, low and broad axial ribs and a spiral sculpture of rather equal-sized spiral lines.

Distribution: This species inhabits circalittoral and bathyal muddy bottoms [34,54]. The upper bathyal in the northern part of the Bay of Biscay to the Ibero-Moroccan Gulf [55] and in the Alborán Sea (Mediterranean) [47]. Ortega and Gofas [47] gave the last new record for *G. abyssorum* in the Canary Islands.

Remarks: Three individuals were collected in Ses Olives and Emile Baudot seamounts on fine or coarse bottoms. The present record extends the distribution to the north-western Mediterranean.

Genetics: For this specimen a fragment of 540 bp was sequenced deposited in GenBank under the accession number: OP328907. Similarity values were different for genetic databases, for the BOLD system highest values with 94.6% and 92.92% were for sequences of *Pagodibela meridionals* and *Gymnobela* sp. published by Criscione et al. [56] and Hallan et al. [57], respectively. While, for GenBank the highest values (from 94.6 to 91.7%) were for *Pagodibela* genus, and a high value (91.7%) was recorded for *Gymnobela* sp. published by Puillandre et al. [58]. Although molecular identification may be unclear for *Gymnobela* and *Pagodibela* genera, it is to know that *Gymnobela* is composed by a high number of species (around 94; http://www.marinespecies.org/; accessed on 01/09/2021) with an extended geographic distribution, while *Pagodibela* is a newly recognized genus from the tropical Indo-Pacific [56]. Considering this and the shell morphological characteristics, it is expected that the specimen studied corresponds to the *Gymnobela* genus.

Class Bivalvia

Family Anomiidae Rafinesque, 1815

Pododesmus squama (Gmelin, 1791)

(Figure 3E$_1$-E$_2$)

Material examined: R/V Ángeles Alvariño; St. BT022, 38°44.570′ N 001°46.250′ E, Ausias March seamount, 105 m depth, A22B_0718, 2 specimens; St. BT049, 38°43.330′ N 001°49.370′ E, Ausias March seamount, 124 m depth, A22B_1019, 1 specimen; St. BT055, 38°45.440′ N 001°47.560′ E, Ausias March seamount, 114 m depth, A22B_1019, 1 specimen. Deposited under the serials code ICMCBR000381, ICMCBR000386.

External morphology: It has radial striate but no riblets on the outside of the upper valve, attached muscle scars, thin and transparent mantle, and the tentacles are thin and narrowly rounded.

Distribution: This species inhabits 20-200 m depth of the continental shelf and it is distributed from Iceland, Norway and English Channel [36,59–61] to Morocco [62] and South Africa [63]. It is also distributed in the central [64] and eastern Mediterranean, cited in Marmara and Aegean Sea [65], and in the Alborán Sea off the coast of Morocco [37].

Remarks: The individuals collected in this study are the first records of the species in the north-western Mediterranean.

Genetics: A fragment of 432 bp was sequenced and deposited in GenBank under the accession number: OP347785. Similarity values observed in GenBank and BOLD system were similar (98.4%), and corresponded to an unpublished sequence of *P. squama* submitted by SweBol Marine invertebrates [59]. Thus, molecular results supported the morphological identification of *P. squama*.

Family Spondylidae Gray, 1826

Spondylus gussonii O. G. Costa, 1830

(Figure 3F$_1$-F$_2$)

Material examined: R/V Ángeles Alvariño; St. DR047, 38°43.840′ N 002°29.400′ E Emile Baudot seamount, 127 m depth, A22B_0720, 1 specimen. Deposited under the serial code ICMCBR000481.

External morphology: White, oval to pyriform shell shape with coarse spiny processes in the attachment area and right valve more irregularly sculptured. expanded posterior side, radial rows of minute, short tubular spines; thin commarginal lamellae more clearly visible towards the ventral margin.

Distribution: Bathyal species that inhabits attached to deep water coral or cemented in hard substrata [66]. Pons-Moya and Pons [67] cited *S. gussonii* in the Balearic Islands from partial or subfossil shells. The species is typical of the Mediterranean, with records also from the Bay of Biscay, Portugal and the archipelago of the Azores [68]. It has been reported in three Spanish demarcations of the MSFD, North Atlantic, South Atlantic and Strait and Alborán Sea [18], between 70-1850 m depth, being common around 600 m [36].

Remarks: A single specimen was collected at Emile Baudot seamount, fixed to rock on rhodolith beds at 127 m depth. The new record provided in this study confirms the presence of the species in the Balearic Islands (north-western Mediterranean).

Genetics: PCR amplification of *S. gussonii* did not work.

Family Lyonsiellidae Dall, 1895

Allogramma formosa (Jeffreys, 1882)

(Figure 3G)

Material examined: R/V Ángeles Alvariño; St. BT036, 38°57.190′ N001°56.110′ E, Ses Olives seamount, 619 m depth, A22B_1019, 1 specimen; St. B0109, 38°53.670′ N 001°55.370′ E, Ses Olives seamount, 715 m depth, A22B_1019, 1 specimen; St. BT0123, 38°58.270′ N 001°55.85′ E, Ses Olives seamount, 675 m depth, A22B_1019, 1 specimen. Deposited under the serial code ICMCBR000396.

External morphology: Sub-rectangular shell and broad, obliquely triangular, resilient cavity; possesses posterior radial ridges gnarled plus some weaker ones in middle part of shell; anterior wrinkles wavy running dorsoventrally; sparse rows of minute pustules, raised in short spines on posterodorsal area.

Distribution: Rare and fragile species, characteristic of the hypobathial mud [69]. *A. formosa* is distributed in the north-western Atlantic, from the Caribbean basin to south-eastern Brazil, in the north-eastern Atlantic off Guinea-Bissau, Canary Islands, Azores and

Bay of Biscay [36,37,70,71]. In the Mediterranean it is distributed in the Levantine basin, from lower slope to abyssal depths [36,68,69,72,73], and in the Aegean Sea [74].

Remarks: Four specimens were collected at the Ausias March seamount between 619 and 715 m depth, in medium to coarse silt sediment. The record provided in this study represents the first record of the species in the north-western Mediterranean.

Genetics: A fragment of 573 bp was sequenced and deposited in GenBank under the accession number: OP328904. Low similarity values (<85%) were recorded in GenBank and BOLD system. The closest taxon was the Euciroidae family, with 80.57% and 76.15% similarity, for BOLD system and GenBank, respectively. There are no COI sequences available for any member of the Lyonsiellidae family. In this case, the molecular result cannot support the morphological identification, but it will be useful for future comparisons.

Family Arcidae Lamarck, 1809

Asperarca nodulosa (O. F. Müller, 1776)

(Figure 3H$_1$-H$_2$)

Material examined: R/V Ángeles Alvariño; St. DR014, 38°58.970′ N001°59.970′ E, Ses Olives seamount, 479–278 m depth, A22B_0718, 3 specimens; St. DR018, 38°57.360′ N 002°01.090′ E, Ses Olives seamount, 263-235 m depth, A22B_0718, 20 specimens; St. DR086, 38°40.650′ N 002°25.730′ E, Emile Baudot seamount, 337-309 m depth, A22B_0718, 1 specimen; St. BT001, 38°56.80′N 001°58.540′ E, Ses Olives seamount, 290 m depth, A22B_0718, 3 specimens; St. BT005, 38°58.620′ N 001°59.880′ E, Ses Olives seamount, 260 m depth, A22B_0718, 3 specimens; St DR057, 38°41.720′ N 002°21.880′ E, Emile Baudot seamount, 665–488 m depth, A22B_0720, 1 specimen. Deposited under the serials code ICMCBR000397, ICMCBR000398.

External morphology: *A. nodulosa* is large with subrectangular shell, flat mantle without siphons, lobes are attached to shell valves along the pallian line, peripheral to which is the mantle edge, roundish D-shaped outline with convex profile.

Distribution: North-east Atlantic (from Norway to Moroco) and the Gulf of Cádiz [75]. Inhabits from the tidal zone to a depth of 730 m [76], being also found at 4134 m depth [77], and the western Mediterranean from depths of 450–550 m [78].

Remarks: It was the most abundant species in the rocky outcrops with medium sand of Ausias March seamount. The specimens of the present study confirm the presence of this species in the Mallorca Channel.

Genetics: A fragment of 561 bp was sequenced and deposited in GenBank under the accession number: OP328905. The highest similarity value was found in BOLD system with 99.46% from an unpublished sequence of *A. nodulosa* (NBMM506-18; NTNU University Museum). While in GenBank the closest taxon (89.05%) was found with a sequence of *A. secreta* published by Plazzi et al. [78]. Thus, molecular results supported the morphological identification of *A. nodulosa*.

Family Poromyidae Dall, 1886

Cetomya neaeroides (Seguenza, 1877)

(Figure 3I)

Material examined: R/V Ángeles Alvariño; St. DR018, 38°57.360′ N 002°01.090′ E, Ses Olives seamount, 263–235 m depth, A22B_0718, 1 specimen; St. BT028, 38°56.750′ N 002°01.160′ E, Ses Olives seamount, 449 m depth, A22B_1019, 1 specimen. Deposited under the serial reference: ICMCBR000389.

External morphology: Shell thin, white, semitransparent, ovate, slightly inequivalve. Sculpture of faint growth lines and densely set minute granules in radial row.

Distribution: Western Atlantic, from Virginia to Gulf of Mexico [79]; Eastern Atlantic: Portugal and south of the Iberian Peninsula [37], Canary Islands [80]; Mediterranean basin: eastern of Sardinia [81] and Greek waters [74]. This species lives in deep habitats. In the Atlantic it is found up to 2980 m depth [79], while in the Mediterranean it is distributed shallower, between 320–350 m depth [81].

Remarks: Specimens were collected in Ausias March seamount on rock and medium sand bottom. It represents the first record of the species in the Balearic Islands.

Genetics: A fragment of 573 bp of the COI fragment was sequenced and deposited in GenBank under the accession number: OP328906. Low similarity values (<80%) were recorded in GenBank and BOLD system. In this last, the closest taxon was the Poromyidae family with 74.95%, whilst in GenBank there are not available COI sequences for members of this family. In this case, the molecular result cannot support the morphological identification, but it will be useful for future comparisons.

Family Verticordiidae Stoliczka, 1870

Haliris granulata (Seguenza, 1860)

(Figure 3J1-J2)

Material examined: R/V Ángeles Alvariño; St. DR086, 38°40.650′ N 002°25.730′ E, Emile Baudot seamount, 337–309 m depth, A22B_0718, 1 specimen. St. BT175, 38°46.070′ N 002°30.150′ E, Emile Baudot seamount, 412 m depth, A22B_1019, 1 specimen; BT026, 38°47.160′ N 001°50.760′ E, Ausias March seamount, 127 m depth, A22B_0720, 1 specimen. Deposited under the serials code ICMCBR000411, ICMCBR000419.

External morphology: Shell solid, semitransparent, inequivalve, right valve being more convex than the left one, inequilateral, the beaks situated close to the anterior margin, sculpture of about 20 strong radial ribs.

Distribution: *H. granulata* inhabits in the circumlittoral seafloor at 195-200 m depth. North Atlantic and northeastern Atlantic in archipelagos of Madeira and Canary Islands [18,82,83]; Mediterranean basin: eastern Mediterranean from the Levantine Coast of Turkey [74,84]. The species is found on muddy bottoms. Most of records cited as syn. *Verticordia granulata* [83,85].

Remarks: The specimens collected were found at Ausias March seamount between 150-300 m depth and at Emile Baudot seamount around 400 m depth. These new records extend the bathymetry and geographic distribution of the species, representing its first record in the western Mediterranean.

Genetics: PCR amplification of *H. granulata* did not work.

Family Lyonsiellidae Dall, 1895

Policordia gemma (A. E. Verrill, 1880)

(Figure 3K1-K2)

Material examined: R/V Ángeles Alvariño; St. BT049, 38°43.330′ N 001°49.370′ E, Ausias March seamount, 124 m depth, A22B_1019, 1 specimen. Deposited under the serial code ICMCBR000424.

External morphology: Shell fragile, white, small, inequivalve, inequilateral, little inflated, shell and ornamented externally with about 15–30 axial threads faintly concentric growth lines present.

Distribution: *P. gemma* has a wide range of distribution cited along the north, south, east and west Atlantic [37,79,83]. In the Mediterranean, it has been found only off Ceuta and along the Alborán Sea [37,71].

Remarks: Only one specimen was found in the Ausias March seamount on medium sand, at 124 m depth. It represents the first record of the species in the north-western Mediterranean.

Genetics: PCR amplification of *P. gemma* did not work.

4. Discussion

At present, marine ecosystems face many threats, mainly due to anthropogenic pressures [86]. In addition to this, climate change is changing marine biodiversity on a global scale, and one of the problems is the loss of biodiversity [87] because marine species respond by shifting ranges poleward and/or into deeper depths [88,89].

Numerous scientific projects and studies are being carried out to monitoring biodiversity and guarantee the health and functioning of the oceans [27,90]. The INTEMARES

project is part of this objective, aiming to ensure the long-term survival of the most endangered species and habitats in Europe (Natura 2000 Network), with the Mallorca Channel seamounts currently being studied for inclusion in the Natura 2000 Network [14].

The research presented is one of the results of the INTEMARES project and has focused on the study of the biodiversity of the Mollusca. The material collected during INTEMRES surveys brings interesting information on the very rich deep-water mollusc fauna occurring off the three seamounts of the Mallorca Channel. Obtaining a total of 68 species of the group (Figure 2; Table 2), of which 11 species have been collected for the first time in the north-western Mediterranean: seven bivalves and four gastropods (Figure 3; Table 2).

The most diverse mollusc groups were the bivalve superfamily belonging to Pectinoidea with 12 species (Figure 2). In agreement with Dijkstra and Gofas [91], seamounts have extensive areas of hard bottom (Table 1), which implies a predominance of epifauna, and under these conditions, Pectinoidea are one of the best represented bivalve families being one of the bivalve taxa, which is successful in deep-sea environments [91]. The next most diverse families were Cuspidariidae and Arcidae, with four and four species, respectively, and the remaining Mollusca families ranged from one to three species.

The number of new occurrences of molluscs was higher than those reported in previous studies conducted in same area, such as the OCEANA report [12,13]. This difference may be due to the sampling methodology (remote operated vehicle ROV transects) applied in the surveys. All records in the present study were based on beam-trawl and rock dredge samples, although non-invasive methodologies such as ROV and photogrammetric sled were also used in two of the surveys [14], (A22B_0820, not included in the present study). However, the mollusc group could not be identified with these methodologies. At the same time, thanks to the collected live specimens, molecular sequences could be obtained.

Of all the species studied, only six were successfully sequenced for the COI fragment, which highlights the need to test specific primers for molluscs. Integrative species-level identification, based on morphological and molecular features, was possible for three species: *Fusiturris similis*, *Pododesmus squama* and *Asperarca nodulosa*. On the other hand, the low percentage of similarity (<85%) detected for these specimens morphologically identified as *Allogramma formosa* and *Policordia gemma* suggest that public genetic databases such as GenBank and BOLD system are far from being complete in the Mediterranean, which makes the detection of these species impossible or leads to incorrect records of closely related species. Therefore, it is necessary to assemble a comprehensive barcode register for the mollusc fauna in the Mediterranean that will be useful for future comparisons in order to have an accurate record of the diversity of this widespread phylum. In addition, it will be useful for new monitoring techniques based on molecular approaches such as environmental DNA (DNA metabarcoding), which require complete genome libraries for a successful application.

The new occurrences of molluscs in the north-western Mediterranean are based on Spanish molluscs from the master list by Gofas et al. [18], the most updated list of molluscs in the area of the study. This list was published following compliance with the requirements of the Marine Strategy Framework Directive (MSFD) of the European Union [25], following descriptor 1 (Biodiversity) of the 11 descriptors in Annex I of the MSFD. Scientific work that provides new information on species distribution and habitats is of great scientific significance for further management and conservation studies of marine areas. The present study provides useful information on the biodiversity of seamounts and contributes towards filling the gap in knowledge in deep-sea mollusc fauna, which adds value to the proposal for their inclusion in the Natura 2000 network.

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