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FOR NATURALISTIC RESEARCH AND ENVIRONMENTAL STUDIES

Eupholus schoenherri Guérin-Meneville, 1830 - New Guinea, Misool Island

The Genus *Eupholus* Boisduval, 1835 (Coleoptera Curculionidae). The Genus *Eupholus* Boisduval, 1835 (Coleoptera: Curculionidae). The family of Curculionidae (Coleoptera) is one of largest families in the kingdom Animalia, with over 40,000 species known worldwide. These beetles being usually called "weevils" and appear in a remarkable diversity of shapes and sizes (length range 1-40 mm), they are characteristic by presence of long snouts and geniculate antennae with small clubs. Weevils are almost exclusively plant eaters, in many cases monophagous, connected with only one plant species. There are about 60 species hitherto known in the genus *Eupholus* Boisduval, 1835, a group of large colourful weevils endemic to the Papuan biogeographical region. These beetles usually feed on yam (*Dioscorea* spp., Liliales Dioscoreaceae) leaves and can be observed in numbers on these plants. *Eupholus schoenherri* Guérin-Meneville, 1830 is 25-30 mm long, usually bluish-green with transverse black bands on elytra; legs are bright blue; the top of rostrum and the end of the antennae are black. On the photograph a specimen of *E. schoenherri* is shown, photographed March 2009 in its natural environment in pristine lowland rainforests of Misool Island, Raja Ampat Archipelago, offshore West New Guinea (Cover photo by: D. Telnov).

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New contribution on the vascular flora of the Aegean Island of Chalki (Archipelago of Rhodes, Aegean Sea)

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ABSTRACT This note is an integration to the study, started in August 2014, of the vascular flora of the Island of Chalki. Special emphasis has been done on the chasmophytic flora which has shown a remarkable richness in terms of endemic species, common to the island and to the SE Aegean Sea, including the west coast of Turkey. Some limestone north-facing cliffs, located on the northern and southern sides of Chalki, have been investigated. It has been tried to develop a reasoned reading on the micro-distribution of the chasmophytic flora of Chalki, taking into account parameters such as morphology of the cliffs, altitude, solar radiance, grazing. Grazing has especially proved a substantial factor, that has affected on confinement of some species in inaccessible sites such *Erica manipuliflora* Salisb. (Ericaceae) and *Medicago arborea* L. (Fabaceae), which are not necessarily chasmophytic species. The almost exclusive finding of chamaephytes and hemicryptophytes in these types of habitats characterized by extreme edaphoclimatic conditions, showed the remarkable specialization as well as the rarity of these species.

KEY WORDS Chalki; chasmophytic flora; grazing; suffruticose chamaephyte; vertical cliffs.

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INTRODUCTION

The Aegean Island of Chalki is part of the Dodecanese Archipelago (SE Aegean); is located between the islands of Rhodes (SW), Tilos (SE) and Karpathos (NE). Its geographical coordinates are: 36°13'44.49" N;27°34'18.74" E. Has a length of 10 km, a width of 4 km and an area of 28,125 km^2 (Fig. 1). Administratively Chalki is part of Rhodes Regional Unit. The Municipality of Chalki includes several uninhabited offshore islands like Alimia, Krevati, Nisaki, Kolofona, Pano Prasouda, Tragousa, Strongyli, Agios Theodoros, Maelonisi (Iliadis, 1950).

Chalki appears as a mountainous and rocky island, consisting mainly of massive and hard limestone, ceroid limestone (that give rise to rendzinas) and siliceous limestone (Desio, 1923; 1924a; 1924b; 1928). The highest peak is represented by Mount Profitis Ilias (578 m). The coastline is very articulate and rich in gorges and steep limestone cliffs mainly in the north and southsides. The island is essentially arid, and lacks of superficial hydrography with an extremely low presence of underground water. The climate of Chalki is dry and warm with strong northern winds. The absence of a weather station on the island, did not allow the elaboration of climate data. The first botanical researches on Chalki were made during the 19th century, starting with Mayor & Barbey (1894). Investigations of Rechinger (1943) Rechinger & Rechinger (1951) and of the zoologist Werner followed. An important contribution to the knowledge of Chalki's flora was given by Carlström (1987), in a study project on the flora and phytogeography of SE Greece and SW Turkey. To Tzanoudakis & Kollmann (1991) is referred the discovery of a new species for the island: *Allium chalki*. Also in the same year Rackham & Vernicos (1991) studied the ecological history and future perspectives of Chalki. Finally, the investigations carried out by Biel & Tan (2009), led to the discovery of some new taxa for the island. Recently was published a contribution on orchid flora of Chalki, where is described a new species for the island: *Ophrys chalkae* (Hirth & Spaeth, 2010).

MATERIAL AND METHODS

For detecting altitude and geographic coordinates has been used a satellite tracking device Garmin GPS III Plus. The names of the local places mentioned in the text, faithfully follow the map of Chalki produced by Anavasi (2008).

The floristic data presented in this article come from collections and field observations made by the authors in Chalki in two different times: in August 2014 and April 2015. The field investigations carried out in April, lasted four days. It was possible integrate the previous checklist, relatively modest, due to the extreme drought of the research period. For the data collected in August 2014 see Cattaneo & Grano (2015). Specimens of the collected species are deposited in the herbarium of the authors: Cattaneo (HCC). For the determination of plant material was mainly used Rechinger (1943, 1949), Rechinger & Rechinger (1951), Davis (1965-1988), Tutin et al. (1964-1980, 1993), Pignatti (1982), Strid & Tan (1997, 2002, 2009), Lafranchis & Sfikas (2009), Dimopoulos et al. (2013).

For the taxonomic-nomenclatural definition of the taxa have been taken into consideration Greuter et al. (1984-1989), Dimopoulos et al. (2013) and the database "Euro + MedPlantbase (http: //www. emplantbase.org/home.html). The division and the denomination of the families were taken from Dimopoulos et al. (2013). In the vascular plant inventory families, genera and species are in al-

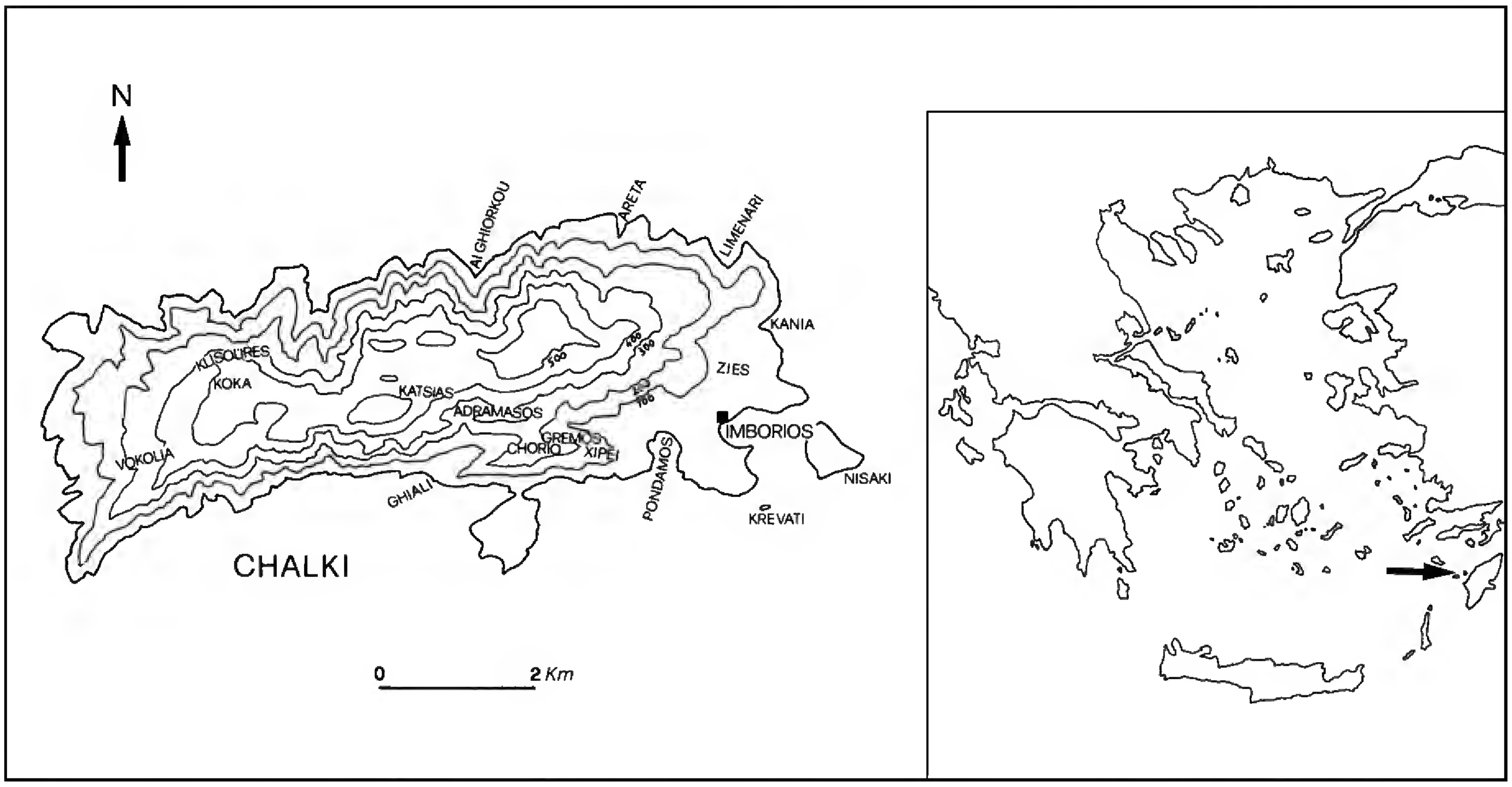


Figure 1. Map of Chalki Island, Archipelago of Rhodes, Aegean Sea.

ABBREVIATION	CHOROLOGICAL CATEGORY	CHOROLOGICAL CATEGORY DESCRIPTION
BK	Balkan	Taxa restricted to Balkan countries, occasionally extending to adjacent parts of SE Europe
BI	Balkan-Italian	Taxa restricted to Balkan countries and Italy
BA	Balkan-Anatolian	Taxa restricted to Balkan countries and to Asia minor (Anatolia), occasionally extending to S Ukraine (Crimea) adjacent Caucasian countries (Georgia, Armenia) or N Iraq
EM	E Mediterranean	Taxa restricted to the E Mediterranean, occasionally extending to S Italy or adjacent Caucasian countries
WM	W Mediterranean	Taxa restricted to the W Mediterranean, extending to eastern countries
Me	Mediterranean	Taxa with a circum-Mediterranean distribution including Portugal, occasionally extending to the Caucasus area and N Iran
MA	Mediterranean-Atlantic	Taxa restricted to maritime W Europe and the Mediterranean
ME	Mediterranean-European	Taxa restricted to the Mediterranean and temperate Europe, occasionally extending to NW Africa and the Caucasus area
MS	Mediterranean-SW Asian	Taxa distributed in one or more Mediterranean countries and extending to SW and C Asia
Eu	European	Taxa with a distribution all over Europe
EA	European-SW Asian	European taxa (occasionally reaching N Africa) with a distribution extending to SW Asia, occasionally reaching C Asia
ES	Euro-Siberian	Taxa with main distribution in temperate Eurasia (occasionally reaching the Caucasus area)
Pt	Paleotemperate	Taxa of extratropical Eurasia including the Himalaya and E Asia, not (or at most marginally) extending to North America
ST	Subtropical-Tropical	Taxa widespread in the warmer regions of both hemispheres
Co	Cosmopolitan	Taxa distributed in all continents
Endem.	Endemic	Taxa with a distribution restricted to the territory of Greece
Neotrop.	Neotropical	Taxa with wide distribution
Pantrop.	Pantropical	Taxa with wide distribution

Table 1. Chorological categories used in the checklist (extrapolated by Dimopoulos et al., 2013).

phabetic order. Life-form categories are based on Raunkiaer (1934), while chorological types (Table 1) are based mainly on information provided by Dimopoulos et al. (2013). Plant species introduced on the island were divided into cultivated (CULT), casual (CAS), naturalized (NAT) and invasive (INV). Where possible is provided an estimate of the local frequency of taxa listed by the initials F (= frequently), R (= rare) and L (= localized). The species collected in the second time, are marked in the floristic inventory by an asterisk (*).

RESULTS

As previously mentioned (Cattaneo & Grano, 2015), Chalki looks like a calcareous island, with a maximum height that do not exceed 600 m above sea level and with few flat areas located in the central part of the island. Probably the most interesting aspect of the island is given by vertical cliffs of massive limestone and deep gorges along the coastline, except for the oriental side. The presence of these vertical cliffs allowed the growth of a rare and highly specialized chasmophytic flora. Several species are endemic with a distribution area limited to the island and to the SE Aegean, including W Turkey. The rest of the island is characterized by a kind of flora essentially phryganic with prevalence of chamaephytes and nano-phanerophytes, as *Sarcopoterium spinosum*, *Salvia fruticosa*, *Origanum onites*, *Thymbra capitata*, *Teucrium capitatum*, *Euphorbia characias* and *E. dendroides*.

Phanerophytes are almost absent or otherwise restricted to the areas used to olive and oak cultivation. The vegetation of the vertical limestone cliffs on the coastline and in the interior, is characterized by a prevalence of chamaephytes, hemicryptophytes and, lastly, of geophytes. It has been observed that the distribution of the saxatile flora, is closely related to several factors including: nature and morphology of the rocky habitats; altitudinal gradient; presence or absence of solar radiation; grazing.

Therefore it was made a distinction between: A) Species found only in the crevices of limestone vertical cliffs north-facing and shady, at altitudes between 300 and 400 m above sea level; B) Species observed either on vertical cliffs, or on sloping limestone rocks, at altitudes between 100 and 300 m above sea level, with partial exposition to solar radiance; C) Chasmophytic species that grow among different kind of rocks, at altitudes below 100 m, which present heterogeneous requirements of solar radiation (Table 2).

Investigated sites

During the second botanical survey carried out in April 2015, were examined more carefully cliffs located on north side of Chalki in the sites of Klisoures, Kamenos Spilios, Areta and cliffs located in the south of the island in sites of Pano and Kato Gremos. These cliffs have shown a remarkable floristic richness in terms of endemics. However, at the time of the investigation several species had not yet reached blooming, so the identification was not possible. Many chasmophytic species, in fact, developed adaptive strategies in harsh environments, such as an increased lignification and delay in reaching the reproductive stage, enabling them greater longevity (Davis, 1951).

Klisoures and Kamenos Spilios

The north-facing limestone cliffs of Klisoures, are characterized by a considerable verticality. They are located a bit interior from the north coastline and reach altitudes of about 500 m above sea level. They are almost constantly in shadow and exposed to strong northerly winds. There is a small presence of sheep and goats grazing due to the too steep environment. Suffruticose chamaephyte is the dominant life form and, thereafter, the scapose hemicryptophyte.

The therophytes are scarce, except for a prevalence of procumbent therophytes, while geophytes have a limited distribution exclusively among the ledges. These cliffs of Klisoures host a very interesting chasmophytic flora, characterized by endemics and relic species, all concentrated at an altitude between 400 and 500 m. These data confirm what is reported in literature, namely in the Aegean islands there's an increase of endemics in the thermo-mediterranean zone between 0 and 600 m above sea level (Georghiou & Delipetrou, 2010).

The plant communities in Klisoures are rather fragmented, with individuals spaced from each other, factor that probably involves a negligible radical competition (Davis, 1951). As said before the predominant life form is suffruticose chamae-

CHASMOPHYTIC SPECIES	CAT. A	CAT. B	CAT. C
Asplenium burgaei			*
Asplenium ceterach			*
Cystopteris fragilis			*
Allosurus acrosticus			*
Anogramma leptophylla			*
Selaginella denticulata			*
Crithmum maritimum			*
Hellenocarum multiflorum	*		
Seseli crithmifolium	*		
Centaurea lactucifolia		*	
Helicrysum orientale	*	*	
Inula verbascifolia	*	*	
Lactuca viminea		*	*
Phagnalon rupestre subsp. *graecum*		*	*
Ptilostemon chamaepeuce	*	*	
Scorzonera cretica	*		
Fibigia lunarioides		*	
Matthiola incana		*	
Campanula delicatula			*
Campanula hagielia		*	
Capparis spinosa			*
Arenaria deflexa		*	
Cerastium comatum		*	
Dianthus fruticosus subsp. *rhodius*	*		
Paronychia macrosepala			*
Silene fruticosa		*	
Rosularia serrata		*	*
Sedum litoreum		*	*
Umbilicus albido-opacus		*	
Umbilicus rupestris		*	*
Cephalaria squamiflora	*		
Erica manipuliflora	*		
Medicago arborea	*		
Ballota acetabulosa	*	*	*
Micromeria juliana		*	*
Origanum calcaratum	*		
Origanum onites	*	*	*
Rhamnus lycioides subsp. *oleoides*	*	*	*
Asperula tournefortii	*		
Galium canum subsp. *ovatum*	*	*	
Valantia hispida		*	*
Verbascum propontideum	*	*	
Parietaria cretica		*	*
Cymbalaria microcalyx	*	*	
Cymbalaria longipes	*	*	

Table 2. Chasmophytic species found in the Aegean Island of Chalki (Archipelago of Rhodes).

- Category A: species found only in the crevices of limestone vertical cliffs north-facing and shady, at altitudes between 300 and 400 m above sea level.
- Category B: species observed either on vertical cliffs, or on sloping limestone rocks, at altitudes between 100 and 300 m above sea level, with partial exposition to solar radiance.
- Category C: chasmophytic species that grow among different kind of rocks, at altitudes below 100 m, which present heterogeneous requirements of solar radiation.

phyte. The woodiness of these pioneer plants is a strategy and an adaptive response to physical and environmental stress. Such structure provides higher longevity to these species subject to extreme edaphoclimatic conditions (barren and rocky soil, strong wind, etc.). Most of the chasmophytic species observed in Klisoures are located in not reachable positions from grazing. This is, doubtless, an essential element for understanding the micro-distribution of the chasmophytes in these rocky sites and in general the macro-distribution of Chalki's flora (Cattaneo & Grano, 2015). On these cliffs were found three specimens of *Erica manipuliflora*, element normally characterizing the Greek phrygana, but not detected in Chalki in previous investigations. The exclusive presence of this species only in this site, indicates that through the years the selective pressure made from grazing was critical in Chalki, which would have confined this species, as well as other taxa, in sites difficult to reach by animals. Probably *Erica manipuliflora* in previous times had a wider distribution in the island, while at present it is almost extinct. It might be expected such a theory also concerning *Medicago arborea*, whose presence in Chalki is limited to very few individuals exclusively among the overhanging rocks of the Kamenos Spilios (cave located east of Klisoures at 396 m above sea level; coordinates: 36°13′ 89″N; 27°32′47″E).

Regarding taxa found among the cliffs of Klisoures, were confirmed chasmophytic species observed in August of 2015 such as: *Asperula tournefortii*, *Cephalaria squamiflora*, *Dianthus fruticosus* subsp. *rhodius*, *Galium canum* subsp. *ovatum* (Fig. 2), *Helicrysum orientale*, *Inula verbascifolia*, *Origanum calcaratum*, *Seseli crithmifolium*, *Cymbalaria microcalyx* (Fig. 3), *Ptilostemon chamaepeuce*, *Verbascum propontideum*. To these were added *Cymbalaria longipes*, *Hellenocarum multiflorum*, *Cerastium comatum*, *Scorzonera cretica*, *Valeriana asarifolia* (Cattaneo, 2015). This kind of saxatile flora is setting up ravines and crevices of limestone rocks formed from atmospheric agents. On the other hand, in the ledges and into the pockets of land formed in the cavities of the rock, grows a chomophytic vegetation (bulbous geophytes) whose most characteristic species are: *Urginea maritima*, *Gagea graeca*, *Umbilicus rupestris*, *Umbilicus albido-opacus*, *Allium subhirsutum*, *Asphodelus fistulosus*, *A. ramosus*, etc...

In fact, within the ledges they accumulate debris forming a layer very shallow, not suitable for the establishment of species with deep roots, but suitable for the development of geophytes (Davis, 1951).

Areta

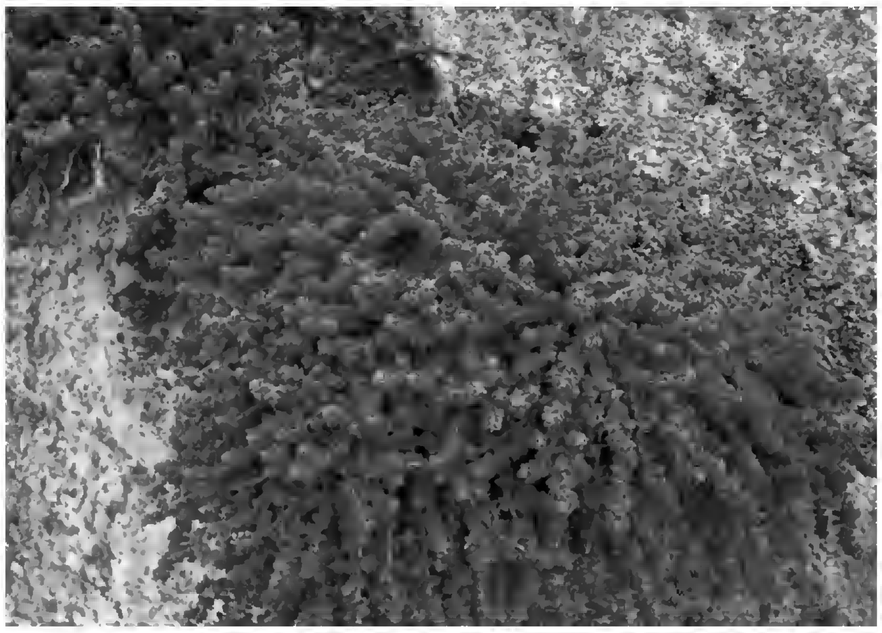
Areta looks like a deep gorge on the northern side of the island, highly beaten by northern winds. It is constituted by limestone cliffs that are located at lower altitude (100-200 m) than those of Klisoures. These cliffs are also characterized by strong verticality and, therefore, by scarce accessibility. The eastern face of the gorge of Areta is totally in shadow, while the western face is partly exposed to the sunlight and has a certain degree of slope. The difficulty of investigation in this site did not allow to obtain an exhaustive overview of the chasmophytic species found there and a quali-quantitative analysis of life forms. The western face, the only accessible, has a certain degree of slope and insolation.

There have been found several procumbent endemic therophytes of SE Aegean Sea, as *Arenaria* sp., *Cerastium comatum* and procumbent and pulvinate chamaephytes as *Cymbalaria longipes* (Fig. 4), *Cymbalaria microcalyx*, *Galium canum*, *Anogramma leptophylla*. Chasmophytic species, such as *Campanula hagielia*, *Inula verbascifolia*, *Scorzonera cretica* (Fig. 5), *Ptilostemon chamaepeuce*, *Rosularia serrata* were also present, whose growth or existence is not restricted by solar radiance. Suffruticose chamaephytes and scapose hemicryptophytes observed with relative frequency on the shady cliffs of Klisoures such as *Asperula tournefortii*, *Cephalaria squamiflora*, *Origanum calcaratum*, *Seseli crithmifolium*, *Verbascum propontideum*, *Hellenocarum multiflorum*, here have not been found. As stated Davis (l.c.), the angle of slope is critical, since it directly affects the sunlight and the amount of rain that can be more or less absorbed by the soil (the more the angle is sloped the least water will be absorbed). In this regard it is also very important the exposure of a cliff. North-facing rocks will have a degree of sunlight almost irrelevant compared to northwest-facing rocks. These factors inevitably influence the distribution of chasmophytic community.

It is said that the north-west cliff of Areta presents a degree of sunlight, promoting the rooting of some chasmophytic species more heliophilous at the expense of other more shade-tolerant. Also the wind on this site has probably more impact than in the interior, and this fact could promote the growth of plant organisms with procumbent and pulvinate features. Finally, it was noted a more intense grazing, that may have played a decisive role in the presence or absence of certain species.

Pano and Kato Gremos

The north-facing limestone cliff placed in Pano and Kato Gremos are located on the southern side of Chalki. Have various angles of slope and different exposure to the solar radiance. They reach an altitude of 200 m above sea level. Only on this site was found *Centaurea lactucifolia* (Fig. 6), exclusive endemic of some islands of the E Aegean including Rhodes and Chalki. It is an obligatory chasmophyte, a probably relic of the Pliocene chasmophytic flora (Carlström, 1986). There is a significant polymorphism between the populations of *Centaurea lactucifolia*, which seems to be related to the different environments of the cliff where it grows. Therefore studying the populations of Chalki and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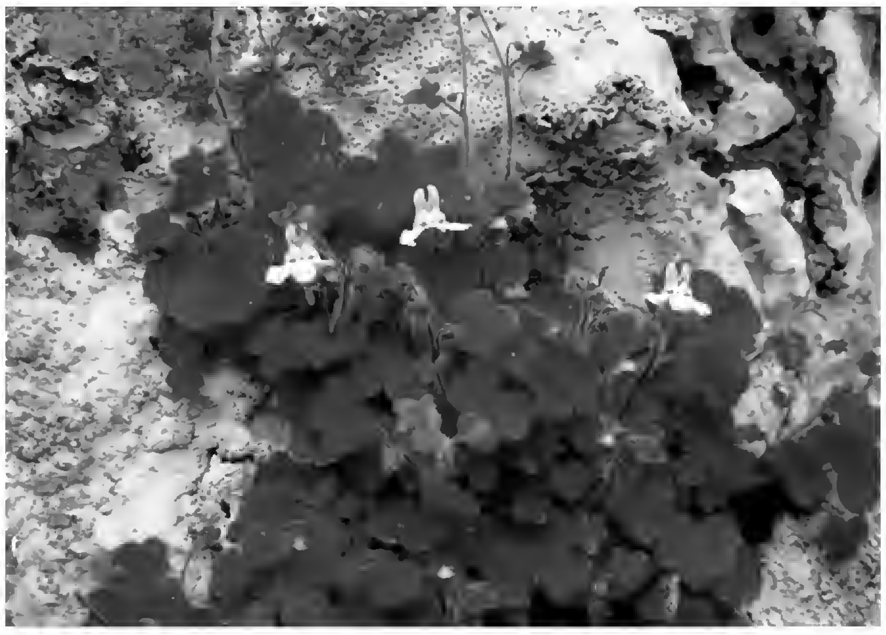
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Figures 2–7. Vascular flora of Chalki Island. Fig. 2. *Galium canum* subsp. *ovatum*. Fig. 3. *Cymbalaria microcalyx*. Fig. 4. *Cymbalaria longipes*. Fig. 5. *Scorzonera cretica*. Fig. 6. *Centaurea lactucifolia*. Fig. 7. *Verbascum propontideum*.

Rhodes, the species above was split in *Centaurea halkensis* Mayor et Barbey (Chalki) and *Centaurea chorionensis* Hoffm.-Grob et Beauverd (Rhodes). However the lack of a real discontinuity between morphological variants, prevented the subdivision of the taxon at issue (Carlström, 1986). Most of the chasmophytic plants found on this site are suffruticose chamaephytes and scapose hemicryptophytes. Have been validated species observed in August 2014 including: *Centaurea lactucifolia*, *Phagnalon rupestre* subsp. *graecum*, *Ptilostemon chamaepeuce*, *Verbascum propontideum* (Fig. 7), *Helicrysum orientale*, *Inula verbascifolia*, *Origanum onites*. In addition are reported: *Silene fruticosa*, *Campanula hagielia*, *Matthiola incana*, *Fibigia lunarioides*, *Cymbalaria longipes*, *C. microcalyx*, *Scorzonera cretica*.

Vascular plant inventory of Chalki

The vascular plant inventory here presented, includes 225 taxa of which 104 have been added with the latest research carried out on the island.

PTERIDOPHYTAE

Family ASPLENIACEAE

****Asplenium burgaei*** Milde - H ros - EM - L
Previous citations: Carlström (1987: 45)
****Asplenium ceterach*** L. - H ros - EA - L
Previous citations: Carlström (1987: 45).

Family CYSTOPTERIDACEAE

****Cystopteris fragilis*** (L.) Bernh. - H caesp - Co - R

Family PTERIDACEAE

****Adiantum capillus-veneris*** L. - G rhiz - ST - R
****Allosurus acrosticus*** (Balb.) Christenh. - G rhiz - Me - L
Previous citations: Carlström (1987: 44, sub *Cheilantes acrostica* (Balb.) Tod.).
****Anogramma leptophylla*** (L.) Link - T caesp - Co - R

Family SELAGINELLACEAE

****Selaginella denticulata*** (L.) Spring - Ch rept - Me - L
Previous citations: Carlström (1987: 44).

GYMNOSPERMAE

Family CUPRESSACEAE

Cupressus sempervirens L. - P scap - CULT
Previous citations: Carlström (1987: 46).
Juniperus phoenicea L. - P scap - Me - L
Previous citations: Carlström (1987: 46).

Family PINACEAE

Pinus brutia Ten. - P scap - Me - L
Previous citations: Carlström (1987: 46).

ANGIOSPERMAE

Family AGAVACEAE

Agave americana L. - P caesp - CAS

Family AIZOACEAE

Aptenia cordifolia (L. f.) Schwantes - Ch suffr - CAS
Carpobrotus edulis (L.) N. E. Br. - Ch suffr - CAS
****Mesembryanthemum nodiflorum*** L. - T scap - CAS
Previous citations: Carlström (1987: 63).

Family ALLIACEAE

****Allium subhirsutum*** L. - G bulb - Me - L

Family AMARANTHACEAE

Amaranthus deflexus L. - H scap - CAS
Previous citations: Biel et Tan (2009: 434).
Amaranthus hybridus L. - T scap - CAS
Previous citations: Biel et Tan (2009: 434).

Family AMARYLLIDACEAE

Pancratium maritimum L. - G rhiz - Me - R

Family ANACARDIACEAE

Pistacia atlantica Desf. - P scap - MS - L
Previous citations: Carlström (1987: 67).
Pistacia lentiscus L. - P scap - Me - L
Previous citations: Carlström (1987: 67).
Pistacia terebinthus L. - P scap - Me - CULT
Schinus molle L. - P scap - CULT

Family APIACEAE

****Cachrys cristata*** DC. - H scap - Me - F
Previous citations: Carlström (1987: 83).
Crithmum maritimum L. - Ch suffr - ME - L
Previous citations: Carlström (1987: 84).

Ferula communis L. subsp. ***glauca*** (L.) Rouy et Camus - H scap - Me
Previous citations: Carlström (1987: 84).
*****Foeniculum vulgare*** Mill. - H scap - Me
Previous citations: Carlström (1987: 83).
****Hellenocarum multiflorum*** (Sm.) H. Wolff - H scap - Me - L
****Lagoecia cuminoides*** L. - T scap - ME
Previous citations: Carlström (1987: 82).
****Scaligera napiformis*** (Spreng.) Grande - H scap - EM
Previous citations: Carlström (1987: 82, sub *S. cretica* (d'Urv.) Vis.).
Seseli crithmifolium (DC.) Boiss. - H scap - Endem. - R
Smyrnium perfoliatum L. - H bienn - ME - L
****Tordylium apulum*** L. - T scap - Me
Previous citations: Carlström (1987: 84).
****Torilis leptophylla*** (L.) Rchb. f. - T scap - EA

Family APOCYNACEAE

Nerium oleander L. - P caesp - Me - R

Family ARACEAE

Dracunculus vulgaris Schott - G rhiz - Me
Previous citations: Carlström (1987: 117).

Family ARECACEAE

Phoenix canariensis Chabaud - P scap - CULT
Phoenix theophrasti Greuter - P scap - EM - L
Previous citations: Rackham & Vernicos (1991).

Family ASPARAGACEAE

Asparagus aphyllus L. subsp. ***orientalis*** (Baker) P.H. Davis - G rhiz - EM
Previous citations: Carlström (1987: 117).

Family ASPHODELACEAE

****Asphodelus fistulosus*** L. - G rhiz - Me
Previous citations: Carlström (1987: 118).
****Asphodelus ramosus*** L. - G rhiz - Me
Previous citations: Carlström (1987: 118).

Family ASTERACEAE

****Anthemis arvensis*** L. - T scap - Co
****Anthemis chia*** L. - T scap - Me - L
Previous citations: Carlström (1987: 90).
****Anthemis rigida*** Heldr. - T scap - EM - L
Previous citations: Carlström (1987: 89).
****Asteriscus aquaticus*** (L.) Less. - T scap - ME - R
Atractylis cancellata L. - T scap - Me
Previous citations: Carlström (1987: 93).
Carlina corymbosa L. - H scap - Me - F
Previous citations: Carlström (1987: 93).
Carlina tragacanthifolia Klatt - H scap - EM - R
Previous citations: Carlström (1987: 93).
Carthamus dentatus (Forssk.) Vahl - T scap - Me
Carthamus lanatus L. - T scap - Me
Centaurea lactucifolia Boiss. - H scap - Endem. - R
Previous citations: Rechinger (1951: 164); Carlström (1987: 92).
****Cichorium pumilum*** Jacq. - T scap - MS
Previous citations: Carlström (1987: 94).
****Crupina crupinastrum*** (Moris) Vis. - T scap - EA
Previous citations: Carlström (1987: 92).
Dittrichia viscosa (L.) Greuter - Ch scap - Me
Echinops spinosissimus Turra - H scap - Me - F
Previous citations: Carlström (1987: 93).
Erigeron canadensis L. - T scap - NAT
****Geropogon hybridus*** (L.) Sch. Bip. - T scap - Me
Previous citations: Carlström (1987: 94).
****Glebionis coronaria*** (L.) Spach - T scap - Me
Previous citations: Carlström (1987: 90, sub *Chrysanthemum coronarium* L.).
****Glebionis segetum*** (L.) Fourr. - T scap - Me
Previous citations: Carlström (1987: 90, sub *Chrysanthemum segetum* L.).
Helichrysum orientale (L.) Vaill. - H scap - EM - L
Previous citations: Major & Barbey in Rechinger (1943: 613); Carlström (1987: 88).
****Helichrysum stoechas*** (L.) Moench - Ch suffr - Me - L
Previous citations: Carlström (1987: 87).
****Hyoseris scabra*** L. - T ros - Me
Previous citations: Carlström (1987: 94).
Inula verbascifolia (Willd.) Hausskn. - Ch suffr - BI - F
****Lactuca viminea*** (L.) J. Presl et C. Presl - H bienn - Pt - R
Lactuca serriola L. - H scap - Pt
Previous citations: Carlström (1987: 95).
Notobasis syriaca (L.) Cass. - T scap - Me
Previous citations: Carlström (1987: 91).
Pallenis spinosa (L.) Cass. - T scap - Me
Previous citations: Carlström (1987: 87).
Phagnalon rupestre L. (DC.) subsp. ***graecum*** (Boiss. et Heldr.) Batt. - Ch suffr - Me
Previous citations: Carlström (1987: 87).

Picnomon acarna (L.) Cass. - H scap - Pt - F
Ptilostemon chamaepeuce (L.) Less. - Ch frut - EM - L
Previous citations: Carlström (1987: 91).
*****Scorzonera cretica*** Willd. - H scap - Endem. - R
Previous citations: Carlström (1987: 94).
*****Scorzonera elata*** Boiss. - H scap - EM
Previous citations: Carlström (1987: 94).
Senecio vulgaris L. - T scap - Pt
Sonchus arvensis L. - H scap - ES
*****Sonchus asper*** (L.) Hill - H bienn - Pt
Previous citations: Carlström (1987: 95).

Family BERBERIDACEAE

*****Leontice leontopetalum*** L. - H scap - MS
Previous citations: Carlström (1987: 48)

Family BORAGINACEAE

*****Anchusa aegyptiaca*** (L.) A. DC. - T scap - EM - L
Previous citations: Carlström (1987: 102).
Echium parviflorum Moench - T scap - Me
Previous citations: Carlström (1987: 103).
Heliotropium hirsutissimum Grauer - T scap - EM
Previous citations: Carlström (1987: 101).

Family BRASSICACEAE

*****Biscutella didyma*** L. - T scap - Me
Previous citations: Carlström (1987: 51).
*****Fibigia lunarioides*** (Willd.) Sweet - Ch suffr - Endem. - R
Previous citations: Carlström (1987: 51).
*****Hirschfeldia incana*** (L.) Lagr.-Foss. - T scap - EA
Previous citations: Carlström (1987: 50).
*****Malcomia nana*** (DC.) Boiss. - T scap - MS - R
*****Matthiola incana*** (L.) R. Br. in W.T. Aiton - Ch suffr - ME - L
Previous citations: Carlström (1987: 53).
*****Matthiola sinuata*** (L.) R. Br. in W.T. Aiton - H scap - ME - L
*****Sinapis arvensis*** L. - T scap - ES
Previous citations: Carlström (1987: 50).

Family CACTACEAE

Opuntia ficus-indica (L.) Mill. - Ch suffr - Neotrop.

Family CAESALPINIACEAE

Ceratonia siliqua L. - P scap - Me - R
Previous citations: Carlström (1987: 67).

Family CAMPANULACEAE

*****Campanula delicatula*** Boiss. - T scap - EM - L
Previous citations: Carlström (1987: 67).
*****Campanula drabifolia*** Sm. in Sibth. et Sm. - T scap - EM - L
*****Campanula hagielia*** Boiss. - H scap - EM - L
Previous citations: Carlström (1987: 67).
*****Legousia pentagonia*** (L.) Druce - T scap - EM
Previous citations: Carlström (1987: 67).

Family CAPPARACEAE

Capparis spinosa L. - NP - Me - L
Previous citations: Carlström (1987: 54)

Family CARYOPHYLLACEAE

Arenaria deflexa Decne. - T rept - EM - R
Previous citations: Carlström (1987: 55).
Arenaria cf. ***luschanii*** Mc Neill - T rept - EM - R
*****Cerastium comatum*** Desv. - T rept - EM - R
Previous citations: Carlström (1987: 57).
Dianthus fruticosus L. subsp. ***rhodius*** (Rech. f.) Runemark - Ch suffr - Endem. - R
Previous citations: Carlström (1987: 58).
*****Paronychia macrosepala*** Boiss. - H caesp - EM - L
Previous citations: Carlström (1987: 60).
*****Polycarpon tetraphyllum*** (L.) L. - T scap - MS
Previous citations: Carlström (1987: 57).
*****Silene fruticosa*** L. - Ch suffr - Me - R
Previous citations: Carlström (1987: 59).
*****Silene sedoides*** Poir. - T scap - Me - L
Previous citations: Carlström (1987: 59).

Family CHENOPODIACEAE

Salsola tragus L. - T scap - Pt / Co
Previous citations: Carlström (1987: 62, sub *S. kali* L. subsp. *tragus* (L.) Nyman).

Family CISTACEAE

*****Cistus creticus*** L. - NP - Me - R
*****Fumana arabica*** (L.) Spach - Ch suffr - Me
Previous citations: Carlström (1987: 54).
*****Fumana thymifolia*** (L.) Webb - Ch suffr - Me
Previous citations: Carlström (1987: 54).

Family CONVOLVULACEAE

*__*Convolvulus althaeoides*__ L. - H scand - Me
Previous citations: Carlström (1987:100).
Convolvulus elegantissimus Mill. - H scand - Me
*__*Convolvulus scammonia*__ L. - H scand - EM
Previous citations: Carlström (1987: 100).
*__*Cuscuta planiflora*__ Ten. - T par - Me
Previous citations: Carlström (1987:101).
Ipomoea indica (Burm.) Merr. - G rhiz - Pantrop.

Family CRASSULACEAE

Rosularia serrata (L.) A. Berger in Engl. et Prantl - Ch succ - EM - R
Previous citations: Carlström (1987: 81).
*__*Sedum litoreum*__ Guss. - T scap - Me - F
Previous citations: Carlström (1987: 81).
*__*Umbilicus albido-opacus*__ Carlström - G bulb - Endem. - R
Previous citations: Carlström (1987: 81).
Umbilicus rupestris (Salisb.) Dandy - G bulb - MA - F

Family CUCURBITACEAE

*__*Bryonia cretica*__ L. - H scand - EM
Previous citations: Carlström (1987: 80).
Ecballium elaterium (L.) A. Rich. - G bulb - MS

Family DIPSACACEAE

Cephalaria squamiflora (Sieber) Greuter - Ch suffr - Me - R
*__*Knautia integrifolia*__ (L.) Bertol. - T scap - Me - F
Previous citations: Carlström (1987: 86)

Family ERICACEAE

Erica manipuliflora Salisb. - Ch suffr - Me - R

Family EUPHORBIACEAE

Andrachne telephioides L. - Ch suffr - MS
Chrozophora tinctoria (L.) A. Juss. - T scap - MS
*__*Euphorbia acanthothamnos*__ Heldr. et Sartori ex Boiss. - Ch frut - EM - L
Previous citations: Carlström (1987: 112).
Euphorbia chamaesyce L. - T rept - ME
Euphorbia characias L. - NP - Me - F
Euphorbia dendroides L. - NP - Me - F
Euphorbia nutans Lag. - T caesp - L - CAS
Previous citations: Biel & Tan (2009: 435, sub *Chamaesyce nutans* (Lag.) Small.).
*__*Euphorbia peplus*__ L. - T scap - Co
Previous citations: Carlström (1987: 113).
*__*Euphorbia valerianifolia*__ Lam. - T scap - EM - R
Previous citations: Carlström (1987: 112).
Ricinus communis L. - P scap - CULT

Family FABACEAE

Anagyris foetida L. - P scap - Me - F
Previous citations: Carlström (1987: 67).
*__*Hippocrepis biflora*__ Spreng. - T scap - MS
*__*Medicago arborea*__ L. - P caesp - Me - R
*__*Trifolium campestre*__ Schreb. in Sturm - T scap - EA
Previous citations: Carlström (1987: 72).
*__*Trigonella corniculata*__ (L.) L. subsp. ***balansae*** (Boiss. et Reut.) Lassen - T scap - EM
Previous citations: Carlström (1987: 74, sub *Trigonella balansae* Boiss. et Reut.).

Family FAGACEAE

Quercus coccifera L. - P caesp - Me - R
Quercus ilex L. - P caesp - Me - L

Family GENTIANACEAE

*__*Centaurium tenuiflorum*__ (Hoffmanns. et Link) Fritsch - T scap - ME
Previous citations: Carlström (1987: 99).

Family GERANIACEAE

*__*Geranium robertianum*__ L. - T scap - Co
Previous citations: Carlström (1987: 65).

Family HYACINTHACEAE

Drimia aphylla (Forssk.) J.C. Manning et Goldblatt - G bulb - EM - F
Previous citations: Carlström (1987: 119, sub *Urginea maritima* (L.) Baker).
*__*Muscari comosum*__ (L.) Mill. - G bulb - ME
*__*Ornithogalum narbonense*__ L. - G bulb - Me

Family HYPERICACEAE

Hypericum empetrifolium Willd. - Ch suffr - EM - L

Family IRIDACEAE

*__*Iris germanica*__ L. - G rhiz - EA - L
Previous citations: Carlström (1987: 122).

Family LAMIACEAE

Ballota acetabulosa (L.) Benth. - Ch frut - BA - F
Previous citations: Carlström (1987: 107).

***Lamium moschatum** Mill. - T scap - EM
Previous citations: Carlström (1987: 107).
***Marrubium vulgare** L. - H scap - EA
Previous citations: Carlström (1987: 108).
Mentha spicata L. - H scap - EA - L
Micromeria juliana (L.) Rchb. - Ch suffr - Me - F
Previous citations: Carlström (1987: 109, sub *Satureja juliana* L.).
Origanum calcaratum Juss. - Ch suffr - Endem. - R
Previous citations: Carlström (1987: 108).
Origanum onites L. - Ch suffr - Me - F
Previous citations: Carlström (1987: 108).
***Prasium majus** L. - Ch frut - Me
Previous citations: Carlström (1987: 107).
Salvia fruticosa Mill. - Ch frut - EM - F
Previous citations: Carlström (1987: 109).
***Salvia verbenaca** L. - H scap - MA
Previous citations: Carlström (1987: 109).
***Salvia viridis** L. - T scap - Me
Previous citations: Carlström (1987: 109).
Satureja thymbra L. - Ch frut - Me
Teucrium capitatum L. - Ch suffr - Me - L
Previous citations: Carlström (1987: 106, sub *T. polium* L.).
Thymbra capitata (L.) Cav. - Ch suffr - Me - F
Previous citations: Carlström (1987: 109, sub *Coridothymus capitatus* (L.) Reichb. fil.).

Family LILIACEAE

***Gagea graeca** (L.) Irmisch - G bulb - BA
Previous citations: Carlström (1987: 121).

Family LINACEAE

***Linum strictum** L. - T scap - Me
Previous citations: Carlström (1987: 65).

Family MALVACEAE

***Malva cretica** Cav. - T scap - Me
Previous citations: Carlström (1987: 64).
***Malva neglecta** Wallr. - T scap - EA
Previous citations: Carlström (1987: 64).

Family MELIACEAE

Melia azedarach L. - P scap - CULT

Family MIMOSACEAE

Acacia cyanophylla Lindley - P scap - CULT
Acacia retinoides Schlecht. - P scap - CULT

Family MORACEAE

Ficus carica L. - P scap - CULT
Ficus retusa L. - P scap - CULT

Family MYRTACEAE

Eucaliptus camaldulensis Dehnh. - P scap - CULT

Family OLEACEAE

Olea europaea L. var. **europaea** - P scap - CULT

Family ORCHIDACEAE

***Anacamptis pyramidalis** (L.) Rich. - G bulb - Eu
Previous citations: Carlström (1987: 124); Hirth & Spaeth (2010: 593).
***Anacamptis sancta** (L.) R.M. Bateman, Pridgeon et M.W. Chase - G bulb - EM
Previous citations: Carlström (1987: 124, sub *Orchis sancta* L.).

Family OROBANCHACEAE

***Orobanche pubescens** d'Urv. - T par - Me
Previous citations: Carlström (1987: 106).
***Phelipanche mutelii** (F.W. Schultz) Pomel - T par - Pt

Family OXALIDACEAE

Oxalis corniculata L. - H rept - Pt / Co
***Oxalis pes-caprae** L. - G bulb - CAS

Family PAPAVERACEAE

Glaucium flavum Crantz - H scap - ME - R
Previous citations: Carlström (1987: 48).
***Papaver apulum** Ten. - T scap - BI
***Papaver rhoeas** L. - T scap - Pt
Previous citations: Carlström (1987: 49).

Family PLANTAGINACEAE

Plantago albicans L. - H ros - Me
Previous citations: Carlström (1987: 111).
***Plantago coronopus** L. - H ros - MA - F
Previous citations: Carlström (1987: 110).

Family POACEAE

Andropogon distachyos L. - H caesp - ST - F
Previous citations: Major & Barbey in Rechinger (1943: 808); Carlström (1987: 135).

*__*Avena barbata*__ Link in Schrad. - T scap - Me
Previous citations: Carlström (1987: 129).
*__*Avena fatua*__ L. - T scap - MS
Avena sterilis L. - T scap - MS
Previous citations: Carlström (1987: 129).
Briza maxima L. - T scap - ST
Previous citations: Carlström (1987: 133).
Bromus madritensis L. - T scap - MS
Previous citations: Carlström (1987: 129).
Hordeum murinum L. - T scap - MS
Hyparrhenia hirta (L.) Stapf - H caesp - ST - F
Previous citations: Carlström (1987: 135).
Lagurus ovatus L. - T scap - Me
Previous citations: Carlström (1987: 130).
Paspalum distichum L. - G rhiz - Neotrop.
Setaria pumila (Poir.) Roem. et Schult. - T scap - Co

Family POLYGALACEAE

*__*Polygala venulosa*__ Sm. - H scap - EM

Family POLYGONACAE

*__*Rumex bucephalophorus*__ L. subsp. ***aegaeus*** Rech. f. - T scap - EM
*__*Rumex pulcher*__ L. - H scap - MS
Previous citations: Carlström (1987: 61).
*__*Rumex tuberosus*__ L. subsp. ***creticus*** (Boiss.) Rech. f. - G bulb - EM

Family PORTULACACEAE

Portulaca oleracea aggr.- T scap - Co

Family POSIDONIACEAE

Posidonia oceanica (L.) Delile - I rad - Me

Family PRIMULACEAE

Anagallis arvensis L. - T rept - Co
Previous citations: Carlström (1987: 98).
Cyclamen graecum Link - G rhiz - EM

Family PUNICACEAE

Punica granatum L. - P scap - CULT

Family RANUNCULACEAE

Delphinium staphisagria L. - T scap - Me - L
Previous citations: Carlström (1987: 46).

Family RHAMNACEAE

Rhamnus lycioides L. subsp. ***oleoides*** (L.) Jahand. & Maire - NP caesp - Me
Previous citations: Carlström (1987: 67, sub *R. oleoides* L. subsp. *oleoides*).

Family ROSACEAE

Prunus dulcis (Mill.) D.A. Webb - P scap - CULT
Sarcopoterium spinosum (L.) Spach - NP - EM - F
Previous citations: Carlström (1987: 79).

Family RUBIACEAE

Asperula tournefortii Spreng. - Ch suffr - EM
Previous citations: Carlström (1987: 115).
Galium canum Req. ex DC. subsp. ***ovatum*** Ehrend. - Ch rept - Endem. - L
Previous citations: Carlström (1987: 115).
*__*Theligonum cynocrambe*__ L. - Me -T scap
Previous citations: Carlström (1987: 63).
*__*Valantia hispida*__ L. - T scap - Me
Previous citations: Carlström (1987: 116).

Family RUTACEAE

Ruta chalepensis L. - Ch suffr - Me

Family SCROPHULARIACEAE

*__*Verbascum mallophorum*__ Boiss. et Heldr. in Boiss - H bienn - BI
Verbascum propontideum Murb. - Ch suffr - EM - L
Previous citations: Major & Barbey in Rechinger (1943: 468); Hoffmann-Grobety in Rechinger (1943: 468); Rechinger & Rechinger (1951: 163); Carlström (1987: 103).
Verbascum sinuatum L. - H bienn - MS

Family SOLANACEAE

Hyoscyamus albus L. - H bienn - Me
Previous citations: Carlström (1987: 103).
Nicotiana glauca R.C. Graham - P scap - NAT
Previous citations: Carlström (1987: 103).
Solanum nigrum L. - T scap - CAS

Family TAMARICACEAE

Tamarix sp.

URTICACEAE

Parietaria cretica L. - T rept - EM
Previous citations: Carlström (1987: 113).

Parietaria judaica L. - H scap - EA
***Urtica pilulifera** L. - T scap - MS
Previous citations: Carlström (1987: 113).

Family VALERIANACEAE

Centranthus ruber (L.) DC. - Ch suffr - Me
***Valeriana asarifolia** Dufr. - H scap - R (first record for Chalki).

Family VERBENACEAE

Vitex agnus-castus L. - P caesp - MS
Previous citations: Carlström (1987: 106).

Family VERONICACEAE

Antirrhinum majus L. - Ch frut - WM
Cymbalaria microcalyx (Boiss.) Wettst. in Engl. et Prantl. - Ch rept - EM - R
Carlström (1987) reports for Chalki *C. microcalyx* subsp. *acutiloba*. Dimopoulos et al. (2013) don't give mention of this subspecies for the Aegean area, citing instead for the Eastern Aegean islands *C. microcalyx* subsp. *dodekanesi* Greuter and *C. microcalyx* subsp. *paradoxa* Gruter. Given the difficulty for determination of species at issue, it chooses to report only the nominal species.
***Cymbalaria longipes** (Boiss. et Heldr.) A. Cheval. - Ch rept- EM - R
Previous citations: Carlström (1987: 104).
***Misopates orontium** (L.) Raf. - T scap - ME
***Veronica cymbalaria** Bodard - T scap - Me
Previous citations: Carlström (1987: 105).

CONCLUSIONS

The north-facing limestone vertical cliffs with shady exposure and especially those inside gorges (less subject to climate changes), offer a stable habitat and refuge for chasmophytic plants. Unfavorable climatic changes during the Pleistocene, grazing pressure, competition with other species, would be the elements that through the ages would have led some species to settle in refuges, such as cliffs ravines and crevices. On these sites suitable microclimatic conditions would allow the survival of these taxa. Such extreme and severe environments caused a hard selection between plant species, however a few of them increasing their chasmophytism degree and their woodiness have managed to survive, responding optimally to new edaphoclimatic conditions. It is currently believed that in the Aegean islands, especially in the Cyclades, where insularity and mountainous appearance have played a decisive role in endemic plants, 43% of local endemic species are below 600 m, but there is also a significant percentage (20%) restricted to areas above 1000 m (Georghiou & Delipetrou, 2010).

Comes therefore natural to underline the remarkable correlation between chasmophytism and endemism, concept which had already been discussed by Kypriotakis & Tzanoudakis (2001) in the study of the chasmophytic flora of Crete. A similar situation is also evident in Chalki, where isolation and mountainous aspect have certainly played a key role in the presence of endemic species. Unfortunately the lack of gene flow due to the isolation of these colonies, leads to poor genetic variation (tendency toward homozygosity). For this reason if a negative character promoted for genetic drift in these populations, or anthropogenic climate changes occurred, these species would most likely be at risk of extinction (Davis, 1951). Rarity inevitably involves criticality. The presence, in fact, of rare plant species included in the Red List of the IUCN, as well as of a particular birdlife related to the cliffs of the island, allowed Chalki to be included in the Network Natura 2000 (GR 4210026) (http: // www. ypeka.gr/).

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First report of three benthic foraminifera from the waters of Andaman Islands, India

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ABSTRACT The living benthic foraminifera *Nevillina coronata* (Millet, 1898), *Sigmoihauerina involuta* (Cushman, 1946) and *Loxostomina limbata* (Brady, 1881) are reported for the first time from the inner shelf regions of Andaman Islands, India. *Nevillina coronata*, very common in the north east, was observed to favorably flourish in the low temperature of rainy season, during monsoon period, whereas the remaining two species were abundant in the non rainy months. Although, in Andaman and Nicobar islands, the mega diversity for Foraminifera has not been studied in details yet, our findings suggest that the three species may be considered as indicators of monsoon and non monsoon periods.

KEY WORDS Wandoor; Andaman Sea; *Nevillina*; Shelled Protozoa and Climate.

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INTRODUCTION

The Andaman Nicobar Islands are tropical islands lying in the Bay of Bengal (6–14° N Lat; 92–94° E Long). The mean summer and winter temperatures often vary because of tropical conditions. Humid climate is a consequence of the annual rainfall ranging from 2900 to 3100 mm. Dry months from January to April show high evaporation since the islands are situated near the Equator and, therefore, solar radiations are more intensive (Velmurugan et al., 2015). These islands are also prone to seismicity as being placed between the subduction and emergence zone of the plate.

Foraminifera are a group of marine Protozoa, ubiquitously distributed throughout the world's marine habitats. They are unicellular (i.e. comprising of a single cell) eukaryote organisms that likely evolved from an amoeba-like ancestor. Foraminifera are usually encased by the protective shell or test that may be composed of organic, agglutinated or calcareous materials. The test may show one or more chambers; chamber arrangement and aperture style, with many slight variations around a few basic themes, are important features for classifying these animals. Various benthic foraminifera are often used for different kinds of biological, environmental and pollution monitoring studies. Microfossils, especially foraminifera, became the prime source to address the environmental issues (Nigam, 2005).

Generally, the larger benthic foraminifera are used to monitor the coral reef environmental changes. Indicator species are used to predict the deposition of oil and natural gas products. The larger symbiont-bearing benthic foraminifera are efficient recyclers and generally require warm clear oligotrophic waters to flourish, and are also important contributors to carbonate budgets (Harney et al., 1999). The meiobenthic community of foraminifera played an important role in the carbon cycle of the sediments (Moodley et al., 2000). The benthic foraminifera group Miliolida was very important as indicator of past and present environmental conditions (Haynes, 1981). According to Wilson (2007), a guild is a group of species having a very similar ecological role within a community, exploiting the same kinds of resources in comparable ways. Live organisms forming a guild may have similar spatial and temporal distribution. Sugihara (1980) observed that such a communities can be divided into smaller and more strongly related functional groups of species. Bandy (1954) reported that temperature is the main factor to determine the different faunal zones at 100 m depth for benthic foraminifera. Changes in abundance of marker species, the introduction of new species or serious loss of previously existing species, changes in species diversity, dominance or abundance may be useful tools to document the extent of environmental changes (Murray, 2000).

Foraminifera distribution is related to water depth, sediment texture and sedimentation rate (Guimerans & Currado, 1999). *Globigerina bulloides* is abundant in the upwelling environment (Kroon et al., 1991). The benthic foraminifera *Stainforthia fusiformis* (Williamson, 1848) is an opportunistic species which may cope with environmental stress (Alve, 2003). Agglutinated species are favored in the low marsh environment and *Miliammina fusca* (Brady, 1870) is dominant in low saline conditions (Moreno et al., 2005). The opportunistic species such as *Nonionella iridea* Heron-Allen et Earland, 1932, *Cassudulina carinata* and *Bolivina dilatata* are very reactive to the phytodetritus deposits. *Nonionella iridea* is dominant with the spring coccolithophore bloom (Duchemin et al., 2008). Low-energy environments are dominated by the families Soritacea and Miliolacea with less percentages of Rotaliacea (Madkour, 2013). Even though the studies on fossil Foraminifera have a long history, the knowledge on live benthic organisms is meager due to the paradigm shift of geology and biological sciences. Hence, it is the time to explore live foraminifera, including benthic communities in order to understand their sensitiveness to the environment to predict future changes on climate.

In particular, in Andaman and Nicobar Islands, only 11 research papers were published about foraminifera, and none of them about living organisms (see Khare et al., 2007). So, an attempt was made to study live foraminifera of Andaman Sea and eastern side of Bay of Bengal and their response to physico-chemical-environmental factors.

MATERIAL AND METHOD

Surface sediment samples were collected by a Van veen Grab from a depth of 10–20 m and the collected sediment transferred into plastic covers; then the samples were preserved with 10 % formaldehyde and 2 % Rose Bengal to distinguish the living fauna (Schonfeld et al., 2012). All samples were carefully stored in laboratory without disturbances. After 14 days of preservation, approximately 100 ml of sediments were sieved through 500 µm and 63 µm standard sieves. The samples retained in the 63 µm sieve were utilized for faunal analysis under a Nikon Binocular Stereoscopic Microscope. The sorted living benthic foraminifera were identified and mounted in cardboard micropaleontological slides.

The area of study is located in South, Middle and North Andaman group of islands, in the Andaman Sea. It comprises: 1) Wandoor station, located in Port Blair, the South Andaman, headquarter of Andaman and Nicobar Islands; 2) Mayabunder, in Middle Andaman, which is also a headquarter for Middle and North Andaman district; and 3) Diglipur, in the North Andaman district. Wandoor is a coral reef environment with coral sand deposits located in the western side of the Island and in the eastern side of Bay of Bengal. The coral sand is covered with the seaweed *Sargassum* sp.; Mayabunder station is located in a coral reef environment near Avis Island with a steep slope and coral sand deposits; and, finally, Diglipur shows sandy deposits near the western approach of Ross and Smith Islands.

RESULTS AND DISCUSSION

During this study we found three species, *Nevillina coronata* (Millet, 1898) (Figs. 1, 2), *Loxostomina limbata* (Brady, 1881) (Figs. 3, 4) and *Sigmoihauerina involuta* (Cushman, 1946) (Figs. 5, 6) not previously reported as living foraminifera for this area. Their habitat and local environmental parameters are discussed herewith (Table 1).

Systematic

The following scheme is according to Loeblich & Tappan (1987).

Order FORAMINIFERIDA Eichwald, 1830
Sub Order MILIOLINA Delage et Herouard, 1896
Family HAUERINIDAE Schwager, 1876
Genus *Nevillina* Sidebottom, 1905

Nevillina coronata (Millet, 1898)
Biloculina coronata Millet, 1989

DESCRIPTION. Test elongate, calcareous, porcellaneous, imperforate. Test surface smooth and very delicate, the earlier chambers are clearly visible. The latest chamber envelopes the older chambers; Earliest chambers are triloculine and the final chamber biloculine. The aperture consists in the terminal end of the final chamber and is arranged at each opposite end of the test. The opening is elongated, with more than six arched ribs joining in a ring around the central opening (Figs. 1–4).

Family HAUERINIDAE Schwager, 1876
Genus *Sigmoihauerina* Zheng, 1979

Sigmoihauerina involuta (Cushman, 1946)
Hauerina involuta Cushman, 1946
Pseudohauerina occidentalis subsp. *involuta* (Cushman, 1946)

DESCRIPTION. The test is calcareous, porcellaneous, ovate to sub-circular, showing five chambers with and a planispiral one. In adult specimens, three chambers can be observed in the final whorl, with 25–28 radial septa. Test may show numerous longitudinal striae on the surface. The aperture is in the terminal end of the final chamber showing a typical trematophore plate with many small openings (Figs. 5–8).

Sub Order ROTALINA Lankester, 1885
Family BOLIVINITIDAE Cushman, 1927
Genus *Loxostomina* Sellier De Civrieux,1969

Loxostomina limbata (Brady, 1881)
Bolivina limbata Brady, 1881
Bulimina limbata Brady, 1881
Euloxostomum limbatum (Brady, 1981)
Loxostoma limbatum (Brady, 1881)
Loxostomoides limbatum (Brady, 1881)
Loxostomum limbatum (Brady, 1881)
Rectobolivina limbata (Brady, 1881)
Loxostomina limbata (Brady, 1881)

DESCRIPTION. The elongated test consists of eight pairs of chambers as biserial, and the last two uniserial. In the first part, the shell shows one chamber increasing its size in the terminal part, and becomes narrower at the end of the aperture side. Longitudinal striae may be present and the test shows a coarse perforation; adult specimens are twisted or slightly depressed. The aperture, in the terminal end of the final chamber, is oval with outer lip; in immature specimens is linear. The shell is made of calcareous hyaline materials (Figs. 9–11).

Discussion

Nevillina coronata and *S. involuta*, belong to Miliolida, whereas *L. limbata* to Bolivinida. *Nevillina coronata* flourished in Wandoor, in the month of September when the south west monsoons play a role of modest change in the environmental parameters (27.5 °C 35.9 PSU, pH 8.3, see Table 1). *Sigmoihauerina involuta* and *L. limbata* flourished in the month of March, in Mayabunder and Diglipur, where the temperature was 28.2°C with salinity of 33.4 PSU and pH of 8.6 (Table 1). The above parameters seem to indicate that *N. coronata* need low temperature, and high salinity (35.9 PSU), whereas the other two species needed higher temperature (28.2°C), and lower salinity (33.4 PSU). But, above all, the three species have never been reported as live foraminifera in any earlier reports from Andaman and Nicobar Islands and this occurrence may be considered as the first time report in these waters. It is also noteworthy to say that, according to available literature, *N. coronata* was never reported from the Indian Ocean, after Millet (1898). On the contrary, it was reported from New South Wales, Pacific Ocean (Albani, 1979) and New Zealand (Hayward et al., 1999), all environments with warm-temperate waters. Recently (2008) it was also reported from Chinese Exclusive Economic zone (WORMS, Foraminifrea Data Base).

	Wandoor, - Bay of Bengal - South Andaman	**Mayabunder - Andaman Sea - Middle Andaman**	**Diglipur – Andaman Sea – Middle Andaman**
Latitude and Longitude	11°35’49.17N 092°36’42.05E	13°17’44.69N 093°03’20.76E	12°55’06.11N 092°56’03.84E
Nevillina coronata	Yes	No	No
Sigmoihauerina involuta	No	Yes	Yes
Loxostomina limbata	No	Yes	Yes
Water Depth (m)	10 m	20 m	20 m
Period	September-2013 September-2014	March-2012 April-2014	March-2012 April-2014
Temperature ° C	27.5C	28.2C	28.2C
Salinity PSU	35.9	33.3	33.3
pH	8.3	8.6	8.5
Dissolved Oxygen (ml/L)	5.5	5.8	5.8
Turbidity (NTU)	5.9	80	102
Sediment character	Sandy	Sandy	Sandy

Table 1. Presence/absence of the three species and environmental parameters observed in the three study areas.

	Nevillina coronata	***Sigmoihauerina involuta***	***Loxostomina limbata***
Type Level	Recent	Recent	Recent
Type Locality	Malay Archipelago, Indian Ocean	Rongelab Atoll, Marshall Islands	Not Designated quotes in Holburn et al. (2013)
Bathymetry as Reported Earlier and Current Observation(*)	Neritic Zones* 0-10 m Depth	Neritic to Upper Bathyl Zones, *15-20 m Depth	Neritic to Upper Bathyl Zones, *15-20 m Depth
Size of the Studied specimen	746.31 µm , length and 308.49 µm width	313.54 µm Dia	847.31 µm length and 266.15 µm width
Chronostratigraphy	Holocene to Recent	Oligocene to Recent	Middle Miocene to Recent
Biogeography	Indo-Pacific Regions	Indo-Pacific Regions	World Wide
References	Loeblich & Tappan, 1994; Albani, 1979; Hayward et al., 1999	Loeblich & Tappan, (1987), 1994; Debenay, 2012	Cushman, 1942; Loeblich & Tappan, 1994; Holburn et al., 2013

Table 2. Species-related oceanographical information.

Figures 1–4. *Nevillina coronata*. Fig. 1: side view, Fig. 2: apertural view, Fig. 3: close view of aperture, Fig. 4: adult specimen. Figures 5–8. *Sigmoihauerina involuta*. Fig. 5: dorsal view, Fig. 6: apertural view, Fig. 7: ventral view, Fig. 8: close view of aperture. Figures 9–11. *Loxostomina limbata*. Fig. 9: ventral side, Fig. 10: dorsal side, Fig. 11: apertural view.

CONCLUSIONS

In the present study we encountered for the first time three species of foraminifera (*N. coronata*, *S. involuta* and *L. limbata*) in the Andaman Archipelago. In particular, *N. coronata* was encountered in September, with rains and low temperature, which might suggest that this species can be considered as an indicator for the rainy season, while the other two species, *S. involuta* and *L. limbata*, more often flourished in the spring-summer months, which would make them as possible non-rainy season indicators.

On this basis, further studies are needed to monitor the occurrence of the very same species with respect to other environmental parameters which may, perhaps, also be helpful to future paleontology and paleocological studies.

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The lichens in a relic wood of *Juniperus turbinata* Guss. (Pinales Cupressaceae) with a new record for Sicily

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ABSTRACT This paper regards a research conducted on terrestrial and epiphytic lichen flora growing in an extensive juniper bush, *Juniperus turbinata* Guss. (Pinales Cupressaceae), in southeast Sicily. The flora recorded, although small in number, 29 species in all, includes several species quite rare in Italy or Sicily. One in particular, *Heppia adglutinata* (Kremp.) A. Massal. is new for Sicily and it is however rather rare in the Mediterranean area. Some considerations about the distribution and ecology of the found species are done.

KEY WORDS Epiphytic lichens; terrestrial lichens; *Heppia adglutinata*; juniper woodland; Mediterranean.

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INTRODUCTION

Juniperus turbinata Guss. (Pinales Cupressaceae) is a threatened tree species occurring in the Mediterranean area; it grows mainly in the coastal belt; only in north Africa it reaches high altitudes (Mazur et al., 2015). It is listed as a vulnerable species in the Red Book of Italian plants and its various communities are included in Annex I of the Habitats Directive 92/43/EEC as a priority habitat for conservation. The recent discovery of a very big population in south Sicily (Minissale & Sciandrello, 2013) has led us to conduct a research on the lichen flora of this site (Fig. 1), taking into account that the good conservation and big age of the population could be a favorable condition for a high and peculiar lichen biodiversity regarding both epiphytic and terricolous taxa.

The lichen flora growing on the Mediterranean junipers is still poorly known and only some bibliographic references are available. The first studies were carried out by Sarrión & Burgaz (1995) Aragón & Martínez (1997) in Spain; later Aragón et al. (2004) made a study on the lichen flora growing on *Juniperus oxycedrus* L. The same taxon was investigated by Zedda & Sipman (2001) for Sardinia.

Regarding the soil lichens of Mediterranean juniper communities, literature data are rather scarce. Gallego Fernández & Díaz Barradas (1997) give some information on dunal lichens into *Juniperus turbinata* woodlands of south western Spain, while Cogoni et al. (2011) examine terricolous lichens and briophythes of well-preserved native *Juniperus* woodlands of Sardinia.

The aim of this study is to increase the knowledge of the lichen flora of a *Juniperus turbinata* woodland growing in a very arid site that is Piano Pirrera near Acate (Ragusa) in south eastern Sicily (Fig. 2).

MATERIAL AND METHODS

The examined material has been collected during a several field trips during January and February 2014. Many trees of *Juniperus* have been analyzed in order to produce a complete epiphytic lichen flora. Samples were collected both on the trunk and on the branches. Other samples on the ground have been collected. For the identification a Zeiss Axiostar Plus binocular (10 x) microscope was used to observe the specimens with objectives having factors of magnification of 5X, 10X, 40X, 100X oil immersion. The following keys were used: Clauzade & Roux (1985, 1987), Nimis et al. (1993), Nimis & Martellos (2008). Spot tests, C, K and I, have been used for testing some species. The nomenclature follows Nimis (1993).

Study area

The study area covers the sandy hill of Piano Pirrera (Acate, province of Ragusa, Sicily, Italy) situated approximately seven kilometers from the coast of the Gulf of Gela. It is mainly composed of Pleistocene substrates such as calcarenites and sand deposits. Juniper community grows mainly on south-facing slopes. Following the phytogeographic subdivision of Sicily by Brullo et al. (2011), this area, characterized by sand deposits, belongs to the Camarino-Pachinense district included in the southern Sicilian subsector, together with the Hyblaean district. According to the bioclimatic classification proposed by Rivas-Martinez (1993, 2004), the study area falls within the Mediterranean pluviseasonal oceanic bioclimate, with thermotypes ranging from the lower thermomediterranean to upper thermomediterranean, and ombrotypes from the lower semiarid to upper semiarid. The *J. turbinata* community covers an area of about 14 hectares and the population was judged to exceed 12,000 individuals, some of which are more than 6 meters high, really the largest known population for Quaternary sand deposits in Sicily (Minissale & Sciandrello, 2013). *Juniperus turbinata* is the dominant species associated with other shrubs such as *Pistacia lentiscus*, *Ephedra fragilis*, *Euphorbia dendroides*, *Rosmarinus officinalis*.

RESULTS AND DISCUSSION

Two annotated lists of the lichens collected in the examined site are presented, one of epiphytic lichens and another regarding terrestrial ones. The lichens are showed with information about their ecology in Italy and when significant in Sicily, as reported by Nimis & Poelt (1987) and by Nimis (1993) and their distribution in Europe based mainly on Nimis (1993) and Nimis & Martellos (2008).

THE LIST OF EPIPHYTIC LICHENS

Familia ARTHONIACEAE

Arthonia albopulverea Nyl

On twigs. In Italy it has been recorded only in a few regions (Nimis, 1993). In Sicily it has been

Figure 1. Study area localized by red square (Sicily map from Sémhur/Wikimedia Commons, 2015, modified).

Figure 2. *Juniperus turbinata* community at Piano Pirrera, Acate (Ragusa, Sicily).

recorded previously near to N-W coast and in the province of Ragusa (Grillo, 2004). Here it is reported for the first time from this locality.

Familia TELOSCHISTACEAE

Caloplaca cerina (Hedw.) Th.Fr. v. ***cerina***

On twigs. *Caloplaca cerina*, sensu strictu, is an epiphytic lichen generally occuring in *Xanthorion* vegetation (Nimis & De Faveri 1981); in southern Italy is most frequent at lower altitudes. Distribution is holoartic (Nimis, 1993).

Familia CATILLARIACEAE

Catillaria nigroclavata (Nyl.) Schuler

On twigs. A common species from Europe to North America, with a large ecological amplitude; it's frequent on eutrophic bark. In Italy is widespread at low altitudes (Nimis, 1993).

Catillaria praedicta Tretiach et Hafellner

On twigs and on bark. *Catillaria praedicta* (Fig. 3) is closely related to *C. mediterranea*, but is distinguished by three morpho-anatomical characters: number of spores per ascus, spore size, and size of the apothecia. It occurs in natural or semi-natural vegetation, along the coasts and on some small islands (Marettimo - Egadi Islands, Mallorca) of the western Mediterranean basin (Tretiach & Hafellner, 1998); in Sicily it has been recorded from Grillo et al. (2002).

Familia PHYSCIACEAE

Diploicia canescens (Dicks.) A.Massal.

On twigs. It is a common lichen in the islands and thyrrenic area. In Europe has been found on a wide variety of substrates incl. base-rich or eutrophicated bark, calciferous sandstone and limestone (Nimis & Martellos, 2008) and it is a species with a very wide ecological amplitude.

Hyperphyscia adglutinata (Flörke) H. Mayrhofer et Poelt

On bark. This is a common lichen in all Italy, also in sites with high eutrophication, such as intensive agricultural areas (Nimis & Martellos, 2008).

Physcia leptalea (Ach.) DC.

On twigs. It is a species common especially in the Mediterranean region. In Italy it is widespread in open woods, in communities of the *Xanthorion* (Nimis 1993). In south Italy it is common mostly on twigs and branches (Nimis & Martellos, 2008).

Physconia venusta (Ach.) Poelt

On twigs. This species is confined to the Mediterranean region, in Italy is rather rare in the Alps, but it is abundant in central and south Italy (Nimis, 1993).

Rinodina sophodes (Ach.) A. Massal.

On twigs. Lichen with a wide ecological range, pioneer on young twigs. It's present in all Italy, but isn't common (Nimis, 1993; Nimis & Martellos, 2008).

Familia LECANORACEAE

Lecanora chlarotera Nyl.

On twigs and on bark. A most common epiphytic *Lecanora* in Italy, widespread in almost all the country. It is common on isolated deciduous trees, mostly in *Xanthorion* communities (Nimis & Bolognini, 1981 1993).

Lecidella elaeochroma (Ach.) M.Choisy

On twigs and on bark. It is a very common epiphytic lichen in Italy, with a wide ecological amplitude, in conditions from very weak to a rather high eutrophication and broad altitudinal range (Nimis & Martellos, 2008). Usually pioneer on young twigs is frequent in *Xanthorion* communities (Nimis, 1993).

Familia OPEGRAPHACEAE

Opegrapha vulgata Ach.

On twigs. Widespread in all Italy, but non common. It is a suboceanic species widespread from southern Scandinavia to Mediterranean region (Nimis, 1993).

Familia PORINACEAE

Porina aenea (Wallr.) Zahlbr.

On bark. Species widespread in the Northern hemisphere, rather rare in all Italy (Nimis, 1993).

Familia ROCCELLACEAE

Schismatomma dirinellum (Nyl.) Zahlbr.

On bark. A mediterranean-atlantic species, in Italy is very rare and not present in all country, (Nimis & Martellos, 2008). In Sicily it has been recorded by Grillo et al. (2002).

Familia TELOSCHISTACEAE

Xanthoria parietina (L.) Th. Fr.

Saxicolous; on twigs and on bark. This species is present in all continents except Antarctica, in Italy is a very common epiphytic lichen (Nimis, 1993). This species is present also in heavily polluted areas, but not such as epiphytic lichen, rather as epilithic lichen (Nimis & Martellos, 2008).

THE LIST OF TERRESTRIAL LICHENS

Familia TELOSCHISTACEAE

Caloplaca variabilis (Pers.) Müll. Arg.

On calcareous sandstone. Species extremely variable and common in all Italy, widespread in temperate regions of the Northern hemisphere, (Nimis, 1993).

Fulgensia fulgens (Sw.) Elenkin f. *subbracteata* (Nyl.) Nimis

On calcareous soil. Species reported in sub-Mediterranean areas; it is found on calciferous soil in clearings of grasslands and shrublands. Rather common in Italy, but not present in all regions (Nimis, 1993).

Familia CLADONIACEAE

Cladonia convoluta (Lam.) Anders

On calciferous soil. This species is widespread in Mediterranean and submediterranean Europe; in Italy it's very common, (Nimis, 1993).

Cladonia pyxidata (L.) Hoffm.

On sandy soil. Temperate species with an ample ecological tolerance, it occurs on different substrata from the lowlands to the alpine belt; it occurs both on calcareous and siliceous substrata, also on bark and wood (Nimis, 1993).

Familia PORPIDIACEAE

Clauzadea monticola (Schaer.) Hafellner et Bellem.

On a small limestone rocks. It's common throughout Italy (Fig. 4), to lowlands to the alpine belt, whit an ample ecological range. It's widespread from the Artic to the Mediterranean zones (Nimis, 1993).

Familia COLLEMATACEAE

Collema tenax (Sw.) Ach.

On sandy soil. Species very variable and with cosmopolitan distribution. It's found on disturbed ground, on walls, on rock, and in all Italy is very common (Nimis, 1993).

Familia THELOTREMATACEAE

Diploschistes gypsaceus (Ach.) Zahlbr.

On sandy soil. It has a wide range in Europe, rare in Italy, not present in some regions, (Nimis & Martellos, 2008).

Diploschistes muscorum (Scop.) R. Sant.

Parasite on squamule of *Cladonia*. Rather common in all Italy, it is an holarctic lichen (Fig. 5). Generally on mosses and plant debris in dry grasslands on limestone (Nimis & Martellos, 2008).

Familia VERRUCARIACEAE

Endocarpon pusillum Hedw.

On calcareous soil. Species widespread from Arctic to Mediterranean regions in Europe; not very common in Italy (Nimis, 1993).

Heteroplacidium imbricatum (Nyl.) Breuss;

On calcareous soil. Species known along the coast of the Mediterranean sea and Macaronesia; is very rare in Italy (Nimis, 1993).

Placidium rufescens (Ach.) A. Massal.

On sandy soil. Common species in Europe except in the northern part (Nimis, 1993). In Italy is rare.

Familia HEPPIACEAE

Heppia adglutinata (Kremp.) A.Massal.

On sandy soil. A very rare species in Italy, previously recorded only from Piedmont and Sardinia (Nimis, 1993; Nimis & Martellos, 2008), but with a wide distribution, from arid areas of Namibia, South Africa, North America in USA and South America with only a record in Brazil (GBIF 2013; Schultz et al., 2009). There are few records for Europe mainly from north and central Europe (GBIF, 2013; Henssen, 1994). This is a new record from Sicily and it is important because the species is almost unknown in the Mediterranean region with a distribution likely to be better defined by appropriate investigations (Figs. 7, 8).

Heppia solorinoides (Nyl.) Nyl.

On sandy soil. Species reported only in Apulia, Calabria and Sicily (Nimis & Martellos, 2008; Cataldo & Minissale, 2013), widespread from Macaronesia to southern part of the Mediterranean area (Nimis, 1993) (Fig. 6).

Familia PSORACEAE

Psora decipiens (Hedw.) Hoffm.

On sandy soil. It's common throughout Italy (Fig. 9), frequent in open dry grasslands (Nimis, 1993).

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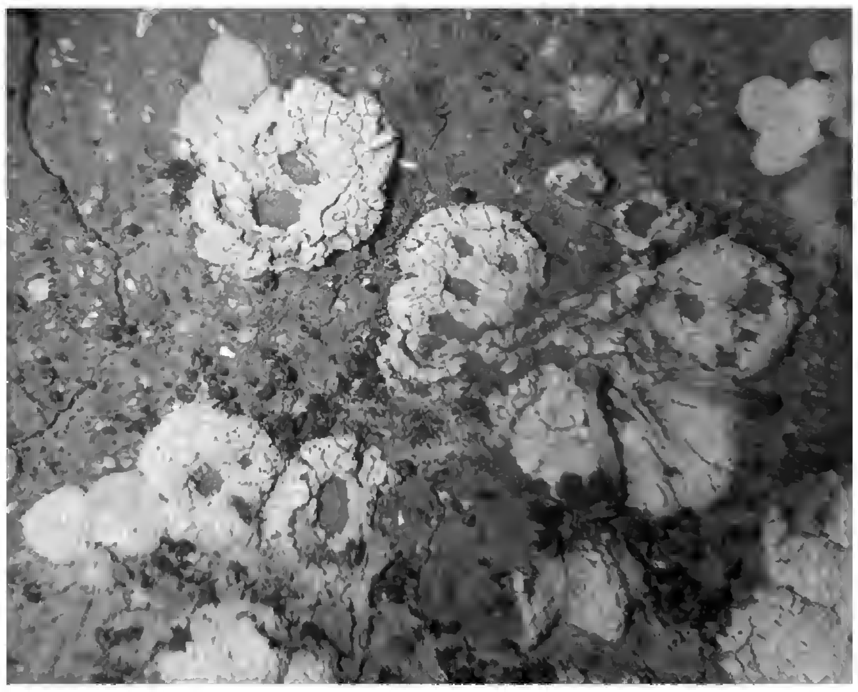

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Figures 3–6. Images of collected lichens observed by binocular microscope (magnification 20X). Fig. 3: *Catillaria praedicta*. Fig. 4: *Clauzadea monticola*. Fig. 5: *Diploschistes muscorum*. Fig. 6: *Heppia solorinoides*.

Familia ACAROSPORACEAE

Sarcogyne regularis Körb. v. ***regularis***

On limestone. Species very common in all Italy, it colonizes an ample variety of calcareous substrata, it's common in the urban area also (Nimis & Martellos, 2008).

Familia STEREOCAULACEAE

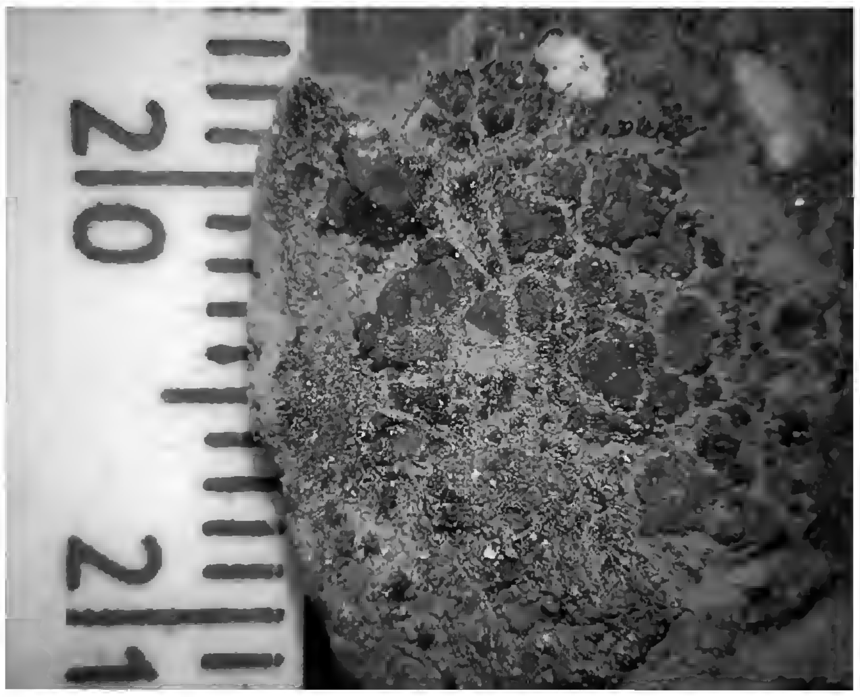
Squamarina lentigera (Weber) Poelt

On limestone. It's a species widespread from central Europe to the Mediterranean areas (Fig. 10); in Italy is present in almost all the regions, but it's not common (Nimis, 1993).

DISCUSSION AND CONCLUSIONS

On the whole, 15 taxa (14 genera) of lichens were found on *Juniperus turbinata* L., and 16 taxa (13 genera) on soil in the locality of Acate (Ragusa, Italy). One species of the lichen flora is recorded for the first time from Sicily. By way of comparison in a coastal area of south eastern Sicily, Cataldo & Minissale (2013) have found 14 terrestrial taxa of which 8 are in common with the current area of study. Among these *Heppia solorinoides* very rare species, even in Vendicari only on sandy substrates.

The most widespread growth form on the total flora surveyed is the crustose type, (58%), the squamulose form follows (19%), then foliose form (16%) at the end the dimorphic form (6%).



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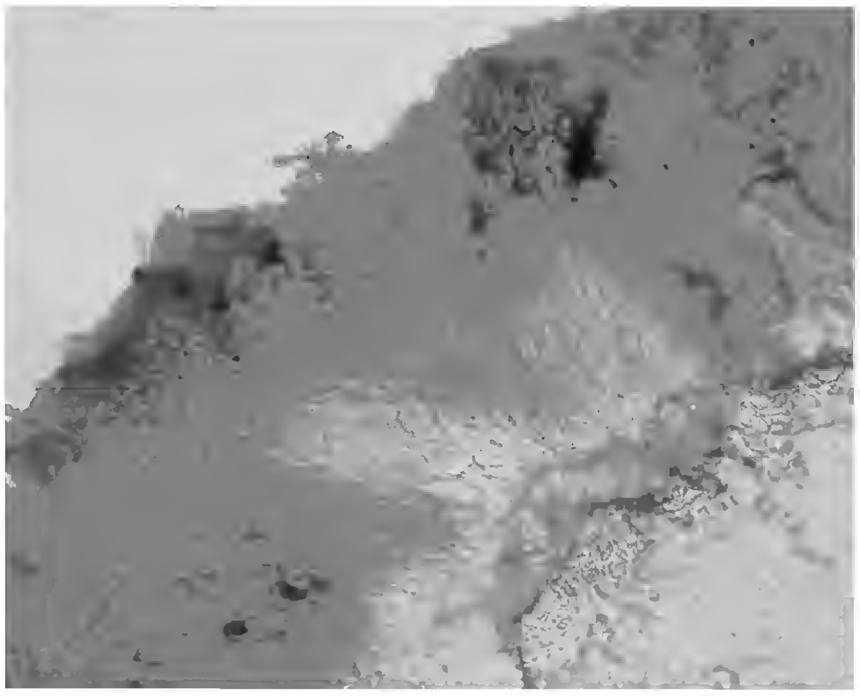

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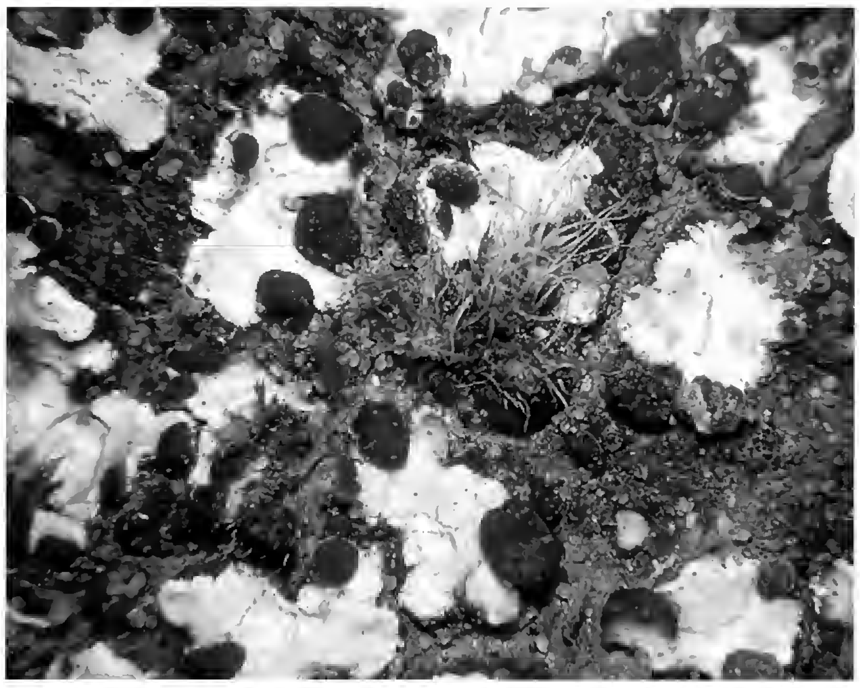

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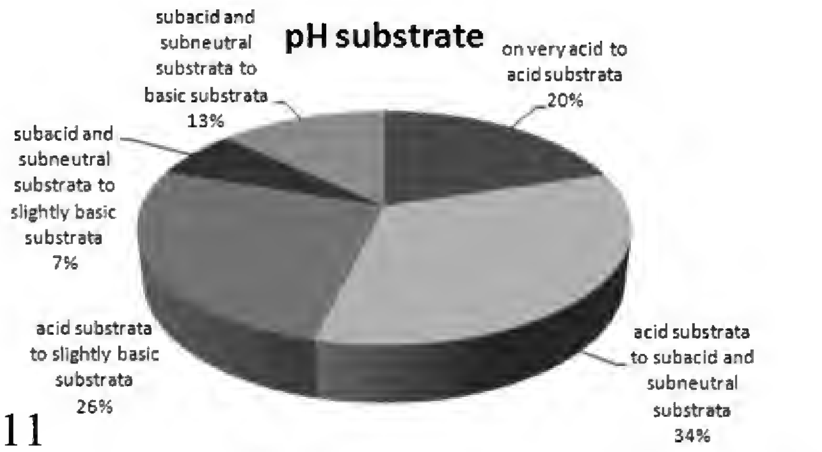
Figures 7, 8. *Heppia adglutinata* collected near Acate. Fig. 7: the lichen observed by binocular microscope with scale in millimeters. Fig. 8: Section of the same lichen (magnification 40X, coloured with J _Iodine). Figures 9, 10. Images of collected lichens observed by binocular microscope (magnification 20X). Fig. 9: *Psora decipiens*. Fig. 10: *Squamarina lentigera*.



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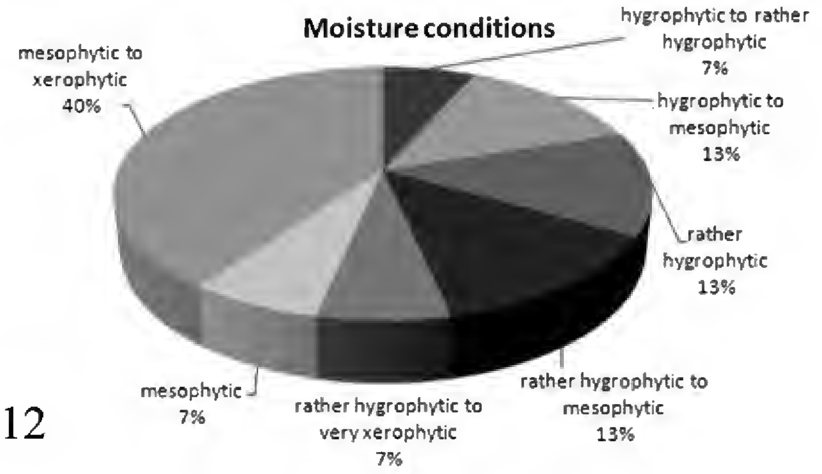

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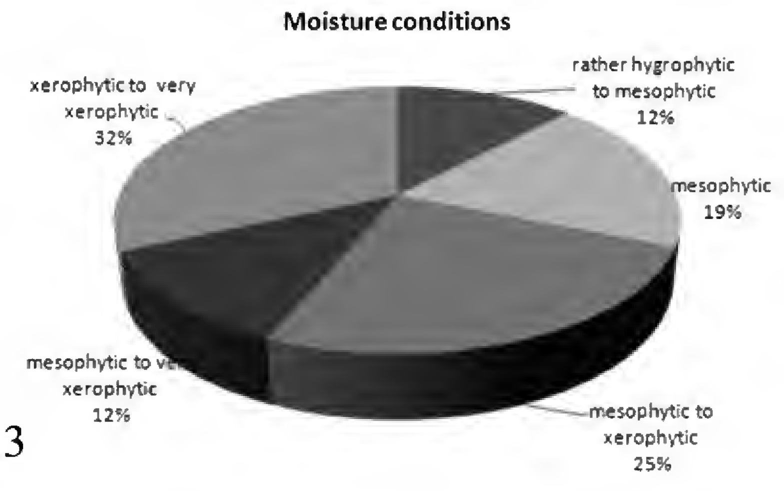

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Figure 11. Ecological preferences spectrum of epiphytic lichens-pH substrate.

Figure 12. Ecological preferences spectrum of epiphytic lichens-moisture conditions.

Figure 13. Ecological preferences spectrum of terrestrial lichens-moisture conditions.

Regarding the ecological preferences the 34% of epiphytic species list are characteristic for acid to subneutral substrata (Fig. 11) indicating a weak acid bark similarly to what has been reported in other species of juniper (Aragon et al., 2004; Scarborough et al., 2009); a small group of species, 7%, is characteristic for acid to slightly basic substrata (*Catillaria praedicta*, *Lecidella elaeochroma*, *Physcia leptalea*, *Xanthoria parietina*).

The 40% of these species are characteristic of mesophytic to xerophytic environment. An another 40% is characteristic of hygrophytic to xerophytic environment (Fig. 12).

About the 30% of terrestrial species list are characteristic of xerophytic to very xerophytic environment (Fig. 13).

The epyphitic flora of Acate (Ragusa, Sicily) is poor if compared with the surveyed flora on *J. oxycedrus* at Campu su Disterru in Sardinia (Zedda & Sipman, 2001); this difference can be attributed to different climatic conditions, as shown in the graphs, more shallows in Acate compared to humid conditions and the highest altitude of Sardinia.

Lichenic flora's significance of Piano Pirrera territory, is especially qualitative, in fact among the reported lichens *Heppia adglutinata* is new to Sicily and many species are from extremely rare to rare for Italy.

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Biodiversity Journal, 2015, 6 (4): 803–804

A new record of the red-eared slider, *Trachemys scripta elegans* (Wied, 1838) (Testudines Emydidae), in Latium (Italy)

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ABSTRACT In this work we report for the first time the presence of non-native invasive turtle *Trachemys scripta elegans* (Wied, 1838) (Testudines Emydidae) in the lake of Nemi in the province of Rome (central Latium, Italy).

KEY WORDS Alien invasive species; Latium; Nemi; Red-eared slider; *Trachemys*.

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INTRODUCTION

The red-eared slider *Trachemys scripta elegans* (Wied, 1838) is a semiaquatic turtle belonging to the family Emydidae (Testudines). It is native to the southern United States and northern Mexico, but actually is established in many other states and has become an invasive species. This turtle is commonly traded all over the world as a pet and for food (Thorbjarnarson et al., 2000), and many specimens are abandoned in natural or artificial ponds and rivers. This slider is considered by the IUCN one of the 100 world's most invasive alien species (Lowe et al., 2000). *Trachemys scripta* Schoepff, 1792 was first introduced in Italy on early '70s (Bruno & Guacci, 1993), but many findings occurred in the whole Italian territory since the '80s (Di Cerbo & Di Tizio, 2006; Ficetola & Scali, 2010).

In Latium this turtle is found in many natural and artificial ponds and watercourses and is known for the province of Viterbo (Vico Lake; Bolsena Lake), Roma (Oasis WWF of Palo Laziale; Oasis WWF of Macchia Grande; Tevere River; ponds in the urban park of Villa Borghese; ponds in the urban park of Villa Ada; ponds in the urban park of Villa Pamphili; pond of Eur; Orto Botanico; Presidential Estate of Castel Porziano; Albano Lake); Rieti (Belmonte in Sabina; Fosso Arianna) and Latina (Bologna et al., 2000).

STUDY AREA

Nemi Lake (Fig. 1) is a small volcanic lake, situated between the towns of Nemi and Genzano in the province of Rome. It is situated 316 m above sea level, has an area of 1, 67 square kilometers, a maximum depth of 33 m and a perimeter of about five kilometers. Nemi Lake is included in the area of "Parco Regionale dei Castelli Romani".

This natural protected area is located in the Castelli Romani district and includes 15 municipalities. This lake is known because it is the only Italian lake where it's present the Argentinian Silverside *Odontesthes bonariensis* Valenciennes, 1835 (Atheriniformes Atherinopsidae). This fish coming

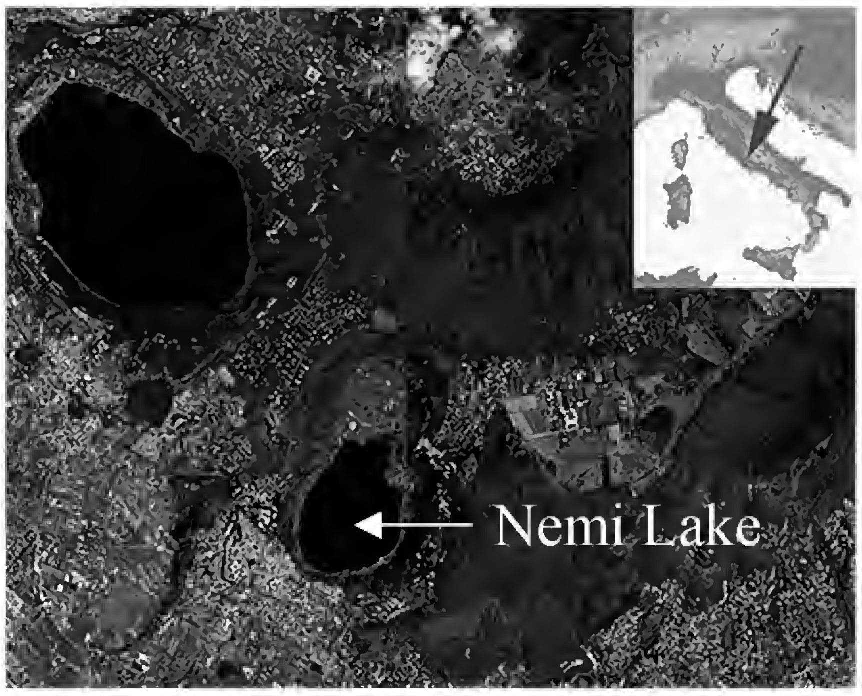

Figure 1. Study area: Nemi Lake, Rome (Latium, Italy).

from South America, was introduced in 1974 for experimental purposes from the Stabilimento Ittiogenico of Rome.

RESULTS

During the month of September 2015 several specimens of *T. scripta elegans* were observed in thermoregulation on some floating logs adjacent to the sides of the lake. All the specimens were big and in apparent good health. Since it has never been previously reported the presence of this exotic turtle in Nemi Lake, it can deduce that the specimens have been deliberately released in relatively recent times. The part of the lake where the red-eared slider were spotted, is a wooded area under the town of Genzano. This area, in contrast to that one in Nemi, is not crossed by a road and even walking is difficult.

CONCLUSION

The introduction of invasive alien species is a major cause of biodiversity loss. The highly invasive red-eared slider has been massively released worldwide with negative consequences on native biota, parasitism, competition, diffusion of diseases and ecosystem modification (Strayer et al., 2006; Ficetola & Scali, 2010). The release of exotic animals is illegal in Italy and involves the use of large human and economic resources for the removal and management of trapped animals (Zuffi et al., 2015). Since 1992 has been established in Italy the ban on trade of *T. scripta elegans*. The presence of this alien invasive turtle in a protected natural area represents a serious problem. Therefore it should monitor the presence and receive guidance on the impact of this species on the environment. In addition, the local population should be informed on the issue of the release of invasive alien species.

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Cerrado's areas as a reference analysis for aquatic conservation in Brazil

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ABSTRACT The Cerrado is recognized as a relevant hotspot, being biologically the richest one in the world, with a significant degree of endemism. The central region of Cerrado Domain is considered the "water cradle" of Brazil, with important springs from South American watersheds. Human activities caused several impacts on drainage-basins, as water pollution and silting of running waters, affecting riparian and aquatic biota. The aquatic biodiversity of this region is yet poorly known, despite studies on terrestrial fauna and flora showed an estimate of 160 thousand species. In this review, the aquatic biodiversity of the Cerrado Domain was evaluated on literature survey from 2004 to 2012. Data obtained until now are sparse and focused in some few organism groups, and the aquatic species richness is estimated to 9,580 species. At least 22.8% of fish species in Brazil are expected to occur in Cerrado, as well as 25.2% of bivalve mollusks, and 41.9% of the diatom algae. The endemism is relevant for some groups, reaching 25% for fishes and more than 10% for bivalves and diatoms. Based on the potential of environmental heterogeneity of the aquatic systems located in high and protected areas, their permanent preservation has been a challenge for shelter of endemic and endangered species, revealing a huge genetic patrimony, as grounded by this study for the Cerrado Domain in central Brazil.

KEY WORDS Brazilian savanna; Preserved areas; aquatic biodiversity; endemic species.

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INTRODUCTION

The Cerrado is the most extensive woodland-savanna in South America and comprises 21% of the Brazil`s territory. The central Brazilian Plateau is covered by Cerrado and spreads across an area of 2,031,990 km^2. It is biologically the richest one in the world, with a significant degree of endemism (Myers et al., 2000).

UNESCO classified the Cerrado as a Biosphere Reserve and it is referred as one of the world's biodiversity hotspots, with a high priority on the biodiversity conservation. This biome has 30% of the Brazilian biodiversity and at least five percent of the flora and fauna richness of the world (Oliveira & Marquis, 2002). The Cerrado region is considered the "water cradle" of Brazil, with important springs from South American basins such as the Platina, Amazonas and São Francisco basins. The predominance of highlands in the central Brazil provides conditions for the surface water drainage to lower regions.

The high quality water sources and springs enable to obtain the water for population uses, and the adequacy of the water management is indispensable. Brazil has a significant portion of the world's surface runoff (12.7%) and the Central Brazil has potential water resources due to preserved headwaters, despite the growing irregular occupation by human population (MMA,1998).

The groundwater is a renewable resource, but adequate time is needed to allow the aquifers replenishment. Such areas must be properly managed in order to prevent the contamination by waste products that can infiltrate and pollute the underground supply.

Thus, the Cerrado in central Brazil comprises a high value region of springs and watersheds, but its management must be directed to the water accumulation in reservoirs for human regional uses. The continent water volume is finite and the springs are irregularly distributed. Currently, the water availability gradually decreases due to environmental degradation, disordered population growth and agricultural expansion (Klink & Machado, 2005).

In the last 35 years, more than 50% of the area has been transformed into pasture and agricultural lands. Deforestation rates have been intensive, but conservation efforts have been modest: only 2.2% is under legal protection. Burning practices for clearing land for cultivation and pasture growth have also caused damages, even in a fire-adapted ecosystem like the Brazilian savanna. Cerrado's agriculture is lucrative, and its expansion is expected to continue, requiring upgradings in transport infrastructure. The landscape modification and threats to numerous species increased the concerns on the Cerrado's conservation, and improvements such as the expansion of protected areas and the development of farming practices are being applied, benefiting the livelihoods of local communities (Klink & Machado, 2005).

These human activities caused several impacts on the drainage-basins, as water pollution, silting of running waters, and losses of riparian and aquatic biota. Despite studies on the fauna and flora of Cerrado showed an estimate of 160 thousand species, the biodiversity of this region is still poorly known. This situation is notable for the diversity of aquatic groups such as invertebrates, algae, macrophytes and fishes (MMA, 2007).

MATERIAL AND METHODS

This paper intends to examine the statement on this high biodiversity estimated in Brazil, which is around 13% of the world's species (Lewinsohn & Prado, 2005). This research was based on a literature survey focused on the aquatic ecosystems of the Brazilian savanna (Cerrado). The Scielo (Scientific Electronic Library Online) and the Web site of the Institute for Scientific Information (Thomson Corporation, 2012) were explored using the keywords "Cerrado"and "biodiversity" (papers published between December 12, 2004 and October 31, 2012). The aquatic biodiversity in Cerrado was also investigated on academic theses referenced by IBICT (Brazilian Digital Library of Theses) from 2005 to 2012.

A comparison between the data presented by this work and those obtained by Agostinho et al. (2005) was made and a short ecological characterization of inland aquatic systems was presented taking into account the hydrological parameters, such as standing or running waters, and the main wetlands categories.

DISCUSSION

A brief characterization of Cerrado's inland waters

The core region of the Cerrado Domain presents a variety of natural aquatic ecosystems. Besides the lotic water bodies (running waters) and the lentic ones (standing waters), there is another specific aquatic systems in this region, which is associated to flooding areas inserted in the category of humid zones. According to the Ramsar convention (1971), a humid zone is considered the whole extension of marshes, swamps, puddles and turfs, or any watery surfaces, artificial or natural, permanent or temporary, fresh or salty. The occurrence and the extension of humid zones in the Cerrado produces a broadening between the terrestrial and aquatic systems and a scientific research still underexplored in these areas.

A large number of low-order streams are part of the Cerrado core region drainage systems. It is a dendritic hydrographic network with small water courses which headwaters emerge at the plateau`s skirts and which extensions are originally protected by a dense riparian vegetation. Under natural conditions, their waters are poor in nutrients, slightly acid and have low electric conductivity (up to 10µS/cm). Because of the shallow, small size and usually shadowed streams, the water temperature remains between 17 and 20°C (Padovesi-Fonseca, 2005). In hotter streams, temperature may reach 25°C during the summer. The dense riparian vegetation cover prevents the direct sunrays incidence, reducing the primary productivity performed by the aquatic vegetation. Scarce light associated with low current and few nutrients limit the aquatic organisms' development, especially of the floating ones, influencing the whole food web. On the other hand, the presence of riparian vegetation regulates excessive water heating, supplies the allochthonous energy by leaves, fruits and seeds for the water system, and furnishes the environmental conditions for reproduction of several species. Allochthonous items, such as vegetal rests and other organisms, are additional feeding sources for the lotic system, linking and broadening the food web. The species present in those regions play an important role in the study of biodiversity, once that many of them occur under distinct environmental conditions, possibly becoming endemic in the Cerrado region (Schneider et al., 2011).

Currently, in many areas, the riparian vegetation is rather altered or even inexistent; due to the frequency it has been replaced by grasses. Margins erosion, water courses silting, pollution and water contamination are the main consequences of the indiscriminate anthropic usage of the drainage basins. Moreover, the mining activities, domestic sewage inflow and the pesticide use in agriculture are the major causes of the water degradation and loss of Cerrado's aquatic biodiversity (De Marco et al., 2014).

About 45,000 km^2 of the Cerrado are fallow lands, where soil erosion can be as high as 130 tons/ha/year (Klink & Machado, 2005). Agricultural practices at the region include extensive use of fertilizers and lime (Mueller, 2003), which pollute streams and rivers. By 1998, 49% of the Tocantins river basin had been converted to crop lands and pastures, increasing river discharge by 24% (Costa et al., 2003). The widespread and illegal clearing of riparian forests reduces the freshwater supplies for urban areas (Mueller, 2003).

The core of Cerrado Domain has countless number of lakes and natural lagoons formed by the upwelling of the groundwater. These standing waters tend to have well defined shapes and depths. Their physical and chemical characteristics reflect the hydrographic basin conditions, such as soil type, relief and geology (Fonseca et al., 2014).

Lakes are transitory elements in the landscape, once they appear and disappear along the geologic time. Their short life term is associated with various phenomena, like sediments and affluent inputs on the drainage basin, and the accumulation of materials in its bottom (Beuchle et al., 2015).

Lagoons are shallow lakes usually with transparent waters. As sunlight can reach their bottom, they are well illuminated and with a plenty of aquatic plants in their margins and bottom. The colonization by these plants represents a sort of environmental heterogeneity, affecting the lagoon`s metabolism (Pompêo & Moschini-Carlos, 2003) and enlarging the ecological groups and the local biodiversity living in this area.

This vegetal amount has an ecological relationship with lagoon aquatic flora and fauna. Areas with macrophyte species represent important refuges, nursery and feeding habitats for aquatic organisms, with the food availability and structural complexity providingthe protection and microhabitats diversity (Sánchez-Botero et al., 2007). They also reduce the winds action and maintain the water condition. Nutrients present in the lagoons' sediment can be absorbed by the roots, and become available for the plant. Vegetal decomposition delivers nutrients that can be reused, and aquatic macrophytes can become the main producers of the lagoon`s organic matter. The habitat structural complexity and its implications for community structure and food web dynamics were discussed by Warfe & Barmuta (2006).

Lagoons tend to become shallower during the dry season and, in the rainy season, their water level fluctuates according to the precipitation regime. During the rainy season, many of them can present turbid waters due to sediments input from the surrounding soil or from water veins originated in the headwaters (Bleich et al., 2009). Several studies showed the influence of precipitation regime, especially during long dry period, on the nutrients and the biota, with the generation of spatial variability from the water quality properties to primary producers (e.g. Odebrecht et al., 2005).

Many of these lagoons are situated in elevated and protected areas, and, part of them is still unknown by the population or even by scientists.

When located in high places and within watersheds, they can act as ecological corridors interlinking the flora and fauna of contiguous basins. These areas are, in general, the shelter of endemic and endangered species, revealing a huge genetic patrimony (Padovesi-Fonseca, 2008). Even situated in preserved areas, some lagoons are already altered due to human settling and agriculture expansion.

The vegetation development is conditioned by several factors such as the soil type and fertility, the level of soil's saturation during the dry season, depth and fluctuation of the groundwater volume. In high and well drained areas, the vegetal cover is a typical "Cerrado", composed by a mixing of grasses, shrubs and small trees. In lower areas, where the soil is saturated, the vegetal cover is usually grass species, different from the Cerrado ones. And, in the humid highlands, the vegetation is formed by Buritis (*Mauritia vinifera* Mart.) trees, typical of the region (Padovesi-Fonseca, 2005).

The "veredas" are very common vegetation formations of the Central Brazilian Plateau which occur in permanently water saturated soils. It has a dense ground-line vegetal layer formed by swamp herbaceous species that live in puddles, such as grasses, Cyperaceae and Pteridophyta. In the other strata of the vereda, there is a strip of buritis, prominent palms that occasionally can reach more than 20 m high. This formation is ecologically important, once it works as landing, resting, sheltering, nestling and feeding place for birds, serving as well as food source for the terrestrial and aquatic fauna. For birds, veredas have been poorly used by Cerrado's endemic species, but are the major habitat requirement of several species, as revised by Tubelis (2004). Thus, this vegetation is an important ecosystem to the regional biodiversity, requesting efforts to its conservation.

Swamp grasslands are widely distributed in central Brazil. They occur on valley's sloping grounds along the margins of the gallery vegetation. The groundwater remains at the soil's surface during the whole year, especially in the rainy season, and, in the dry season, it keeps the subsurface layers soaked. This vegetation is composed mainly by grasses of herbaceous strata, and exhibits a highly organic and spongy soil (not peat-turf like). Surface and deeper groundwaters tend to be slightly acid (about pH = 5), poor in ions (electric conductivity below 10 μS/cm), have lower temperatures (up to22°C) and enough oxygen. Such marches contain poorly drained hydromorphic soils, as discussed by Haridasan (2008).

Swamp grasslands are situated between gallery forest and the closed grasslands or veredas. The Graminea and reed species composition in humid grassland is diversified and exhibits a spatial zoning (Goldsmith, 1974), where in less soaked areas, it is possible to find marsh plants of *Drosera* L. (Caryophyllales Droseraceae) carnivorous plant, *Sphagnum* L. (Sphagnales Sphagnaceae) peat moss, and *Utricularia* L. (Scrophulariales Lentibulariaceae) carnivorous plant, and in water saturated places, complex filaments algae develop on the soil surface (Amaral et al., 2013).

Inside the swamp grasslands, areas with elevated and exposed soils are called"murundus". The murundus are round shaped and slightly high ranges from 1 to 10 m in diameter and up to two meters in height (Oliveira-Filho, 1992). They are formed by differentiated ground erosion and, more often, are colonized by termites (Goldsmith, 1974).

According to Furley (1986), two situations contribute to murundus formation: one is by the upwelling of the groundwater that remains close to the surface, keeping the generally organic soil soaked in the valley's lower lands. The other possibility is by the seasonal rainfall cycling and water surface runoff, which is more uncommon, but occurs in flatter areas.

The murundus present in clean areas have a discontinuous spatial arrangement along a longitudinal axis that somehow affects the aquatic organisms' abundance and distribution. In a hillside flush marsh near to Brasilia, capital of Brazil, it was recorded an endemic Copepoda species at a Cerrado area, registered as *Murunducaris juneae* Reid, 1994 (Reid, 1993; 1994; Corgosinho et al., 2008, and references). The murundus are widespread in the central Brazil highlands (Reid, 1993) as well as in other areas of Cerrado Domain, but studies in such areas are still needed to improve the knowledge of the abiotic and biotic systems of the Brazilian savanna.

Aquatic biodiversity

The high degree of endemism of the Cerrado's biota is already acknowledged, with an exceptional biological richness, holding five percent of the planet's known biodiversity (Oliveira & Marquis, 2002). For that reason, it is considered a world hotspot, and one of the richest and endangered biomes on earth. The most important areas for biological preservation are situated along the Brazilian Cerrado central axis (MMA, 2007).

A review done by Agostinho et al. (2005) concerning to species diversity and threatened species revealed the difficulty to have a more precise number of the inland aquatic species of Brazil. This literature survey produced 217 results from 1990 to 2004, whereas the present study had 308 results from 2004 to 2012. The results obtained by these two surveys showed two main issues: the lack of data of Brazilian biodiversity and the tendency to produce similar results, in Brazil or Cerrado surveys, although from different periods. Among the 308 researches for Cerrado, only four percent referred to freshwater organisms; while Agostinho et al. (2005) found 11%.

As the not published academic theses were investigated, they revealed a predominance of studies related to aquatic macroinvertebrates (about 40%), followed by phytoplankton and zooplankton (15%). Researches including fish and aquatic macrophyte species reached only six percent of the explored theses (Fig. 1).

The Brazilian savanna richness is estimated in 9,580 species (MMA, 2002; 2004) and, as argued by Agostinho et al. (2005), the number of aquatic species in its inland waters is irregular due to the lack of basic requirements for the production of realistic inventories. The estimated number of species in the Brazilian and Cerrado inland waters is represented in Table 1.

At least 22.8% of fish species in Brazil are expected to occur in Brazilian savanna, as well as 25.2% of bivalve mollusks, and 41.9% of the diatom algae. The endemism is considerably elevated for some groups at the Cerrado, reaching 25% for fishes and more than 10% for bivalves and diatoms (Table 1).

In consideration to the high biodiversity that the Cerrado biome presents, especially for the aquatic biota, the fish diversity is rather expressive. Estimations indicate the occurrence of almost 3,500 fish species in South America, with more than 800 being found in the Cerrado Domain. This estimate can even reach higher values since about 30 to 40% of Brazilian freshwater species are still unknown (Agostinho et al., 2005). Such information highlights the native species composition, including the migratory fishes, of the ichthyofauna presented in the hydrographic regions of the central Brazil (Langeani et al., 2007).

Taking into account the potential endemism and the number of endangered fish species in this region, it is necessary to expand the knowledge on this fauna, especially at the headwaters. A study

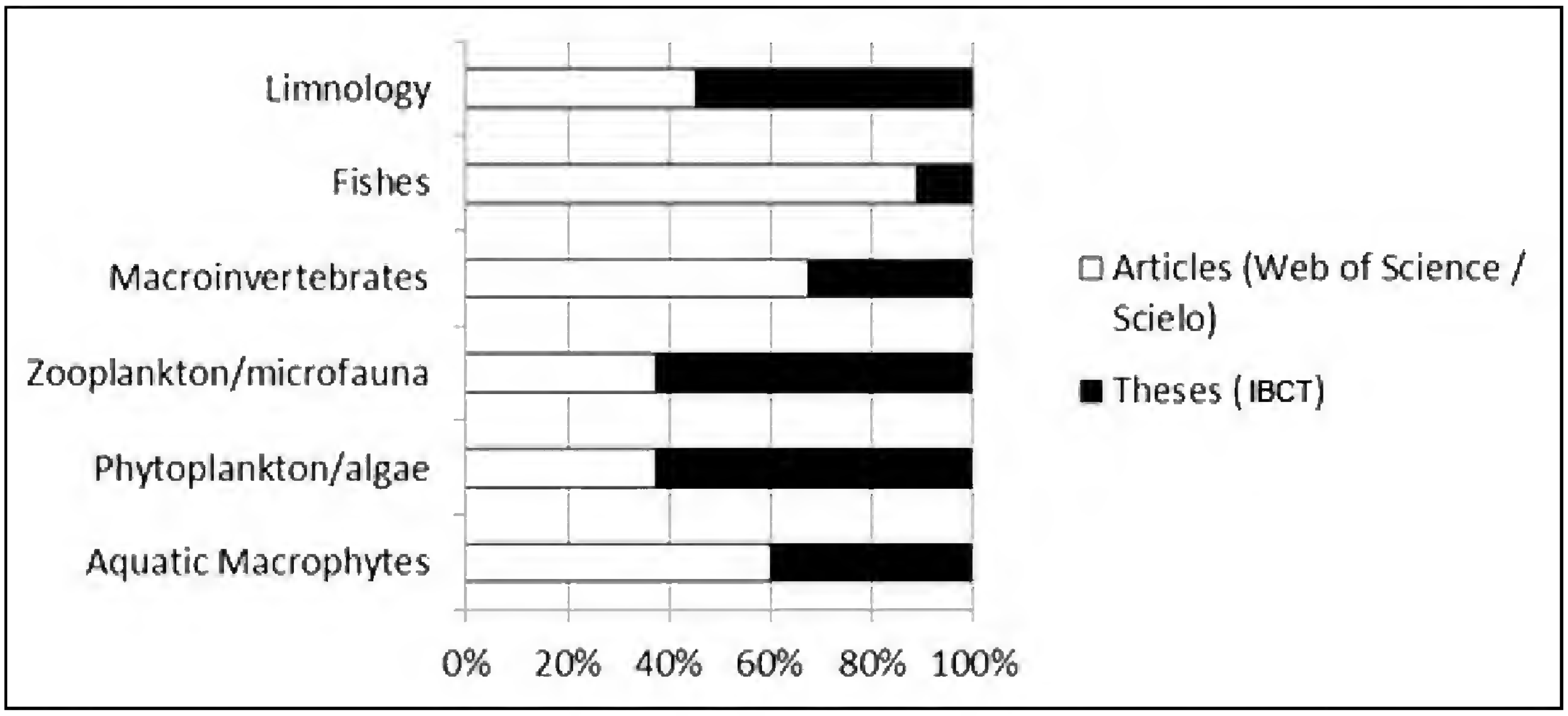

Figure 1. Potential increase of aquatic biodiversity in Cerrado Domain, Brazil.

TAXA	CERRADO [a]	CERRADO (endemic spp) (10–25%)[b]	BRAZIL	References
Macrophytes	100-300**	10–75	500–600	Pott et al., 2011**; Agostinho et al., 2005
Algae total	2,500	250–625	10,000	MMA,2003
Bacillariophyta (diatoms)	503**	51–126	1,000–1,200	Silva et al., 2011**; Lewinsohn & Prado, 2005
Chlorophyta	563**	53–141	2,500–3,500	Freitas & Loverde-Oliveira, 2013**; Lewinsohn & Prado, 2005
Cyanobacteria	115	12–29	460	Sant'Anna et al., 2011
Protozoa (Sarcodina)	400	40–100	550	MMA, 1999
Protozoa (Ciliate)	1,500	150–375	= 1,500	MMA, 1999
Platyhelminthes (Cestoda)	30	3–8	120	Rego, 2004
Mollusca (Bivalvia)	29	3–8	115	MMA, 2003; Agostinho et al., 2005
Mollusca (Gastropoda)	48	5–12	193	MMA, 2003; Agostinho et al., 2005
Rotifera	137	19	457	MMA, 2003
Arthropoda (Acari)	83	8–21	332	MMA, 2003; Agostinho et al., 2005
Crustacea (Copepoda)	31	3–8	273 + 36** Total: 309	MMA, 2003; Previatelli et al., 2013**
Crustacea (Cladocera)	56**	6–14	153	Sousa & Elmoor-Loureiro, 2012; MMA, 2003;
Insecta (Ephemeroptera)	52	–	166	Salles et al., 2004
Insecta (Chironomidae)	47	5–12	379	Mendes, 2014
Insecta (Odonata)	67**	7–17	800	Galvão et al., 2014**; Paulson, 2014
Insecta (Plecoptera)	28	–	110	MMA, 2003; Agostinho et al., 2005
Insecta (Trichoptera)	219–230**[1]	22–55	625 + 29**[2] Total: 406	Paprocki & França, 2014; Santos et al., 2014 **[1]; Dumas et al., 2010**[2]
Pisces	800	200 (25%)	3,500	MMA, 2003; Agostinho et
Amphibia	113	32	687	MMA, 2002; Lewinsohn & Prado, 2005

Table 1. Estimated number of species in freshwater environments in Cerrado (brazilianSavanna) and Brazil, a: estimated number corresponded to 25% registered for Brazil; b: estimated number corresponded to 10-25% registered for Cerrado; **number registered by reference coupled for the taxon.

conducted in the headwater of the Paraná basin region, in the Brasilia National Park, central Brazil, detected 14 new fish species, all of them endemic in the area (Aquino et al., 2009).

The Protozoa is the less known group of the Cerrados's aquatic invertebrates and studies dealing with its importance in the aquatic ecosystems functioning, particularly as an additional link in the food web, and the use of special techniques (expensive in most of the time) for sampling and identification, are really necessary, although the high cost may somehow limit the study (MMA, 2003; Agostinho et al., 2005),

Within Protozoa, Flagellates are the organisms with the grater lack of data, and their diversity cannot even be estimated. Among Sarcodine, the *Thecamoeba* is well studied and its richness is estimated in about 400 species for the Brazilian savanna. Nevertheless, in recent studies, about 20 genera and 150 *Thecamoeba* species were identified (MMA, 2003). The Ciliates, however, are the most expressive members of the Protozoa in terms of species richness, besides being useful as bioindicators for water quality evaluation. From the 8,000 species described around the world, 1,500 are estimated to occur in the Cerrado biome.

In relation to aquatic microinvertebrates besides Protozoa, representatives of Rotifera and microcrustaceans (Cladocera and Copepoda) must be mentioned. A great amount of rotifer species is widely distributed, and they are present in almost all kinds of freshwater habitats. From the 457 Brazilian known species, at least 30% are found in the Cerrado's freshwater environments, where nearly four percent are likely endemic. Copepoda and Cladocera are the mainly groups of freshwater microcrustaceans, with an estimation of almost 100 species, but this number is expected to increase by the registration of new species (Elmoor-Loureiro et al., 2004; Elmoor-Loureiro, 2007; Sousa & Elmoor-Loureiro, 2008). The endemism degree of these groups is high, and when associated to the scarce data for the Cerrado Domain, inserts the possibility of the biodiversity to increase for the area and for the country.

Benthic macroinvertebrates community is composed by several groups that live in the substrates and sediments of the water bodies, such as annelids, molluscs and aquatic insects, with the majority of the studies on the region focusing on aquatic insects. Some research conducted in several streams of central Brazil revealed a wide fauna, with different taxonomic levels, but with only a few organisms identified as species, probably due to the difficulty of the taxonomic identification in some groups (Bispo et al., 2006; Martins-Silva, 2007; Martins-Silva et al., 2008). Therefore, the Cerrado's benthonic fauna composition has a generalized configuration, and shows an increasing perspective of the biodiversity records at the area.

The Cerrado's aquatic flora, which covers macrophytes, phytoplankton and periphyton, has been evaluated in natural environments, but the aquatic assemblages are still poorly documented by the published articles. A rich microflora composed by Desmidiaceae algae was registered at Lagoa Bonita, a lagoon situated in a permanent preserved area of Distrito Federal, central Brazil (Souza et al., 2008 and references). An increase of algae diversity in a periphyton community associated to aquatic macrophytes was also noted in a lotic environment at the Roncador stream, situated in the IBGE Ecological Reserve (Distrito Federal), where it was recorded 171 taxa (Mendonça-Galvão, 2002). Along the Descoberto River, sixteen taxa were registered, with their majority classified as first occurrence in the Distrito Federal and Goiás state (Delgado & Souza, 2007).

Despite such few studies, the high biodiversity of the natural aquatic ecosystems in Cerrado is perceived as requiring more efforts and contributions for researches in the region (Silva et al., 2011). From the 38 studies carried out over almost 30 years, only 19 were published in periodicals. However, sixty-four genera and 503 species of diatoms were catalogued based on these researches.

The existence of wetlands in the Cerrado increases the inventory of aquatic species in the country. The aquatic community that develops in the central Brazilian wetlands is quite unknown; nevertheless, studies conducted in this region detected a rather expressive biological diversity, with some endemic species. Benthonic invertebrates are numerous and the fishes have small size. The fish *Cynolebias boitonei*, Carvalho, 1959, named pirá-brasília, is endemic and endangered in the veredas of Distrito Federal (Aquino et al., 2009). Because of its beauty, the species is used as ornamental fish, raising its demand by aquarists and worsening the species situation in relation to its conservation.

Macrophytes species have been also related to high levels of biodiversity and endemism. As observed by Pott et al. (2011), the number of species collected in the upper watershed of Paraná basin is two times bigger than the one found in the Pantanal, reaching at least 574 species.

In relation to algae species, their high variety with new species in the Cerrado inland waters was mentioned by Senna & Ferreira (1986; 1987), Padovesi-Fonseca & Adamo (2007) and Souza et al. (2008). In a humid grassland habitat, Reid (1982; 1984; 1987; 1993) described a community composed by nematodes, rotifers, Harpacticoida copepods, Protozoa, Turbellaria, Cyclopoida copepods, Cladocera, Ostracoda, Oligochaeta, Hydrocarina and larvae of many families of insects. At least ten Copepoda species were registered for the first time and identified as endemic species for the region.

Therefore, due to the scarce number of studies on various aquatic groups in the central Brazil, the support for new researches is essential, as well as the recognition of the inland waters of Cerrado as a priority on the aquatic biodiversity conservation.

The potential increase of aquatic biodiversity

The Cerrado Domain has a great heterogeneity of aquatic environments across a high altitude landscape. Its nuclear region represents a basin divisor, with spring's profusion, infinite network of small lotic ecosystems, lakes and wetlands formed by the upwelling of groundwater. There, the water courses transit between mountains and rocky cliffs exhibiting shallow and narrow bodies, with backwater areas and small pools formations alternated by fast-current rivers and waterfalls along its course.

The Cerrado's core region involves an area of headwaters and watersheds of the main hydrographic basins of the country, playing an important role in the biological diversity. Brazil owns a significant portion of the world's rivers runoff and the elevated level of endemism for Cerrado's aquatic species reaffirms the importance of the conservation of inland waters in the Brazilian savanna.

Connection areas between basins, comprehending their drainage headwaters, are endemism nucleus for freshwater species, representing one of the aquatic biodiversity conservation priority areas (MMA, 2007). Streams originated in this region naturally flow towards the basins, most of the time forming ecological corridors for many aquatic species. Depending on the species adaptation capacity, and their ability of stabilizing in other regions, the Cerrado's waters can represent dispersion paths for aquatic species. Thus, the core area is indispensable for the preservation of aquatic diversity and its genetic inheritance. Moreover, this necessity is imminent once that less than 0.5% of the Cerrado is covered by truly aquatic conservation areas (MMA, 2007).

Hydrogeological variations along these courses form distinct environments and create degrees of isolation, which affect the distribution of aquatic biota. The geological events had a historical influence on the formation of inland waters in central Brazil, causing the predomination of small aquatic environments, as streams, pools and lakes, and affecting the species distribution. The highest proportion of fish biodiversity in the Neotropical region was registered in the streams' headwaters and lagoons of Cerrado (Langeani et al., 2007).

The potential increase of aquatic biodiversity in Cerrado has also been reported for wetlands as a result of environmental heterogeneity, which enables a higher biodiversity (Leibowitz, 2003), especially in protected areas with a pristine condition. This potential encompasses species from a variety of taxonomic groups, as algae, protozoa, invertebrates, vertebrates and many plant species. However, for instance, this tendency was observed only for microcrustacean fauna as argued by Reid (1982; 1984; 1987; 1993). Phytophilous cladocerans, for example, have been evaluated in several wetlands areas distributed in central Brazil, and more than a half of them were classified as new or endemic species (Elmoor-Loureiro, 2007; Sousa & Elmoor-Loureiro, 2008; Sousa et al., 2013).

Pristine areas as reference for biological analyses

Aquatic species have been used as biological indicators because of their sensitivity and rapid response to subtle changes caused by anthropic or natural impacts. Benthonic macroinvertebrates and fishes have been broadly used in biological analyses due to the particular characteristics of these aquatic assemblages.

Benthonic macroinvertebrates show a wide spatial distribution and, in general, restrict limits of tolerance to environmental variables alterations (Lampert & Sommer, 2007), and each species or functional group have specific tolerances, according to their sensitivity to pollution (Metcalfe,1989). Moreover, their sedentary life and high longevity facilitate the analysis of temporal changes in response to environmental perturbations.

As biological indicator, benthic invertebrates reinforce the relevance of pristine areas in Cerrado as a reference of environmental condition. In these areas, the water courses are protected by gallery vegetation and the large allochthonous matter comes from the forest, allowing the predomination of specific groups (Couceiro et al., 2009).

The preservation of the gallery vegetation provides environmental heterogeneity in the lotic systems, and when associated with natural disturbances, such as droughts and floods, are important factors for the potential increase of benthic macroinvertebrates diversity (Bunn & Davies, 1992).

Fishes of Brazilian streams are highly endemic (Langeani et al., 2007) and little resistant to habitat degradation and other anthropic modifications (Araújo et al., 2003), which enables their use as bioindicators of environmental quality (Karr, 1981).

The Cerrado's natural landscape, as a whole, was very impacted by anthropic activities, but many efforts are still possible in favour of the preservation of reminiscent habitats. In this context, surveys on the Cerrado's fauna and flora are fundamental for future regional research, and indispensable for the creation and management of protected areas.

CONCLUSIONS

Even when the Cerrado has been considered one of the most biodiverse and threatened biomes of the world, little attention has been paid to the conservation of its natural aquatic ecosystems and biota. The high endemism detected in the Cerrado and the ignorance on its aquatic environments, reveal important gaps that hind the evaluation of the aquatic ecosystems, once that, nowadays, the defined areas for conservation rarely include them. This situation can be associated to the widely accepted idea that, once the terrestrial environments are protected, so are the aquatic ones, as discussed by Padovesi-Fonseca (2005).

When considering the Cerrado`s biome broadness and potential high biodiversity, the aquatic flora and fauna must be evaluated and visualized as essential tools for the region's environmental conservation. One of the relevant aspects concerning aquatic environments conservation is the lack of data on the Cerrado's pristine systems. These areas, besides being an important biodiversity source as indicated by this review, can also become a reference for the recover and restoration of degraded habitats.

The springs and wetlands profusion attests that water is an abundant source in the Cerrado region. However, human settlements in the spring's area can result in serious problems due to the low rate of replenishment and the use of groundwater as a water source. The good quality water withdraws for different uses by the industries and population is a main challenge today. Water is a high value resource, with potential uses such as power generation, domestic and industrial supplies, navigation, irrigation, recreation, farming and fishing, among others. As a result, many springs and natural lakes have been drained (Hunke et al., 2014).

In this context, it is evident the necessity of intensifying efforts devoted to the study of these regional peculiar ecosystems, as well as their biodiversity and aquatic species biology and ecology. Such purposes would guarantee the theoretical basement for the preservation and sustainable use of water sources by the current and future generations.

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Genetic diversity of *Typha domingensis* Pers. (PoalesTyphaceae) and *Phragmites australis* (Cav.) Stued (Poales Poaceae) populations in lake Manzala coast and inland salines at Suez Canal region (Egypt) in relation to some ecological variables

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ABSTRACT *Typha domingensis* Pers. (Poales Typhaceae) and *Phragmites australis* (Cav.) Stued (Poales Poaceae) are important wetland plants, valuable in remediation of wetland environment from heavy metals; moreover they can be used in biofuel production. Determination of genetic diversity in their natural populations is important for species conservation and ecological restoration. The present study compared the genetic variability of four populations of *T. domingensis* and *P. australis* growing in Manzala lake coast and inland swamps in Ismailia and Sinai by using random amplified polymorphic DNA (RAPD) technique. Nine primers generated a total of 175 RAPD bands (loci) of which 127 (72.57%) were polymorphic across all individuals of the two species. At Manzala lake coast (i.e. sites 3 and 4, contaminated sites), the genetic diversity measures (PPL%, I, h, N_a, N_e) observed in the populations of the two species showed higher diversity in comparison to the less contaminated sites 1 and 2 (Ismailia and Sinai). Gene diversity within populations (h_S) and total gene diversity (h_T) at species level were lower in *P. australis* (0.0104, 0.0579) than in *T. domingensis* (0.0825, 0.1284). This study revealed also the presence of a significant correlation between genetic diversity measures of *T. domingensis* and *P. australis* with some edaphic variables and heavy metal concentration in soil of the studied sites and leaves of the two species. The previous correlation indicated that populations from sites 3 and 4 respond with increased genetic variation, resulting possibly from new mutations affecting allele frequencies, as a consequence of adaptation to changes or disturbances in the environment. This may indicate that increased diversity levels may act as a buffer to severe heavy metal stress, which explains the importance of monitoring the genetic diversity of *T. domingensis* and *P. australis* populations in detecting trends that should alert ecologists to potential problems.

KEY WORDS Genetic diversity; RAPD; environmental factors; Manzala; Sinai.

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INTRODUCTION

Typha domingensis Pers. and *Phragmites australis* (Cav.) Stued species form a major component of wetland ecosystems in many parts of the world, including littoral zones of lakes, along rivers and irrigation/drainage canals, shallow fresh water swamps and anthropogenic habitats where soil is periodically flooded (road side ditches, fields, stormwater retention basin). The geographical distribution of the two species extends from cold temperate regions to the tropics (Good, 1974; den Hartog et al., 1989).

In Egypt, *T. domingensis* and *P. australis* species are usually distributed throughout the running water of the main River Nile streams and its branches, irrigation and drainage canals as well as in the still water of some specific habitats like fresh water swamps and salt marshes (Serag et al., 1999). The two species are used by farmers (in Egypt and many other parts of the world) from ancient periods, for roofing, fencing and baskets manufacture. Ecologically, wetland plants are important for oxygen production, nutrient cycling, control of water quality, sediment stabilization and shelter for aquatic organisms and wildlife (Mohan & Hosetti, 1999).

Wetland plants are potentially studied as "biomonitors" that accumulate contaminants in their tissues and therefore may be analyzed to identify the abundances and bioavailability of such contaminants in aquatic environments. Therefore, the use of *T. domingensis* and *P. australis* appears to be particularly promising as they can accumulate heavy metals from sediments and water (Zurayk et al., 2001). Recently, Abideen et al. (2011) explored wetlands for its potential as lignocellulosic biomass of "good" quality for bioethanol production.

The main threats facing the management of wetland plants are due to the fact that its habitats are subjected to greater stress from various human activities. As a result, large quantities of organic and inorganic materials were introduced into these ecosystems (Zurayk et al., 2001). Understanding the effects of the environmental contaminants on the plant genome is crucial for preserving the evolutionary potential of natural populations, as genetic diversity provides potential to adapt to environmental changes (Bourret et al., 2008). Many chemical contaminants have been demonstrated to induce genetic mutations and therefore affect the genetic structure of populations (Hoffmann & Willi, 2008). The toxicity of different pollutants and their physical disturbance can influence plant survival, recruitment, reproductive success, mutation rates, and even migration and consequently affect the genetic diversity of exposed populations (Deng et al., 2007).

In the last few years, the field of molecular biology has provided new tools for studying population structure and genetic diversity in wetland species. For example, cattain (*Typha* L.) and cordgrass (*Spartina* Schreb.) were studied for the first time, using allozyme polymorphism (McNaughton 1975; Silander, 1985; Raybould et al., 1991). Since the 1980s new perspectives in how to study population dynamics in common reed became available with the development of molecular markers (Jackson et al., 1985; de Kroon & van Groendael, 1997). One of the most efficient molecular marker methods in terms of ability to produce polymorphic markers within a comparatively short time and with a limited budget is RAPD (random amplified polymorphic DNA). Since its introduction by Williams et al. (1990), RAPD has become widely used in various areas of plant research. Therefore, the aims of the present study are to: 1) determine habitat characteristics, 2) assess heavy metals accumulation in the leaves of *T. domingensis* and *P. australis*; and 3) describe these plants genetics using random amplified polymorphic DNA (RAPD), focusing on their genetic diversity and genetic differentiation. This study provides some molecular information to understand the genetic background to support the formulation of effective measures for genetic resources characterization, genetic improvement and sustainable utilization of these species.

MATERIAL AND METHODS

Plant populations

A total of 40 accessions of *T. domingensis* and 40 accessions of *P. australis* were used in this study. Soil samples and leaves were collected from four populations (see Table 1), namely two populations in the Manzala coastal land (indicated as Manzala lake 1, elgameel and Manzala lake 2, Bahr kuwar), one from the saline in Ismailia (gate of the industrial zone) and one from salt marshes in Sinai, at the east bank of Suez Canal (New Meet Abu elkom village).

Soil analysis

Three soil samples were collected from each stand at a depth of 0-50 cm, mixed, air-dried and passed through a 2-mm sieve for physical and chemical analyses. Soil texture was determined by the use of Bouyoucos hydrometer; organic matter content was determined by Walkely and Black rapid titration method. Calcium carbonate content was estimated in the dry soil samples using Collins Calcimeter. Soil-water extracts (1:5) were used for the estimation of soil salinity (EC) using conductivity meter, soil reaction (pH) was determined using pH-meter, soluble carbonates (CO3^{--}) and bicarbonates (HCO3^{-}) by titration against standard H_2SO_4 using methyl orange and phenol- phenolphthalein as indicators, chlorides (Cl^-) by direct titration against standard $AgNO_3$ solution using K_2CrO_4 as an indicator, calcium and magnesium were estimated by Versene (EDTA) method. Sodium and potassium were determined using a flame photometer. All these procedures were according to Chapman & Pratt (1961), Jackson (1973), Allen et al. (1974), and Baruah & Barthakur (1997).

Heavy metals (Cd, Cr, Mn, Ni, Pb, Co, Cu and Fe) in soil samples were analyzed by the total sorbed metals method according to USEPA (1986) using atomic spectrophotometer. Leaves of *Typha domingensis* and *Phragmites australis* were collected at the four sites for heavy metals (Cd, Cr, Mn, Ni, Pb, Co, Cu and Fe) analysis using Perkin Elmer Atomic Absorption Spectrophotometer (model PYEUNICAM SP9, England) according to Allen et al. (1974). Soil characteristics supporting the four study populations and heavy metal measurements in leaves are shown in Tables 2 and 3.

DNA analysis

Fresh leaves of plants were collected and total genomic DNA was extracted using Wizard genomic DNA extraction kit promega (USA). 10- to 21-mer arbitrary primers were used for RAPD analysis.

Nine primers were screened for their amplification (Table 4). PCR amplification was performed in total volume of 25 µl containing 10× reaction buffer, 2.5 mM dNTPs, 5 mM $MgCl_2$, 10 pmol/reaction primer, 100 ng of genomic DNA and (0.5 U/ µl) of Taq polymerase (promega, Germany) in Thermocycler Gene Amp 9700 (Applied Biosystems (ABI), USA). After a denaturation step for 5 min at 95°C, amplification reactions were carried out for 40 cycles. Each cycle comprised of 1 min at 95°C, 1 min of annealing temperature ranging from 28 to 30°C and 1 min at 72°C. The final elongation step was extended to 10 min.

Population	**Population site**	**Longitude (N)**	**Latitude (E)**	**Elevation (m)**
1	Industerial zone, Ismailia	30°34' 20.43"	32°11' 51.04"	15.41
2	New Meet abou elkom, Sinai	30° 23' 57"	32°26 ' 6.28"	13.45
3	Manzala lake 1, elgameel	31°17' 12.42"	32°12' 42.79"	9.92
4	Manzala lake 2, Bahr kuwar	31°15' 43.57"	32°13' 12.16"	8.69

Table 1. Location of the collection sites of the four study populations of *Typha domingensis* and *Phragmites australis* and their respective geographic coordinates in Egypt.

Soil factor	**(1) Elelwi bridge Ismailia**	**(2) New Meet Abu elkom village**	**(3) Manzala lake, elgameel**	**(4) Manzala lake 2, Bahr kuwar**
Sand (%)	81	77	83	83
Silt (%)	2.6	4.6	2.6	2.6
Clay(%)	16.4	18.4	14.4	14.4
pH	10.3	9.52	8.71	8.55
$CaCO_3$ (%)	4.34	2.6	6.08	4.34
CO_3^{--}(ppm)	26.4	4.8	-	-
HCO3^{-} (ppm)	2.44	21.96	29.28	12.2
O.M. (%)	0.68	0.37	0.71	0.37
EC (ms/cm)	5.29	22.3	2.56	1.96
Cl^- (ppm)	798.8	816.5	106.5	30
Ca^{++} (mg/100 gm)	390	330	370	500
Mg^{++} (mg/100 g)	44.6	39.6	32	17.6
Na^+ (mg/100 gm)	390	670	120	50
K^+ (mg/100 gm)	14.4	17.2	15.6	15.6
P (mg/100gm	2.3	1.2	1.5	2.5
Fe (ppm)	23.2	9.7	21.1	19.4
Zn (ppm)	14	5	5.9	9.6
Ni (ppm)	18.7	15.4	8.8	5.5
Pb (ppm)	24	34	20	26
Cd (ppm)	0.07	0.28	0.35	0.42
Co (ppm)	0.9	3	1.8	4.2

Table 2. Characteristics of soil supporting the studied populations of *Typha domingensis* and *Phragmites australis*.

	SITE 1		SITE 2		SITE 3		SITE 4	
Metal conc	*P. aus*	*T. dom*	*P. aus*	*T. dom*	*P. aus*	*T. dom*	*P. aus*	*T. dom*
Ni (ppm)	22	27.5	44	38.5	49.5	88	55	71.5
Pb (ppm)	90	60	130	70	80	90	40	10
Cd (ppm)	6.7	4.9	7	6.3	6.7	6	5.6	7.6
Co (ppm)	1.5	1.5	0	0	1.5	15	13.5	22.5
Fe (ppm)	194.4	183.6	156.6	135	200	405	43.2	283.5
Zn (ppm)	30.6	32.9	26.6	23.9	21.6	30.9	29.7	20.3

Table 3. Heavy metal concentration in the leaves of *Typha domingensis* and *Phragmites australis*.

Amplification products were separated on agarose gel electrophoresis using 1.5% (w/v) agarose in 0.5× TBE buffer, stained with ethidium bromide and photographed by using gel documentation system. Amplification products were analysed by a 100 to 1000 bp molecular weight marker.

Statistical analysis

RAPD bands were scored as binary presence (1) or absence (0) characters to assemble the matrix of the RAPD data. Then, the indices of genetic diversity, such as percentage of polymorphic loci (PPL), observed number of alleles (N_a), number of effective alleles (N_e), Nei's gene diversity (h), Shanon information index (I), the coefficient for gene divergence (G_{st}) and gene flow (N_m), and Hierarchical analysis of molecular variance (AMOVA) within and among populations were estimated using allele frequencies, by POPGENE 3.2 software (Yeh et al., 1999) GenAlEx version 6.4 (Peakall & Smouse, 2006).

The Pearson correlation between the genetic diversity index within population and ecological factors was analyzed using the SPSS 17 software.

RESULTS

Nine primers produced a total of 175 RAPD bands (loci), among which 127 were polymorphic. The number of bands per primer varied from 5 to 39 with an average of 19.44. The average proportion of polymorphic markers across primers was 72.57%, ranging between 53.85% (UBC76) and 100% (UBC1) (Table 4), and these primers produced fragments ranging from 142 to 2066 bp in size.

The genetic diversity parameters (PPL%, I, h, N_a, N_e) among populations of *T. domingensis* showed higher values than *P. australis* at mean population level. In *T. domingensis*, PPL= 17.285%, I= 0.116, h= 0.082, N_a= 0.346, N_e= 1.159, respectively. For *P. australis*, the means of genetic parameters were PPL= 7.285%, I= 0.048, h= 0.034, N_a= 0.146, N_e= 1.065, respectively.

It was found that the genetic parameters in the population of *T. domingensis* growing in Manzala lake elgameel reached the highest values (PPL = 19.43%, I = 0.129, h= 0.091, N_a = 0.389, N_e =1.173) whereas in the population of *P. australis* growing in New Meet abou elkom, Sinai, attained the lowest (PPL = 2.86%, I = 0.018, h= 0.010 , N_a = 0.057, N_e =1.022) (Table 5).

Gene diversity within populatios (hs) and total gene diversity (h_T) at species level, were lower in *P. australis* (0.0104, 0.0579) compared to *T. domingensis* (0.0825, 0.1284). Low values of G_{st} were estimated at species level for *T. domingensis* (0.36) and *P. australis* (0.42). The estimate of gene flow Nm based on Gst for *T. domingensis* and *P. australis* populations was 0.8985 and 0.6946, respectively, which indicated that gene flow among populations was low (Table 6).

Soil and heavy metals analysis

Soil chemical and physical features are in Table 2. As shown, soil of site 1(Industrial zone, Ismailia) had the highest values of pH (10.3), CO_3 (26.4 ppm), Mg^{++} (44.6 mg/100 gm soil) and the lowest values of HCO_3^- (2.44 ppm). Soil of site 2 (New Meet abou elkom, Sinai) attained the highest values of silt (4.5%), clay (18.4%), EC (22.3 mm/cm, CL (816.5 ppm), Na^+ (670 mg/100 mg soil and K^+(17.2 mg/100 mg soil) but the lowest of sand (77%), $CaCO_3$ (2.6%) and Ca^{++} (330 mg/100 gm soil). Soil of site 3 (Manzala lake, elgameel) showed the highest values of sand (83%), $CaCo_3$ (6.08%),

Primer	Sequences of primer (5→ 3)	Total number of bands	Number of polymorphic bands	Percent of polymorphic bands %
UBC1	CCTTCGGCTC	5	5	100
UBC3	GGCTTGACCT	7	5	71.34
UBC6	GAAGGCGAGA	8	5	62.5
UBC9	GTCATGCGAC	16	15	93.75
UBC13	CCTGGCACAG	17	15	88.24
UBC16	CCAGACTCCA	30	22	73.33
UBC64	GAGGGCGGGA	39	30	76.92
UBC76	GAGCACCAGT	26	14	53.85
UBC77	GAGCACCAGG	27	16	59.26
	Total	175	127	
	Average	19.44	13.89	72.57

Table 4. Sequences of the nine primers used in this study.

Pop.	Species	Sample size	Polymorphic loci	Percentage population level (PPL%)	Observed number of alleles N_a	Number of effective alleles N_e	Shannon's index of diversity (I)	Nei's gene diversity (h)
1	*T. domingensis*	10	30	17.14	0.343	1.166	0.117	0.084
2	*T. domingensis*	10	26	14.86	0.297	1.137	0.100	0.070
3	*T. domingensis*	10	34	19.43	0.389	1.173	0.129	0.091
4	*T. domingensis*	10	31	17.71	0.354	1.161	0.118	0.084
	Mean	10	30.25	17.285	0.346	1.159	0.116	0.082
1	*P. australis*	10	10	5.71	0.114	1.052	0.038	0.027
2	*P. australis*	10	4	2.86	0.057	1.022	0.018	0.010
3	*P. australis*	10	23	13.14	0.263	1.126	0.090	0.064
4	*P. australis*	10	13	7.43	0.149	1.060	0.047	0.033
	Mean	10	12.5	7.285	0.146	1.065	0.048	0.034
	Overall mean		21.375	12.29	0.246	1.112	0.082	0.058

Table 5. Genetic diversity parameters in plant populations of *Typha domingensis* and *Phragmites australis*.

HCO_3^- (29.28) and O.M. (0.71%) and the lowest of pH (8.71). Soils of Manzala lake 2, Bahr kuwar had the highest values of Ca^{++} (500 mg/100 mg soil) and the lowest of Cl^- (30 ppm), Na^+ (50 mg/ 100 mg soil) and Mg^{++} (17.6 mg/100 mg soil).

Heavy metals (Iron, Zinc, Nickel, Lead, Cadmium and Cobalt) were recorded in high concentrations in all studied sites. The highest values of Iron and Zinc (23.2 ppm and 14 ppm) were recorded in site 1. Lead recorded the highest value (34 ppm) in site 2. The highest values of Cadmium (0.42 ppm) and Cobalt (4.2 ppm) were recorded in Site 4.

The estimate of heavy metals content in the leaves of *P. australis* and *T. domingensis* indicated the highest accumulation in the leaves of *T. domingensis*, Zn (32.9 ppm) in site 1, Ni (88 ppm) and Fe (405 ppm) in site 3, Cd (7.6 ppm) and Co (22.5 ppm) in site 4. On the other hand, *P. australis* showed the highest accumulation of Pb (130 ppm) in site 2 (Table 3).

Some combinations of soil and genetic diversity indices of *T. domingensis* and *P. australis* produced significant positive correlations, such as sand, $CaCO_3$ and O.M. with PPL%, N_a, N_e, h and I of the two species. On the other hand, Silt, Clay, pH, EC, Cl^-, Na^+ and K^+ produced significant negative correlations with PPL%, N_a, N_e, h and I of the two species also. Ca^{++} showed significant positive correlations with PPL%, (r = 0.36), N_a (r = 0.36), N_e (r = 0.38), h (r =0.39) and I (r= 0.38) of *T. domingensis*. Similarly, HCO_3^- produced significant positive correlations with PPL% (r = 0.48), N_a (r = 0.48), N_e (r = 0.49), h (r = 0.45) and I (r = 0.49) of *P. australis*.

Population group	h_s	h_T	N_m	G_{st}
T. domingensis	0.0825	0.1284	0.8985	0.3575
SD	0.0081	0.0174	-	-
P. australis	0.0104	0.0579	0.6946	0.4186
SD	0.0037	0.0104	-	-

Table 6. Genetic differentiation at species level of *Typha domingensis* and *Phragmites australis* study sites; h_S = Gene diversity within population, h_T = total gene diversity, N_m = estimate of gene flow, and G_{st} = coefficient of gene differentiation.

Correlations between some heavy metal concentrations in the soils of the studied sites and genetic diversity indices of *T. domingensis* and *P. australis* indicated that, Fe showed significant positive correlations with PPL%, N_a, N_e, h and I of the two species. On the other hand, Ni and Pb produced significant negative correlations with PPL%, N_a, N_e, h and I of the two species. Zn produced significant positive correlations with N_a (r =0.25) of *T. domingensis* and Cd produced significant positive correlations with PPL% (r = 0.39), N_a (r = 0.39), h (r = 0.36) and I (r = 0.36) of *P. australis* (Table 7) .

Correlations between some heavy metal concentrations in the leaves of *T. domingensis* and *P. australis* and genetic diversity parameters of both species showed that, Ni, Co and Fe produced significant positive correlations with PPL% (r = 0.76, 0.68 and 0.94 respectively), N_a (r = 0.76, 0.68 and 0.94 respectively), N_e (r = 0.51. 0.51and 0.77), h (r =0.63, 0.60 and 0.86 respectively) and I (r = 0.68, 0.63 and 0.89, respectively) of *T. domingensis*. Ni produced significant positive correlations with PPL% (r = 0.36), N_a (r = 0.37), and I (r= 0.33) of *P. australis*. On the other hand, Pb produced significant negative correlations with PPL% (r = -0.51), N_a (r = -0.51), N_e (r = -0.43), h (r = -0.43) and I (r = -0.49) of *P. australis*. Zinc demonstrated significant positive correlations with PPL% (r = 0.36), N_a (r = 0.37), N_e (r = 0.53), h (r =0.45) and I (r = 0.43) of *T. domingensis* and significant negative correlations with PPL% (r = -0. 67), N_a (r =- 0.67), N_e (r = -0.7), h (r =-0.66) and I (r = -0.68) of *P. australis* (Table 8).

DISCUSSION

The genetic diversity in wetland plant populations has been reviewed in some studies, and a considerable amounts of diversity have been found in most plant species (Tsyusko et al., 2005; Diyanat et al., 2011). Studies on *P. australis* and *T. domingensis* examining genetic variation showed high levels of genetic differentiation among populations (Zeidler et al., 1994; Koppitz et al., 1997; McLellan et al., 1997).

RAPD is an effective method to detect intra- and interpopulation variation and is still used widely in many plants (Koppitz et al., 1997; Koppitz, 1999;

	Typha domingensis					***Phragmites australis***				
Soil variables	**PPL%**	**N_a**	**N_e**	**H**	**I**	**PPL%**	**N_a**	**N_e**	**H**	**I**
Sand	0.98**	0.93**	0.91**	0.94**	0.94**	0.81**	0.81**	0.76**	0.81**	0.79**
Silt	-0.86**	-0.86**	-0.95**	-0.93**	-0.91**	-0.68**	-0.68**	-0.65**	-0.70**	-0.67**
Clay	-0.92**	-0.92**	-0.85**	-0.90**	-0.91**	-0.84**	-0.84**	-0.79**	-0.87**	-0.81**
pH	-0.50**	-0.49**	-0.21	-0.35*	-0.40*	-0.58**	-0.58**	-0.52**	-0.54**	-0.55**
$CaCO_3$	0.99**	0.99**	0.94**	0.97**	0.98**	0.97**	0.97**	0.97**	0.98**	0.97**
HCO_3	0.22	0.21	-0.09	0.04	0.10	0.48**	0.48**	0.49**	0.45**	0.49**
OM	0.64**	0.64**	0.76**	0.71**	0.69**	0.62**	0.61**	0.68**	0.66**	0.64**
EC	-0.89**	-0.89**	-0.94**	-0.94**	-0.92**	-0.73**	-0.73**	-0.70**	-0.74**	-0.71**
Cl^-	-0.77**	-0.76**	-0.57**	-0.67**	-0.71**	-0.76**	-0.76**	-0.70**	-0.73**	-0.73**
Ca^{++}	0.36*	0.36*	0.38*	0.39*	0.38*	0.17	0.17	0.08	0.15	0.13
Na^+	-0.88**	-0.88**	-0.80**	-0.86**	-0.86**	-0.78**	-0.78**	-0.72**	-0.77**	-0.75**
K^+	-0. 57**	-0.57**	-0.81**	-0.72**	-0.67**	-0.35*	-0.35*	-0.35*	-0.38*	-0.35*
Fe	0.79**	0.79**	0.95**	0.89**	0.86**	0.60**	0.60**	0.60**	0.63**	0.60**
Zn	0.11	0.11	0.43**	0.29	0.23	-0.16	-0.16	-0.16	-0.12	-0.16
Ni	-0.55**	-0.55**	-0.31	-0.44**	-0.48**	-0.58**	-0.58**	-0.50**	-0.53**	-0.54**
Pb	-0.96**	-0.96**	-0.99**	-0.99**	-0.98**	-0.88**	-0.88**	-0.88**	-0.90**	-0.88**
Cd	0.28	0.28	-0.02	0.12	0.18	0.39*	0.39*	0.32	0.34*	0.36*

Table 7. Pearson correlation coefficient (r value) between the soil variables and genetic diversity parameters of *Typha domingensis* and *Phragmites australis*; ** correlation is significant at the 0.01 level (2-tailed); * correlation is significant at the 0.05 level (2-tailed).

	Typha domingensis					***Phragmites australis***				
Metal conc.	**PPL%**	**N_a**	**N_e**	**H**	**I**	**PPL%**	**N_a**	**N_e**	**H**	**I**
Ni	0.76**	0.76**	0.51**	0.63**	0.68**	0.36*	0.37*	0.30	0.31	0.34*
Pb	0.10	0.10	0.05	0.06	0.07	-0.51**	-0.51**	-0.43**	-0.49**	-0.47**
Cd	0.02	0.02	-0.21	-0.10	-0.06	-0.19	-0.19	-0.09	-0.16	-0.14
Co	0.68**	0.68**	0.51**	0.60**	0.63**	0.10	0.10	0.00	0.07	0.06
Fe	0.94**	0.94**	0.77**	0.86**	0.89**	0.19	0.19	0.29	0.23	0.23
Zn	0.36*	0.37*	0.53**	0.45**	0.43**	-0.67**	-0.67**	-0.70**	-0.66**	-0.68**

Table 8. Pearson correlation coefficient (r value) between the concentrations of heavy metal variables in leaves and genetic diversity parameters of *Typha domingensis* and *Phragmites australis*; ** correlation is significant at the 0.01 level (2-tailed); * correlation is significant at the 0.05 level (2-tailed).

Keller, 2000; Bussell et al., 2005; Curn et al., 2007). Our results also show that RAPD is suitable for genetic diversity assessment in *P. australis* and *T. domingensis*.

Attempts were made in this study to use environmental variations for appropriately interpreting genetic information of *P. australis* and *T. domingensis*. A number of previous studies have shown that there is a correlation between genetic diversity and environmental heterogeneity in common reed populations (Hargeby et al., 2004; Curn et al., 2007; Hansen et al., 2007; Engloner, 2009), but very few studies have explicitly tested the causal environmental factors behind the pattern of genetic variation. In our study we found significant positive correlations of sand, $CaCO_3$ and O.M. with all the genetic parameters of the two species and significant negative correlations of Silt, Clay, pH, EC, Cl^-, Na^+ and K^+ with the two species. Heather et al. (2011) found significant negative correlations between genotypic richness of *P. australis* and potassium concentration in the soil. Similarly, Lexuan et al. (2012) found significant negative correlations between soil salinity and genetic diversity of *P. australis*.

Soil analyses revealed that the coastal sites of Manzala lake (site 3 and site 4) have higher levels of cadmium and cobalt whereas the sites of salines in industrial zone, Ismailia and new Meet Abou Elkoum, Sinai (site1 and site2) consistently grouped as the sites with the significantly least amount of metals. The present study showed significant positive correlation between genetic diversity parameters and some heavy metals such as Iron, Zinc and Cadmium and significant negative correlation between genetic diversity parameters with Nickel and Lead. The high level of genetic variability within *T. domingensis* and *P. australis* from site 3 and site 4 could be ascribed in part to these conditions. These findings are in conjunction with the results reported by Bush & Barret (1993) on isozyme diversity that indicate the population grown in contaminated sites were higher polymorphic than uncontaminated populations. Brian et al. (1999) detected that there are significantly higher genetic diversity at polluted sites. The retention of such elevated levels of genetic diversity within these contaminated populations can be attributed to a number of selective, reproductive and demographic factors. As described by Bourret et al. (2007) if tolerance to the adverse environmental condition increases as a function of individual heterozygosity and/or if the contaminant is a mutagen, genetic variation within the affected population will remain elevated and may increase. The correspondence between ecological and genetic landscapes may be indicative of the potential role of environmental variables in driving population divergence (Schlotterer et al., 2004; Nielsen, 2005; Guo & Mrazek, 2008; Hancock et al., 2010). Possibly, these variations among studied populations will assist in successful management of *P. australis* and *T. domingensis*.

CONCLUSIONS

In conclusion, the present results demonstrated that both *T. domingensis* and *P. australis* showed high capacity of metal bioaccumulation, moreover higher genetic diversity is found in *T. domingensis*, especially in contaminated sites, than in *P. australis*. Overall, the correspondence between ecological and genetic landscapes may be indicative of the potential role of environmental variables in driving population differences (Schlotterer et al., 2004; Nielsen, 2005; Guo & Mrazek, 2008; Hancock et al., 2010).

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A brief note on the aphidiphagous *Endaphis aphidimyza* Shivpuje et Raodeo, 1985 (Diptera Cecidomyiidae) in Chitrakoot Dham region and Parbhani district (India)

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ABSTRACT *Endaphis aphidimyza* Shivpuje et Raodeo, 1985 (Diptera Cecidomyiidae) is an endoparasitoid gall midge, feeding within the body of the aphids *Uroleucon* (*Uroleucon*) *sonchi* (Linnaeus, 1767) (Hemiptera Aphididae); *U.* (*Uromelan*) *compositae compositae* (Theobald, 1915) and *U.* (*Uromelan*) *gobonis* (Matsumura, 1917). Aphids are one of the major insect pests of many crops including mustard, safflower, ground nut, cabbage, cauliflower, knol-khol, radish, bean, soybean, wheat, sorghum, peas, potato, cotton and maize. In the present work four districts of Chitrakoot Dham region, as well as nearby villages of Parbhani district (Maharashtra), were surveyed for the above endoparasitoid gall midge. None *E. aphidimyza*, at any stage, was found in Chitrakoot Dham, while other natural enemies of aphids such as syrphids, coccinellids and lacewings were recorded.

KEY WORDS Cecidomyiid; Safflower; Gall midge; Endoparasitoids; Biological control.

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INTRODUCTION

The Coccinellids, syrphids, lacewings and cecidomyiids are the natural enemies of aphids. In cecidomyiids (Diptera Cecidomyiidae), *Aphidoletes aphidimyza* (Rondani, 1847) and *Monobremia rishikeshensis* Grover, 1979 are predators, while *Endaphis* Kieffer, 1896 and *Pseudendaphis* Barnes, 1954 are parasitoids of aphids (Grover & Chandra, 1988; Chandra & Kumar, 2010).

The genus *Endaphis* was erected by Kieffer (1896) and one of its species, *E. perfidus* (Kieffer, 1896), was reported as parasitoid of *Drepanosiphum platanoides* (Schrank, 1801) (Hemiptera Callaphididae). In India, Shivpuje & Raodeo (1985) described a new species of this genus, i.e. *Endaphis aphidimyza* (Shivpuje et Raodeo, 1985).

Present study was planned to explore the presence/absence of the aphidophagous *E. aphidimyza* and its distribution pattern in four districts of Chitrakoot Dham region as no such information exist in literature.

MATERIAL AND METHOD

Aphids and their natural enemies were surveyed in mustard, radish, cauliflower, cabbage, wheat, brinjal, cucurbit and bean plants in all blocks of Hamirpur, Mahoba, Banda and Chitrakoot districts

Name of District	Name of Crop							
	Mustard & Radish		Cauliflower/ Cabbage		Brinjal and Cucerbit Plants		Bean	
	Aphids	Natural enemies	Aphids	Natural enemies	Aphids	Natural enemies	Aphids	Natural enemies
HAMIRPUR	*L. erysimi* *B. brassica* *M. persicae*	Coccinellids (E - L - A) Syrphids (E - L) *Chrysoperla* sp. (L)	*M. persicae* *L. erysimi* *M. persicae*	Coccinellids (E - L - A) Syrphids (E - L)	*A. gossypii* *A. craccivora*	Coccinellids (A) Syrphids (L - A)	*A. craccivora*	Coccinellids (E - L) Syrphids (E - L) *Chrysoperla* sp. (A - E)
MAHOBA	*L. erysimi* *B. brassica*	Coccinellids (L - A) Syrphids (L)	*L. erysimi* *M. persicae*	Syrphids (E - L) Coccinellids (L - A)	*A. gossypii* *A. craccivora*	Syrphids (E - L) Coccinellids (L)	*A. craccivora*	Coccinellids (L - A) Syrphids (E - L)
BANDA	*L. erysimi* *M. persicae*	Coccinellids (E - L - A) Syrphids (L)	*M. persicae* *L. erysimi* *B. brassica*	Coccinellids (L - A) Syrphids (L)	*A. gossypii*	Syrphids (L) Coccinellids (L - A) *Chrysoperla carnea* (A)	*A. craccivora*	Coccinellids (L - A) Syrphids (E - L)
CHITRAKOOT	*L. erysimi* *M. persicae* *B. brassica*	Syrphids (E - L) Coccinellids (L - A)	*M. persicae* *L. erysimi*	Syrphids (L) Coccinellids (L - A) Syrphids (L)	*A. craccivora* *A. gossypii*	Syrphids (E - L) Coccinellids (L - A)	*A. craccivora*	Coccinellids (L - A) Syrphids (E - L)
UNIVERSITY AGRICULTURAL FARM, RAJAULA (M.P.)	*L. erysimi* *M. persicae*	Coccinellids (E - L - A) Syrphids (L)	*L. erysimi* *M. persicae*	Syrphids (L) Coccinellids (L - A) *Chrysoperla carnea* (A)	*A. gossypii*	Syrphids (L) Coccinellids (A)	*A. craccivora*	Coccinellids (L - A) Syrphids (L)

Table 1. Survey report of aphids and their natural enemies in Chitrakoot Dham Region (L = Larva, A = Adult, E = Egg). *Lipaphis erysimi* Kaltenbach, 1843; *Brevicoryne brassicae* (Linnaeus, 1758); *Myzus persicae* (Sulzer, 1776); *Aphis gossypii* Glover, 1877; *Aphis craccivora* C.L.Koch, 1854.

of Chitrakoot Dham region as well as in campus and research farms of the Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya rural areas (Chitrakoot, Satna, MP) during the Rabi season (starting with the onset of the north-east monsoon in October). Fifteen samples of highly aphids infested parts of the plants were collected in polythene bags. Each sample was observed with help of a stereoscopic trinocular research microscope in the laboratory.

As per survey report by Grover et al. (1991), safflower crops were surveyed in the research farm of Marathwada Agricultural University, Parbhani (Maharashtra) and in the nearest villages i.e. Taroda, Pokharni, Brahman Goan and Umripata. Highly aphids infested safflower leaves and terminal twigs were collected in plastic containers, the mouth of which was covered by muslin cloth. Meteorological data of the surveyed areas were also recorded.

RESULTS AND DISCUSSION

As shown in Table 1, eggs, larvae and adults of natural enemies of aphids like syrphids, coccinellids and lacewings (species of genus *Chrysoperla* Steinmann, 1964, Neuroptera Chrysopidae) were recorded during the observation of collected samples; on the contrary, different stages (eggs, larvae and

Name of Place	Name of Crop					
	Mustard		Safflower		Niger	
	Name of aphids	Name of natural enemies	Name of aphids	Name of natural enemies	Name of aphids	Name of natural enemies
MARATHWADA AGRICULTURAL UNIVERSITY, PARBHANI	*L. erysimi* *U. sonchi*	Coccinellids (L - A) Syrphids (E - L)	*U. gobonis* *U. sonchi*	Coccinellids (E - L - A) *E. aphidimyza* (E - L)	*U. compositae*	Coccinellids (L)
TARODA	*L. erysimi* *U. gobonis*	Coccinellids (E - L - A) *E. aphidimyza* (E - L)	*U. sonchi*	Coccinellids (L - A) *E. aphidimyza* (E - L)	*U. compositae*	Coccinellids (L - A) *E. aphidimyza* (L)
POKHARNI	*L. erysimi*	Coccinellids (A) Syrphids (L)	*U. gobonis*	*Coccinellids* (L - A) Syrphids (L) *E. aphidimyza* (L)	*U. sonchi* *U. compositae*	Coccinellids (L - A) Syrphids (E - L) *E. aphidimyza* (A - L)
BRAHMAN GAWN UMRIPATA	*L. erysimi*	Coccinellids (L - A)	*U. sonchi*	Coccinellids (A) *E. aphidimyza* (E - L - A) Syrphids (L)	*U. compositae*	Coccinellids (L - A) Syrphids (E - L)
UMRIPATA	*L. erysimi*	Coccinellids (E - L - A)	*U. sonchi*	Coccinellids (A) *E. aphidimyza* (E - L - A)	Crop not Availab	Crop not Available

Table 2. Survey report of aphids and their natural enemies in Parbhani District, Mahashtra (L = Larva, A = Adult, E = Egg). *Uroleucon* (*Uroleucon*) *sonchi* (Linnaeus, 1767); *U.* (*Uromelan*) *compositae compositae* (Theobald, 1915)*U.* (*Uromelan*) *gobonis* (Matsumura, 1917).

adults) of the endoparasitoid gall midge *E. aphidimyza* were not seen in any collected samples from Chitrakoot Dham region.

On the other hand, in nearby villages of Parbhani district (Maharashtra) all stages of natural enemies of aphid like Coccinellids, syrphids and, in line with Grover et al. (1991), even *E. aphidimyza*, were recorded during observations on Mustared, Safflower and Niger crops (Table 2). Probably, maximum and minimum temperature, humidity and rainfall play an important role in the distribution of *E. aphidimyza* in the above working stations, but, at the moment this item remains to be further investigated.

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Exotic plant species in the restoration project area in Ranupani recreation forest, Bromo Tengger Semeru National Park (Indonesia)

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ABSTRACT Exotic plant species invasiveness is the crucial issue in mountain forest ecosystems restoration programs. The aim of this research was identifying the diversity of exotic species in Tengger highlands. There are some important exotic plant species in Ranupani restoration area, including *Salvinia molesta* D. S. Mitch., *Acacia decurrens* Willd., *A. mangium* Willd. , *Eupatorium inulifolium* Kunth., *E. riparium* Regel, *Solanum pseudocapsicum* Medik., *Zantedeschia aethiopica* (L.) Spreng., *Lantana camara* L., and *Fuchsia magellanica* Lam. Actually, among factors most favorable to exotic plants species invasion there are forest and habitat degradation. Clearing exotic plant species in restoration areas, building community awareness about exotic species and enhancing the capacity of national park management to control and monitor the existence of exotic plant species is extremely important.

KEY WORDS Mountain biodiversity; non-native plant; native habitat conservation.

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INTRODUCTION

Exotic plant species, nowadays, are a significant issue in biodiversity conservation as they significantly contribute to native ecosystems disturbance by triggering biodiversity extinction. Ecologically, exotic plant species are able to alter ecosystem structure and function. Invasion of exotic plant species - particularly high in the degraded lands - is one of the crucial steps in the process of native species extinction. Recently, most of the world's ecosystems have been affected by exotic plant species invation. Exotic plant species have been the subject of extensive ecological research in many countries, especially in terms of biodiversity conservation (Stadler et al., 2000; D'Antonio & Meyerson, 2002).

Exotic plants are defined as those species that are naturally not occurring within their biographical ranges. Such plants are introduced from outside mostly due to anthropogenic (i.e. economic, social and cultural) factors. For example, numerous exotic plants are planted in home gardens due to their high economic value, or, some species have been introduced as ornamental plants. However, the contribution of humans in exotic plant species invasion is significant and exotic plants are particularly abundant in human-influenced ecosystems

(Mack & Lonsdale, 2001; Hakim & Nakagoshi, 2007; Dehnen- Schmutz et al., 2007).

A recent survey in Indonesian national park suggested that exotic plant species did contribute to biodiversity decline due to the extinction of several local species, many of which endemics to particular areas (Hakim, 2011; Hakim & Miyakawa, 2014). Hence, restoring tropical mountain forest is very important in mountain biodiversity conservation.

Tropical mountain forest restoration projects, however, exhibit a number of limitations (Hakim & Miyakawa, 2014), one of which certainly is the lack of a scientific comprehensive database of exotic plant species. The aim of this research is to provide basic data of exotic plants in Ranupani forest area in order to contribute to the near-future restoration management projects.

MATERIAL AND METHODS

Study site

In the end of 2010, the Japan International Co-operation Agency implemented the national restoration program in protected areas known as "Project on Capacity Building for Restoration of Ecosystems in Conservation Areas in Indonesia". Bromo Tengger Semeru National Park (BTSNP), particularly the Ranupani forest recreation area (2000–2200 m asl; average temperature 10-20 ºC; relative humidity 80–85%), was one of the selected study areas (Fig.1). The project aimed at protecting the Lakes Pani and Regulo and restoring the tropical mountain forest surrounding them. In the past, Ranupani area was characterized by a great diversity in mountain flora species and both lakes were crucial freshwater resources for humans and wildlife. However, recently, the combination of population growth and forest fire led these areas under rapid degradation. Hence, the conflict between biodiversity protection in national park and socio-economic development appears all around Tengger Highland (Hakim, 2011). In Ranupani, human disturbance and natural forest fire damaged systematically the ecosystem, leading to the forest degradation with major consequences for Lake Ranu. Recently, also Lake Pani has been seriously degraded due to increasing population and intensive agricultural practices.

From a geological standpoint, the soil is composed of volcanic ash; the climax vegetation disappeared being replaced by a recent vegetation structure including pioneer to sub-climax species.

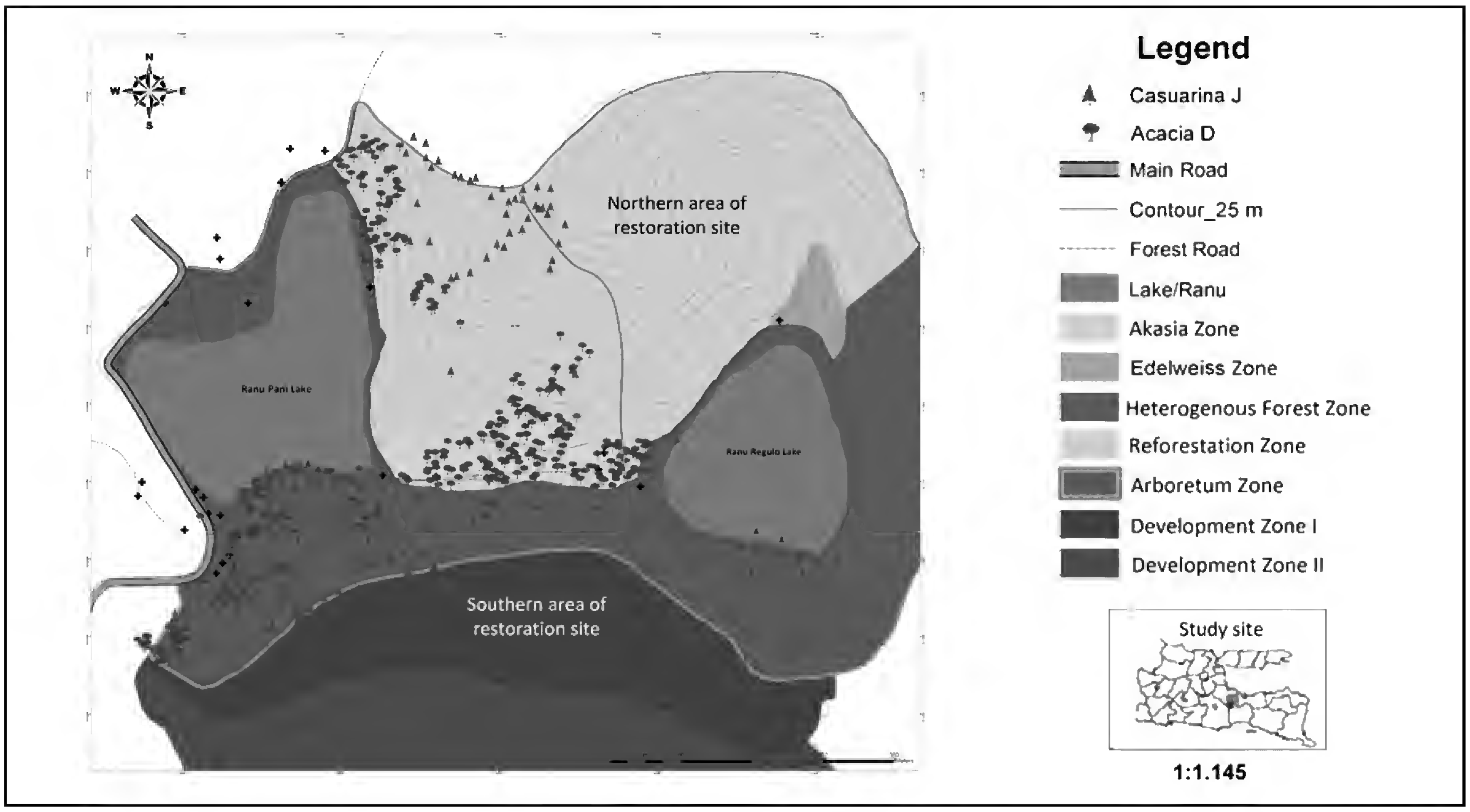

Figure 1. Restoration target area in Ranupani sector of the Bromo Tengger Semeru National Park.

In the eastern part of the lakes, young populations of *Casuarina junghuhniana* (Cemara Gunung) grow as pioneer species and occupy nearly 60% of the area. About 40% of the area was invaded by shrubs and herbs, including *Eupatorium inulifolium* (Kirinyuh), *E. riparium* (Tekelan), Gonostegia hirta, and *Imperata cylindrica* (Alang-alang). Original tropical mountain forest with *Acer laurinum* (Dadap putih), *Acmena acuminatissima* (Jambon, Tinggan, Salam badak), *Lithocarpus sundaicus* (Pasang), *Macropanax dispermum* (Pampung, Endog-endogan, Kodokan), *Engelhardia spicata* (Danglu, Kukrup, Morosowo), *Astronia spectabilis* (Kayu Ampet, Gembirung), *Turpinia sphaerocarpa* (Kayu Bangkong), *Cyathea contaminans* (Paku pohon) and *Omalanthus giganteus* (Tutup, kebu, belantih) has been replaced by grassland and barren lands dominated by shrubs.

In the past, the main threats to woody trees species primarily came from illegal logging, firewood collection and forest conversion into settlement and agricultural lands; dwellers of the village depended on firewood as fuel to cook and warm cold rooms (Hakim & Miyakawa, 2014). Many epiphytes orchids have been endangered due to the loss of woody vegetation however, in the eastern part of the area, there still is a woody vegetation with epiphytes orchids. Recently, Ranupani recreation forest has been considered as one of the most important tourism destinations in BTSNP.

Methods

The study consisted of two fundamental parts. First, an intensive literature survey was done focusing on available references on exotic flora of mountainous regions, including "Flora Pegunungan Jawa" (van Steenis et al., 2006), "The Ecology of Java and Bali" (Whitten et al., 2002) and some other relevant books and scientific reports dealing with the ecology of Bromo Tengger Semeru National Park. All the information related to potential exotic plant species in mountain environments was listed systematically and verified using the Germplasm Resources Information Network or GRIN-USDA databases.

The list was used as guidance in plant species recognition in the field. Second, field surveys were carried out in February and August 2011, March and July 2012 and January and August 2013, covering both rainy and dry seasons. All suspected exotic species were documented by photographs and some part of the plant species was collected and stored for the herbarium. Species identification was done by examining morphological and flora characters. In order to identify the type of relationship connecting humans and exotic plant species, we also conducted a semi structured interview with national park rangers, national park technicians, and representatives of local people in Ranupani Villages.

RESULTS AND DISCUSSION

Exotic plant species in restoration area

Ranupani forest is one of the hotspot of exotic plant species in Bromo Tengger Semeru National Park. Some notable important exotic species with high potentiality to hamper restoration programs are listed below.

Salvinia molesta D.S. Mitch.

Giant salvinia (Ki Ambang). Familia Salviniaceae. Native to South America, has been naturalized widely in tropic and subtropic regions. The species was considered as noxious weed (Arthington & Mitchell, 1986). Firstly recorded at Pani Lake in the middle of 2011 as small population in the periphery of lakes, its population grew very fast and covered about 75% of lake surface by the end of the same year (Fig. 2). Little is known of the introduction mechanism of Giant salvinia to Lake Pani. The rapid invasion of *Salvinia* in Pani Lake is one of the most important implications of water eutrophication.

Acacia decurrens Willd.

Black wattle, Green wattle (Akasia). Familia Fabaceae. Species native to Australia, New Zealand, Ethiopia, Tanzania, South Africa, India. In Mt. Merapi (Yogyakarta), after 1996 eruption, *A. decurrens* is one of the important species in ecosystems succession (Suryanto et al., 2010). In Ranupani, these trees grow to about 10 meter with a very dense crown of foliage; dead and down woody trees are collected as fuel wood. The species is tolerant to frost attack.

Acacia mangium Willd.

Broadleaf salwood. Familia Fabaceae. Native to Australia, Vietnam, and Malaysia. In the past, few elements were introduced in an area adjacent to Ranu and Regulo lakes for reforestation. *Acacia mangium* is one of the rapid-growth species, especially in humid tropical environment. In Sabah, *A. mangium* was introduced and used to reduce forest fire. The species was reported as high competitor with *Imperata cylindrica* (Tsai, 1988). Norisada et al. (2005) reported that *A. mangium* can be used to enhance the survival rate of dipterocarp seedlings in reforestation programs.

Eupatorium inulifolium Kunth.

Familia Asteraceae. Synonym of *Austroeupatorium inulifolium* (Kunth) R. M. King et H. Rob. Locally called Triwulan. The species is native to Central and Southern Americas (Panama, Guyana, Venezuela, Brazil, Bolivia, Equador, Peru, Argentina, Paraguay, Uruguay). During the early 1990s, *Euphatorium* was introduced for numerous agricultural purposes, i.e. compost, shading plant and soil conservation plant (van Steenis et al., 2006). It is found wherever there is open habitat. In the absence of forest trees canopy, the population of *E. inulifolium* is large and frequent. Under trees canopy, plants' density is low. The seedlings of *E. inulifolium* survive and grow under moderate to low light levels. Forest clearing in Ranupani area has severely increased *E. inulifolium* habitat over the years. In this area, the species blooms in the dry season, from June to September.

Eupatorium riparium Regel

Familia Asteraceae. Sinomym of *Ageratina riparia* (Regel) R. M. King et H. Rob. Native to Mexico but widely naturalized in Africa, Australia, Pacific, Southern America and Tropical Asia (including Indonesia). *Eupatorium riparium* grows on open grasslands and degraded lands (Tripathi et al., 1981). In Ranupani, the distribution and habits of the species is very large, ranging from open area to habitats under forest canopy. Ecologically, *E. riparium* is one of the most adaptive exotic species, which is why it was able to distribute in numerous habitats. The leaves are not resistant to frost attack.

Solanum pseudocapsicum Medik.

Familia Solanaceae. Jerusalem cherry is a shrub up to 1.5 m tall, employed as ornamental plant. *Solanum pseudocapsicum* was found to invade small paths under *Acacia decurrens* canopy in Lake Regulo area. It forms dense patches and prevents the regeneration of native trees. *Solanum pseudocapsicum* is intolerant to drought (Aliero et al., 2006), which might explain its abundance in riparian area of Lake Regulo, but its absence in hills open area. The plant has the capacity to invade and transform areas by displacing existing native species thus allowing the soil erosion.

Zantedeschia aethiopica (L.) Spreng.

White-arum-lily. Familia Araceae. Native to Southern Africa. It grows abundant in riparian zone of Ranupani Lake, but is absent in Ranu Regulo Lake. In Pani Lake, *Z. aethiopica* population grows fast, up to 75 cm with white trumpet-shape flower, spreading by rhizomes. Its density is higher in the semi-open habitat, in the south, whereas there are no populations in the northwest of the lake, which is dominated by sedimentations land and waste. The distribution and invasion of *Z. aethiopica* is limited by water content in soil as the plant is not drought tolerant (Bown, 2000).

Lantana camara L.

Common lantana. Familia Verbenaceae. Locally called Kembang telekan. Van Steenis et al. (2006) note that *L. camara* was introduced in 1850 as ornamental plant. It is one of the most colorful exotic plant species. The species was reported as fire tolerant and has better adaptability and ability compared to the indigenous flora (Gentle & Duggin, 1997; Sharma et al., 2005). The shrubs grow rapidly on degraded lands.

Fuchsia magellanica Lam.

Fuchsia. Locally called Anting-anting. Familia Onagraceae. Native to Argentina and Chile, naturalized in Bolivia, Canary Islands, Kenya, Tanzania, Australia, New Zealand, UK, and Hawaii. At first, it was introduced as ornamental plant (Hakim & Nakagoshi, 2007). When in bloom, *F. magellanica*

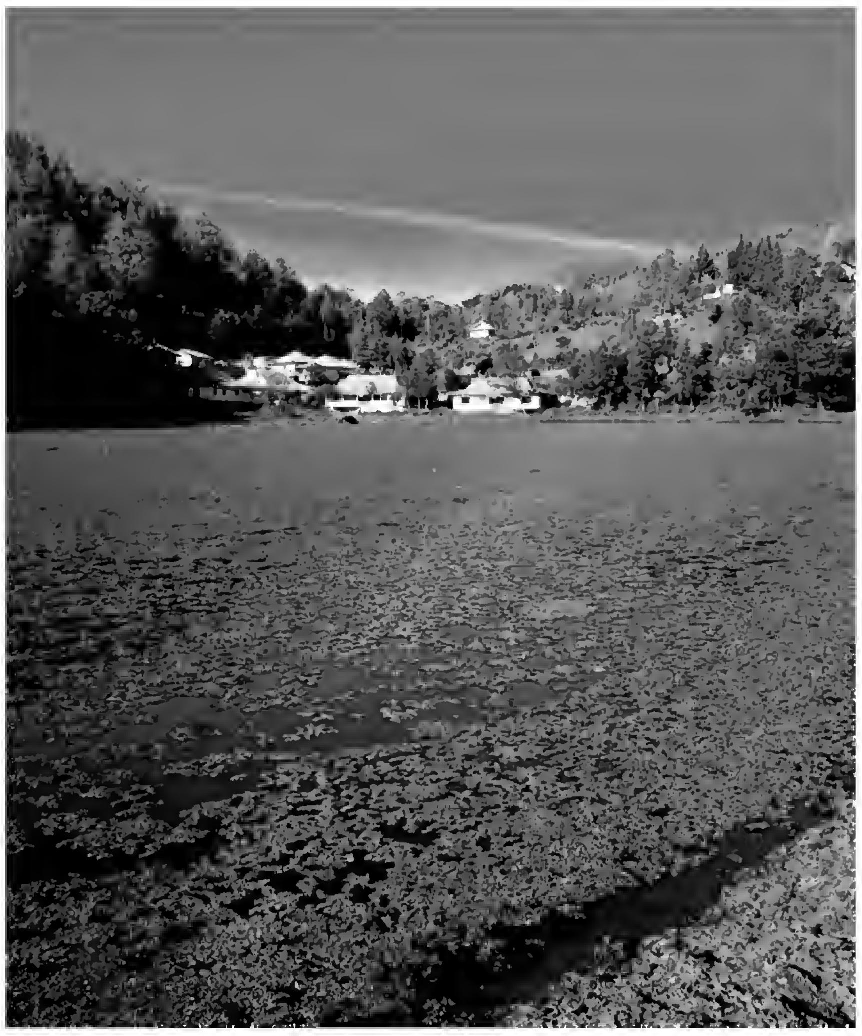

Figure 2. The invasion of *Salvinia molesta* in Lake Pani (Ranu Pani).

is a very beautiful decorative species. *Fuchsia magellanica* inhabits grassland and shrubs land, but is absent under forest canopy.

The implication for forest restoration program

According to national park's ranger and technicians, there has been a rapid increase of the area covered by exotic plant species, which is attributable to several important factors, including forest disturbance, poor public understanding and even less government attention. The open forest structure is usually dominated by exotic plant species, especially *E. inulifolium*.

Intensive forest disturbance was considered to be the greatest factor of exotic plant species abundance as the absence of the canopy provides suitable habitat for exotic plants. Consequently, maintaining forest canopy could be a successful strategy to significantly reduce exotic plants invasion. In such a case, controlling illegal woody tree cutting and harvesting becomes crucial. In Ranupani Village, woody trees are essential resources for human every-day life. For instance, *A. decurrens* and *Casuarina junghuhniana* Miq. (Casuarinaceae) are widely used as fire wood (Bhatt & Sachan, 2004). Actually, collecting of *A. decurrens* and *C. junghuhniana* as fire wood is prohibited but, according to national park's ranger, there still is illegal harvesting and colleting by local people.

Forest fires, one of the main causes of tropical forest degradation, contribute to the invasion of exotic species, especially *E. inulifolium*. Forest fires occur in dry months (July–August). Although not very frequent, they have serious implications in native vegetation decline. Therefore, a proper forest fire prevention strategy should be involved in restoration and management projects.

Another factor is the poor public understanding about exotic plant species. In Ranupani forest area, *S. pseudocapsicum* and *F. magellanica* have been neglected as potential invasive species. These species were introduced as ornamental plants. According to the informant, seeds were obtained from an European family living in Ranupani in the beginning of 1940. Subsequently, a small pioneering community that settled in the Ranupani village in the early 1960 introduced some ornamental plants from Malang, Pasuruhan and Probolinggo. Incresing of human population in Ranupani Village contributes to the increase of exotic plant species in this area; according to Hakim & Nakagoshi (2007) there are about 154 ornamental plant species from 52 plant families. In particular, local people gardening activities have a direct effect on the introduction and invasion of some exotic plant species, such as *Solanum pseudocapsicum*, *F. magellanica* and *Z. aethiopica*. Therefore, a severe control of exotic ornamental plant seedlings and establishment in restoration areas should be implemented systematically.

The thirds factor is the least government attention to the existence of exotic plant species in protected areas. The existence of *A. mangium* in Ranupani forest is the evidence of such a case. In Indonesia, only limited attention has been paid to invasion of exotic plant species. Overtime, many exotic plant species have gradually expanded, with government institutions generally paying less attention to take any initiative to combat such an invasion (Whitten et al., 2002; Garsetiasih & Siubelan, 2005). According to national park's rangers and staff, funding for restoration programs has been a major uncertainty. Providing significant funding support in order to enhance restoration programs, based on long-term research and monitoring, is crucial.

CONCLUSION

The degraded forest in Ranupani area provides habitat for a numerous exotic plants, including aquatic fern, herbs, shrubs and woody trees. Virtually all of the degraded and open forest areas have been invaded by exotic plants. *Acacia decurrens* and *E. inulifolium* are dominant in restoration area. The invasion of exotic plant species, in Ranupani forest area, constitutes one of the most serious threats to the success of forest restoration programs. The main factors governing the distribution and invasion of numerous exotic plant species include habitat disturbance, poor human knowledge/awareness, and lack of ecological monitoring and control by national park authority. In order to enhance the success of restoration programs, clearing exotic plant species in restoration area, building community awareness about exotic species and enhancing the capacity of national park management to control and monitor the existence of exotic plant species are certainly needed.

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Updated checklist of freshwater and brackish fishes of Phetchaburi Basin, Northwest Gulf of Thailand Drainages

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ABSTRACT The present paper reports on an updated checklist of freshwater and brackish fishes of Phetchaburi Basin, Northwest Gulf of Thailand Drainages, resulting from a study carried out in the period April 2012 – September 2013. All the species encountered in this region belonging to 11 orders, 41 families and 126 species, are listed. In particular, 39 species are new records for Phetchaburi Basin: *Parachela siamensis* (Günther, 1868); *Barbonymus schwanefeldii* (Bleeker, 1854); *Puntioplites proctozystron* (Bleeker, 1865); *Acanthopsoides gracilentus* (Smith, 1945); *Homaloptera smithi* Hora, 1932; *Mystus mysticetus* Roberts, 1992; *Plotosus canius* Hamilton, 1822; *Macrognathus semiocellatus* Roberts, 1986; *M. siamensis* (Günther, 1861); *Doryichthys boaja* (Bleeker, 1850); *Ichthyocampus carce* (Hamilton, 1822); *Hyporhamphus limbatus* (Valenciennes, 1846); *Dermogenys siamensis* Fowler, 1934; *Oryzias javanicus* (Bleeker, 1854); *O. minutillus* Smith, 1945; *Phenacostethus smithi* Myers, 1928; *Poecilia latipinna* (Lesueur, 1821); *Ambassis vachellii* Richardson, 1846; *Oreochromis mossambicus* (Peters, 1852); *Sillago sihama* (Forsskål, 1775); *Scatophagus argus* (Linnaeus, 1766); *Gerres filamentosus* Cuvier, 1829; *Ellochelon vaigiensis* (Quoy et Gaimard 1825); *Moolgarda cunnesius* (Valenciennes 1836); *Terapon jarbua* (Forsskål, 1775); *Lates calcarifer* (Bloch, 1790); *Lutjanus monostigma* (Cuvier, 1828); *Siganus javus* (Linnaeus, 1766); *Butis butis* (Hamilton, 1822); *B. koilomatodon* (Bleeker, 1849); *Pseudogobius javanicus* (Bleeker, 1856); *Gobiopterus chuno* (Hamilton, 1822); *Pseudapocryptes elongatus* (Cuvier, 1816); *Acentrogobius kranjiensis* (Herre, 1940); *Rhinogobius* sp.; *Istiblennius lineatus* (Valenciennes, 1836); *Trichopsis pumila* (Arnold, 1936); *Trichopodus pectoralis* Regan, 1910; *Cynoglossus puncticeps* (Richardson, 1846).

KEY WORDS Freshwater fishes; brackish fishes; Phetchaburi Basin; Gulf of Thailand.

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INTRODUCTION

The Phetchaburi Basin originates at Tanow Sri mountain range. This river system runs through Phetchaburi Province, West Thailand, and flows into the Upper Gulf of Thailand at Ban Lam District, the Phetchaburi Estuary, with a total length of about 90 kilometers. Phetchaburi Basin is a very important river basin, but in some areas of Phetchaburi River, especially the lower mainstream under the Kaeng Krachan Reservoir and the estuary of Phetchaburi River, very little is known about fish populations. At the present moment available data are extremely scarce and fragmented, marking it difficult to use them. A survey project aimed at studying freshwater and brackish fishes of Lower Phetchaburi Basin in Phetchaburi Province, West Thailand (see Figs.1–5) was carried out during April 2012–September 2013 (collecting the specimens every 2 month). We separated this area into six regions: 1) small tributary stream in Kaeng Krachan District (transparent rapid waters with an average width of about 5 m, average depth less than 1 m, and sandy bottom); 2) fishing ports of Kaeng Krachan Reservoir; 3) main stream of Phetchaburi River in Ban Lad District; 4) main stream of Phetchaburi River in Meuang Phetchaburi District; 5) main stream of Phetchaburi River in Tha Yang District; 6) mangrove areas and estuary of Phetchaburi River in Ban Lam District.

In particular, we found 39 species of fishes which are new records in this area and are reported for the first time in this paper (for previous reviews, see Fowler, 1935; Yamsontrat, 1965; Banasopit & Wongratana, 1967; Depart of Fisheries, 1969; Wongratana, 1980; Suvatti, 1981; Sukhavisith & Chuenchitpong, 1982; Vanagosoom, 1983; NIFI, 1985; Chantsavang et al., 1989; Monkolprasit et al., 1997; Department of National Parks, Wildlife and Plant Conservation, 2007; Kunlapapuk et al., 2012): *Parachela siamensis*, *Barbonymus schwanefeldii*, *Puntioplites proctozystron*, *Acanthopsoides gracilentus*, *Homaloptera smithi*, *Mystus mysticetus, Plotosus canius, Macrognathus semiocellatus, M. siamensis, Doryichthys boaja, Ichthyocampus carce, Hyporhamphus limbatus, Dermogenys siamensis, Oryzias javanicus, O. minutillus, Phenacostethus smithi, Poecilia latipinna, Ambassis vachellii, Oreochromis mossambicus, Sillago sihama, Scatophagus argus, Gerres filamentosus, Ellochelon vaigiensis, Moolgarda cunnesius, Terapon jarbua, Lates calcarifer, Lutjanus monostigma, Siganus javus, Butis butis, B. koilomatodon, Pseudogobius javanicus, Gobiopterus chuno, Pseudapocryptes elongatus, Acentrogobius kranjiensis, Rhinogobius* sp.; *Istiblennius lineatus, Trichopsis pumila, Trichopodus pectoralis, Cynoglossus puncticeps.*

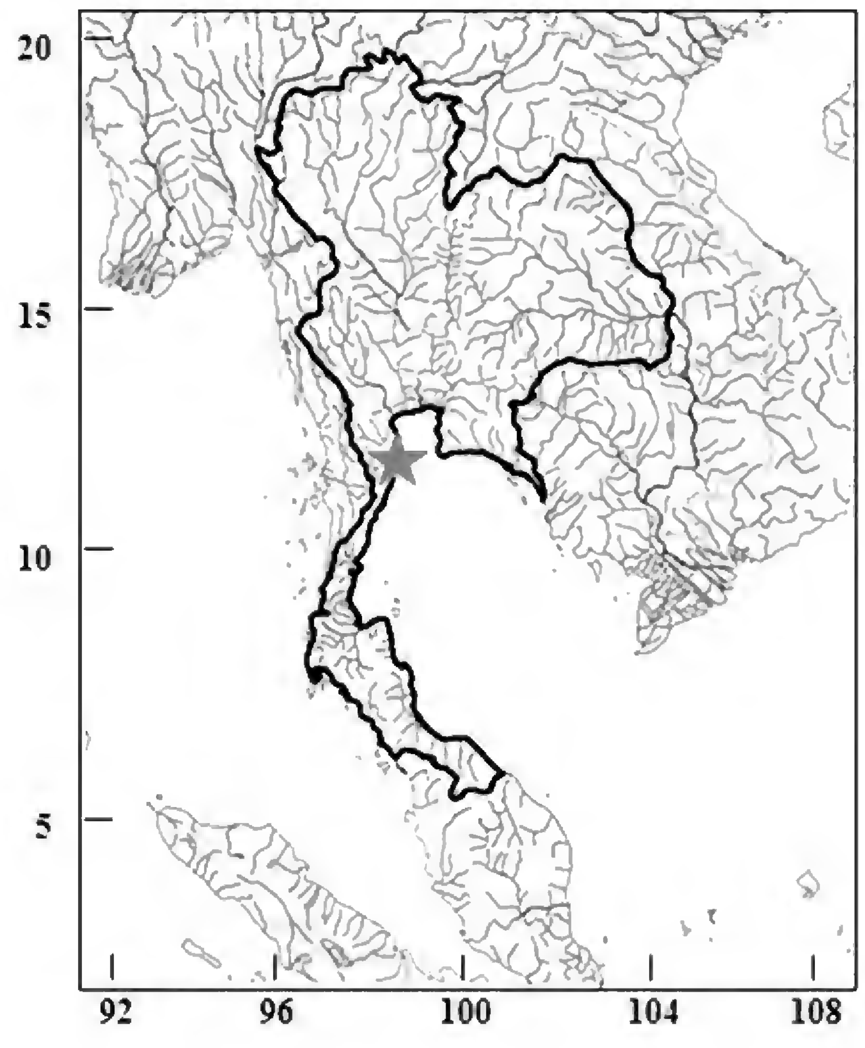

Figure 1. Study area: Phetchaburi Basin, Northwest Gulf of Thailand Drainages.

Currently, all specimens used in these studies are deposited into the Reference Collection of Aquatic ecology, Silpakorn University, Phetchaburi IT campus (RAESUP).

ABBREVATIONS. RAESUP = Reference Collection of Aquatic ecology, Silpakorn University, Phetchaburi IT campus. *** = newly recorded species; ** = species recorded in past works and observed by the authors; * = species recorded in past works but not observed by the authors.

RESULTS

Checklist of freshwater and brackish fishes of Phetchaburi Basin, Northwest Gulf of Thailand Drainages

According to known literature (see above) and present study, freshwater and brackish fishes in Phetchaburi Basin in Phetchaburi Province belong to 11 orders, 41 families and 126 species. In particular, 39 species are new records for Phetchaburi Basin.

Order OSTEOGLOSSIFORMES Berg, 1940
Family NOTOPTERIDAE Bleeker, 1859

Notopterus notopterus (Pallas, 1769)**

Order CLUPEIFORMES Bleeker, 1959
Family CLUPEIDAE Cuvier, 1817

Clupeichthys goniognathus Bleeker, 1855**
Hilsa kelee (Cuvier, 1829)*

Order CYPRINIFORMES Bleeker, 1859
Family CYPRINIDAE Swainson, 1839

Barbonymus altus (Günther, 1868)*
Barbonymus gonionotus (Bleeker, 1849)**
Barbonymus schwanefeldii (Bleeker, 1854)***
Barbodes rhombeus (Kottelat, 2000)*
Carassius auratus (Linnaeus, 1758)*
Cirrhinus molitorella (Valenciennes, 1844)**
Cirrhinus siamensis (Sauvage, 1881)**
Cyclocheilichthys apogon (Valenciennes, 1842)**
Cyclocheilichthys armatus (Valenciennes, 1842)**
Cycloceilos enoplos (Bleeker, 1849)*
Cyclocheilichthys repasson (Bleeker, 1853)
Cyprinus carpio Linnaeus, 1758*
Devario regina (Fowler, 1934)*
Esomus metallicus Ahl, 1924**
Hampala macrolepidota Kuhl et van Hasselt, 1823**
Hypsibarbus wetmorei (Smith, 1931)*
Labeo rohita (Hamilton, 1822)*
Labiobarbus siamensis (Sauvage, 1881)**
Lobocheilos rhabdoura (Fowler, 1934)*
Labeo chrysophekadion (Bleeker, 1849)*
Mystacoleucus marginatus (Valenciennes, 1842)**
Neolissochilus stracheyi (Day, 1871)*
Osteochilus vittatus (Valenciennes, 1842)**
Osteochilus waandersii (Bleeker, 1853)*
Parachela maculicauda (Smith, 1934)*
Parachela siamensis (Günther, 1868)***
Puntioplites proctozystron (Bleeker, 1865)***
Puntius brevis (Bleeker, 1849)**
Puntigrus partipentazona (Fowler, 1934)**
Rasbora borapetensis Smith, 1934**
Rasbora myersi Brittan, 1954*
Rasbora sumatrana (Bleeker, 1852)*
Rasbora tornieri Ahl, 1922**
Rasbora trilineata Steindachner, 1870*
Systomus orphoides (Valenciennes, 1842)**
Tor tambroides (Bleeker, 1854)*

Family BALITORIDAE Swainson, 1839

Homaloptera smithi Hora, 1932***
Nemacheilus masyae Smith, 1933*
Schistura poculi (Smith, 1945)*
Schistura schultzi (Smith, 1945)*
Schistura kengtungensis (Fowler, 1936)*


2


3


4


5

Figure 2. Small tributary stream in Kaeng Krachan District. Figures 3, 4. Main stream of Phetchaburi River in Tha Yang District (Fig. 3) and, (Fig. 4) in Meuang Phetchaburi District. Figure 5. Mangrove areas and estuary of Phetchaburi River.

Family COBITIDAE Swainson, 1838

Acantopsis choirorhynchos (Bleeker, 1854)*
Acanthopsoides gracilentus (Smith, 1945)***
Paracanthocobitis zonalternans (Blyth, 1860)*
Syncrossus helodes (Sauvage, 1876)*
Lepidocephalichthys berdmorei (Blyth, 1860)*
Lepidocephalichthys hasselti (Valenciennes, 1846)**
Pangio anguillaris (Vaillant, 1902)*

Order SILURIFORMES Cuvier, 181
Family AMBLYCIPITIDAE Day, 1873

Amblyceps variegatum Ng et Kottelat 2000*

Family BAGRIDAE Bleeker, 1858

Batasio tengana (Hamilton, 1822)*
Hemibagrus nemurus (Valenciennes, 1840)**
Hemibagrus wyckioides (Fang et Chaux, 1949)*
Mystus gulio (Hamilton, 1822)**
Mystus nigriceps (Valenciennes, 1840)*
Mystus mysticetus Roberts, 1992***
Mystus vittatus (Bloch, 1794)*
Pseudomystus siamensis (Regan, 1913)**

Family CLARIIDAE Bonaparte, 1845

Clarias batrachus (Linnaeus, 1758)**
Clarias macrocephalus Günther, 1864*

Family PANGASIIDAE Bleeker, 1858

Laides hexanema (Bleeker, 1852)*
Pangasianodon hypophthalmus (Sauvage, 1878)*

Family PLOTOSIDAE Bleeker, 1858

Plotosus canius Hamilton, 1822***

Family SILURIDAE Rafinesque, 1815

Ompok siluroides Lacepède 1803

Order SYNBRANCHIFORMES Nelson, 1994
Family MASTACEMBELIDAE Swainson, 1839

Macrognathus semiocellatus Roberts, 1986***
Macrognathus siamensis (Günther, 1861)***
Mastacembelus armatus (Lacepède, 1800)*
Mastacembelus favus Hora, 1924**

Family SYNBRANCHIDAE Bonaparte, 1835

Monopterus albus (Zuiew, 1793)**

Order BELONIFORMES L.S. Berg, 1937
Family BELONIDAE Bonaparte, 1835

Xenentodon cancila (Hamilton, 1822)**

Family ADRIANICHTHYIDAE Weber, 1913

Oryzias javanicus (Bleeker, 1854)***
Oryzias minutillus Smith, 1945***

Family HEMIRAMPHIDAE Gill, 1859

Hyporhamphus limbatus (Valenciennes, 1846)***

Order SYNGNATHIFORMES Berg, 1940
Family SYNGNATHIDAE Bonaparte, 1831

Doryichthys boaja (Bleeker, 1850)***
Ichthyocampus carce (Hamilton, 1822)***
Dermogenys siamensis Fowler, 1934***

Order ATHERINIFORMES D.E. Rosen, 1966
Family PHALLOSTETHIDAE Regan, 1916

Phenacostethus smithi Myers, 1928***
Neostethus lankesteri Regan, 1916**

Order CYPRINODONTIFORMES L.S. Berg, 1940
Family POECILIIDAE Bloch et Schneider, 1801

Poecilia latipinna (Lesueur, 1821)***

Order PERCIFORMES Bleeker, 1859
Family AMBASSIDAE Klunzinger, 1870

Ambassis vachellii Richardson, 1846***
Parambassis siamensis (Fowler, 1937)**
Parambassis ranga (Hamilton, 1822)*

Family NANDIDAE Bleeker, 1852

Nandus nebulosus (Gray, 1835)*
Pristolepis fasciata (Bleeker, 1851)**

Family TOXOTIDAE Cuvier, 1816

Toxotes jaculatrix (Pallas, 1767)*

Family CICHLIDAE Heckel, 1840

Oreochromis niloticus (Linnaeus, 1758)**
Oreochromis mossambicus (Peters, 1852)***

Family CARANGIDAE Rafinesque, 1815

Ulua mentalis (Cuvier, 1833)*

Family SILLAGINIDAE Richardson, 1846

Sillago sihama (Forsskål, 1775)***

Family SCATOPHAGIDAE Gill, 1883

Scatophagus argus (Linnaeus, 1766)***

Family GERREIDAE Bleeker, 1859

Gerres filamentosus Cuvier, 1829***

Family MUGILIDAE Cuvier, 1829

Ellochelon vaigiensis (Quoy et Gaimard, 1825)***
Moolgarda cunnesius (Valenciennes, 1836)***

Family TERAPONTIDAE Richardson, 1842

Terapon jarbua (Forsskål, 1775)***

Family LATIDAE Jordan, 1888

Lates calcarifer (Bloch, 1790)***

Family LUTJANIDAE Gill, 1861

Lutjanus monostigma (Cuvier, 1828)***
Lutjanus rivulatus (Cuvier, 1828)*
Pinjalo pinjalo (Bleeker, 1850)*
Pterocaesio pisang (Bleeker, 1853)*
Pterocaesio tile (Cuvier, 1830)*

Family SCIAENIDAE Cuvier, 1829

Johnius axillaris (non Cuvier, 1830)*
Johnius trachycephalus (Bleeker, 1851)*

Family SIGANIDAE Woodland (1990)

Siganus javus (Linnaeus, 1766)***

Family ELEOTRIDAE Bonaparte, 1835

Butis butis (Hamilton, 1822)***
Butis koilomatodon (Bleeker, 1849)***
Oxyeleotris marmorata (Bleeker, 1852)**

Family GOBIIDAE Cuvier, 1816

Acentrogobius kranjiensis (Herre, 1940)***
Gobiopterus chuno (Hamilton, 1822)***
Pseudapocryptes elongatus (Cuvier, 1816)***
Pseudogobius javanicus (Bleeker, 1856)***
Rhinogobius sp.***

Remark. In Thailand, many species of goby of the genus *Rhinogobius* still have unclear identifications. Although further studies are certainly needed, nevertheless we believe this taxon to be different from other *Rhinogobius* species of Thailand.

Family BLENNIIDAE Rafinesque, 1810

Istiblennius lineatus (Valenciennes, 1836)***

Family OSPHRONEMIDAE van der Hoeven, 1832

Osphronemus goramy Lacepède, 1801**
Trichopsis pumila (Arnold, 1936)***
Trichopsis vittata (Cuvier, 1831)**
Trichopodus trichopterus (Pallas, 1770)**
Trichopodus pectoralis Regan, 1910***

Family ANABANTIDAE Bonaparte, 1831

Anabas testudineus (Bloch, 1792)**

Family CHANNIDAE Fowler, 1934

Channa striata (Bloch, 1793)**
Channa lucius (Cuvier, 1831)**
Channa micropeltes (Cuvier, 1831)**
Channa cf. ***gachua*** (Hamilton, 1822)*

Remark. In Thailand, the taxonomic status of this taxon is still unclear, being reported from time to time as *C. gachua* or *C. limbata*.

Order PLEURONECTIFORMES Linnaeus, 1758
Family CYNOGLOSSIDAE Jordan, 1888

Cynoglossus puncticeps (Richardson, 1846)***

Order TETRAODONTIFORMES L.S. Berg, 1940
Family TETRAODONTIDAE Bonaparte, 1831

Pao leiurus (Bleeker, 1850)**

CONCLUSION

In this work a total of 11 orders, 41 families and 126 species of fishes were recorded from Petchaburi Basin, Northwest Gulf of Thailand Drainages. In particular 39 species are new records for Phetchaburi Basin.

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A new species of *Setia* H. Adams et A. Adams, 1852 (Prosobranchia Caenogastropoda Rissoidae) from the Mediterranean Sea

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ABSTRACT A new species of *Setia* H. Adams et A. Adams, 1852 (Prosobranchia Caenogastropoda Rissoidae) is here described as new for science. Specimens were found in samples collected in two localities of the Ionic Sea. Here the description and figures of the new species follow, which is compared to the most similar congeners and to species of different genera, which share the cylindrical shape, smooth shell and rounded top-whorl. Biological notes of the environment where the new species was found are added to complete its profile.

KEY WORDS *Setia homerica*; Rissoidae; new species; Recent; Mediterranean Sea.

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INTRODUCTION

The family Rissoidae Gray, 1847 is a hyperdiverse group of gastropods with a worldwide distribution, living from the infralittoral to the bathyal region (Ponder, 1985; Criscione & Ponder, 2013 and herein). In the Mediterranean Sea and along the Atlantic coasts of Europe Rissoidae are extraordinarily represented (Ávila et al., 2012). While some recent contributions utilized molecular data to discriminate generic taxa (Criscione & Ponder, 2013), species are traditionally arranged in genera according to both anatomical and morphological criteria (Ponder, 1985). The last one is based on the general shell shape, size and sculpture, which could range from entirely smooth (*Setia* H. Adams et A. Adams, 1852, *Peringiella* Monterosato, 1878; *Botryphallus* Ponder, 1990; *Pseudosetia* Monterosato, 1884; the subgenus *Ovirissoa* Hedley, 1916 of *Onoba* H. Adams et A. Adams, 1852) to slightly sculptured (*Crisilla* Monterosato, 1917; *Porosalvania* Gofas, 2007; *Gofasia* Bouchet et Warén, 1993; *Rissoa* Desmarest, 1814; *Pusillina* Monterosato, 1884) to cancellate (*Alvania* Risso, 1826).

The species of *Setia* are characterized by minute shells, smooth teleoconch, where only faint growth lines can be detected. Shells are generally colourless with dark strips and/or spots; aperture almost rounded with simple peristome; the protoconch has a dome-shaped shape of about 1 to 1.5 whorls, smooth or with spiral threads. *Setia* seems to be a quite speciose genus, with more than 30 extant species, mainly living in the North East Atlantic Ocean and the Mediterranean Sea (in the latter 17 species are currently known, 10 of which are considered endemic) (Ávila et al., 2012 and herein; Cordeiro & Ávila, 2015; CLEMAM database: Gofas & Le Renard, 2015; WoRMS database: Rosenberg & Gofas, 2015).

In this framework, a single shell of a peculiar, small and smooth rissoid was found in the Jonian Sea (E-Sicily) and reported as "undetermined

Rissoidae" (Scuderi et al., 2006). Other material of the same species were afterwards collected in the same area of the first finding and along the Calabrian side of Strait of Messina. These further specimens allowed us to make a more detailed taxonomic study of this undescribed species, which, due to its morphological features, is assigned to the genus *Setia*.

MATERIAL AND METHODS

The material was picked up from bioclastic bottom samples collected by SCUBA diving. A shell was collected during a benthonic characterisation work in the Gulf of Catania, it was sampled utilising a 15 l Van Veen grab; samples were sifted out and saved in a 4% tamponed formalin solution; they were sorted at the stereoscope in laboratory. Living specimens of other species were collected brushing handily hard substrata and picking crawling animals under stereomicroscope. Shells were studied with a stereomicroscope. Photos were taken with a digital photocamera and Scanning Electron Microscope (SEM). Protoconch whorls are counted following Verduin (1977).

ABBREVIATIONS AND ACRONYMS. AM: Australian Museum, Sydney, Australia; APC: Attilio Pagli collection (Lari, Italy); AVC: Alberto Villari collection (Messina, Italy); CBC: Cesare Bogi collection (Livorno, Italy); DSC: Danilo Scuderi collection (Catania, Italy); NBC: Naturalis Biodiversity Center; NHMB: Naturhistorisches Museum, Bern, Switzerland; RMNH: Rijksmuseum van Natuurlijke Historie (now NCB: Naturalis Biodiversity Center, Leiden, the Netherlands); SBC: Stefano Bartolini collection (Firenze, Italy). UMA: University of Malaga, Malaga, Spain. d: diameter of the nucleus (in µm); D: diameter of the first half whorl of the protoconch (in µm); H: maximum height (in mm); Nwp: number of protoconch whorls; Nwt: number of whorls of the teleoconch; SEM: scanning electron microscope; W: maximum width (in mm);

RESULTS

Sistematics

Class GASTROPODA Cuvier, 1795
Subclass CAENOGASTROPODA Cox, 1960
Superfamily RISSOOIDEA Gray, 1847
Family RISSOIDAE Gray, 1847
Genus *Setia* H. Adams & A. Adams, 1852
Type-species: *Rissoa pulcherrima* Jeffreys, 1848, by subsequent designation (Kobelt, 1878). Recent, Europe.

Setia homerica n. sp. (Figs. 1–9, 12, 16)
Rissoide indet. - Scuderi et al., 2006, p. 647, fig. 2b

EXAMINED MATERIAL. Holotype. Scilla (Reggio Calabria, Italy), 57 m depth, Stefano Bartolini legit, 07-2009, H: 1.78 mm, in MNHN (IM-2000-31233) (Figs. 1, 2). Paratypes. Paratype 1: Scilla (Reggio Calabria, Italy), summer 2007, 48 m depth, H: 1.27 mm, in AM (C.474170) (Figs. 5, 8). Paratypes 2–11: same data of holotype, H: 1.47 to 1.95 mm, in SBC (Figs. 4, 7, 9, 16). Paratypes 12-13: Riposto, N of the harbour, (Catania, Italy, 37°44'464"N, 015°12'561"E), pebble bottom, 6/8 m depth, H: 1.68 (Fig. 3) and 0.55 mm, in DSC. Paratype 14: Riposto, N of the harbor, muddy pebble bottom, 50 m depth, 16.VII.2004, H: 1.60 mm, in DSC (Fig. 6; Scuderi et al., 2006, p. 647, fig. 2b). Paratypes 15–19: same data of paratype 1, H: 1.35 to 1.90 mm, in DSC. Paratypes 21–30: same data of holotype, H: 0.91 to 1.90 mm, in SBC.

OTHER EXAMINED MATERIAL. *Setia antipolitana* (van der Linden et W.M. Wagner, 1987). 1 shell, le Brusc (Toulon, France), 1 m depth, J.H. Hoenselaar legit 09-1988, H: 1.83 mm, in CBC; 1 shell, La Maddalena island (Olbia-Tempio, Sardinia, Italy), 1 m depth, H: 1.85 mm, in CBC; 2 shells, Vernazza (La Spezia, Italy), beached, in DSC; *Cingula antipolitana* holotype (RMNH. MOL.55933), Antibes (Alpes-Maritimens, France), H: 2.05 mm.

Setia ambigua (Brugnone, 1873). More than 100 shells, Porticello (Villa San Giovanni, Reggio Calabria, Italy), 1–2 m depth; 50 shells, Scilla (Reggio Calabria, Italy), 30 m depth, all in SBC.

Setia gittenbergeri (Verduin, 1984). More than 100 shells, Tarifa (Spain), 20 m depth, in SBC.

Setia scillae (Aradas et Benoit, 1876). More than 100 shells, Capo Peloro (Messina, Sicily, Italy), 40 m depth; more than 100 shells, Cannitello (Villa San Giovanni, Reggio Calabria, Italy), 40 m depth, all in SBC; one living specimen and 2 shells, Messina harbor (Sicily, Italy), among algae on breakwaters, -2/6 m depth, AVC and DSC.

Setia turriculata Monterosato, 1884. More than 50 shells, Vada (Rosignano Marittimo, Livorno, Italy), 1 m depth; 20 shells, Porto Palo (Siracusa, Sicily, Italy), 1 m depth; 20 shells, Filicudi Island (Messina, Sicily, Italy), 30 m depth, all in SBC.

Cingula nikolarianae Oberling, 1970. NHMB, Lectotype (NMBE.21186), Malia (Crete, Greece), H: 1.7 mm.

DESCRIPTION OF HOLOTYPE. Shell (Figs. 1–6) small, slender, ovate-subconical, rather thin. Height 1.78 mm, width 0.95 mm. Protoconch (Figs. 7, 8, 12) completely smooth, dome-shaped, 1.1 whorls, diameter 345 μm, separated from the teleoconch by a marked scar, often the protoconch-teleoconch border is characterized by a shallow depression of the spire. Teleoconch with 2.8 convex whorls, with maximum curvature just under the middle of the whorl. Sculpture absent, except for faint prosocline axial growth lines. Suture quite deep, in fresh specimens is visible a “false suture” marking the internal contact between the whorls. Spire moderately high, whorls have conspicuous increase in size. Last whorl large, inflated but not globose, cylindrical, 71% of shell length. Base rounded, slightly curving, almost straight in some specimens. Aperture large, oval, drop-shaped, oblique with continuous and simple peristome (not thickened, smooth inside) and posterior angulation. Parietal and columellar regions rather straight or gently angulated. Outer lip well rounded. Seen from aside, the edge of the outer lip is orthocline, gently curved in the middle, and straight or shallow concave near the suture. It is clearly reflexed outwards (Fig. 9). Umbilicus reduced to a very narrow chink.

The colour of the protoconch is uniformly brownish to light violet, the nucleus being darker. Fresh shells are transparent with a background colour whitish or yellowish, while older are almost whitish opaque. Teleoconch shows a pattern of elongated, longitudinal and irregular strips of red-brownish tinge running from suture to suture and reaching the periumbilical zone (Fig. 6).

VARIABILITY. Paratypes shell: height 1.47–1.95 mm, width 0.83–1.03 mm, protoconch with 1.0–1.1 whorls, diameter 340–345 μm, teleoconch with 2.5 to 3 convex whorls, last 70–73% of shell length. The size of mature shells range from 1.43 mm to 1.97 mm; the general outline as well as the convexity of the whorls can be more or less slender. In larger shells the aperture, in frontal view, exceeds the spire outline (Fig. 1). Some shells have some stronger growth lines, others are almost smooth. The colour is quite variable, some shells are uniformly whitish or yellowish (Fig. 16), the colour pattern can be more or less sharp. Soft parts are unknown.

ETYMOLOGY. After the Greek poet Homer, who in the Odyssey dealt with the two Sicilian and Calabrian localities which constitute two of the classic places of the mythical Ulysses' journey and where material of this species was found.

BIOLOGY AND DISTRIBUTION. No living material was collected and most of the shells were found in shell grit from coralligenous bottoms at 48–57 m depth. Further dead specimens were found in materials from an ecotone between coastal detritical and muddy bottom biocenosis, as desumed by the associated species, such as *Anadara gibbosa* (Reeve, 1844), *Thyasira biplicata* (Philippi,1836), *Mysella bidentate* (Montagu, 1803), *Plagiocardium papillosum* (Poli, 1795), *Tellina donacina* (Linnaeus,1767), *Abra nitida* (O.F. Müller, 1776), *Timoclea ovata* (Pennant, 1777). Notwithstanding these findings, the species is likely associated to the algal film on the pebbles of the lower littoral zone, commonly present in the Northern Ionian Sea. This could be inferred by the finding, along the Northern coast of Catania, of some fresh-collected specimens of the new species in materials from 6-8 m depth, associated with numerous specimens of the congener *S. turriculata* and, by analogy, by recent observations of one of us (DS) on the habit of the similar congener *S. scillae.*

This species is known only from the Messina Strait and the Eastern coast of Sicily. The Messina Strait has been considered a separate Mediterranean biogeographical microsector, inhabited by rich benthic communities and some particular assemblages that are unknown in other Mediterranean regions (Guglielmo et al. ed., 1991; Bianchi, 2004; Giacobbe et al., 2007), with characteristic malacofauna including endemic or subendemic taxa (Vazzana, 2010; Smriglio & Mariottini, 2013).

COMPARATIVE NOTES. *Setia homerica* n. sp. can only be compared with few congeners and similarly shaped Rissoidae taxa. The most similar species is *S. antipolitana* (Figs. 10, 13), which has a more conical, slender, straight-sided shell; whorls less convex; the apex is smaller (d/D: 120/200 μm vs. 145/255 μm in *S. homerica*), with a very dark, often comma-shaped spot. The outer lip is thickened, prosocline and seen from aside appears straight. The color pattern is composed by two rows of spots, the adapical ones elongated, the abapical shorter. *Setia antipolitana* is distributed in the northern part of the Western Mediterranena Sea, from Bouches-du-Rhône to Liguria (van der Linden J. & Wagner, 1987; Giannuzzi-Savelli et al., 1997; Buzzurro et al., 1999). Here we report our finding of a single, beached shell from Northern Sardinia that seems to confirm its distributional area, being the record from Malta by Cachia et al. (1993) to be confirmed.

Setia ambigua (Fig. 11) is more slender with a more pointed protoconch with small apical stain; the aperture is smaller, the whorls are very convex and the color pattern is different (Verduin, 1984; Reina & Giannuzzi Savelli, 1985).

Setia scillae (Fig. 17) and *S. gittenbergeri*, sometimes regarded as synonyms, are similar to *S. homerica* n. sp. but differ by the smaller size, more convex whorls, different color pattern, smaller and less globose protoconch (without darker stains), the outer lip is very flexuous (Verduin, 1984; Gaglini, 1994; Gofas et al., 2011).

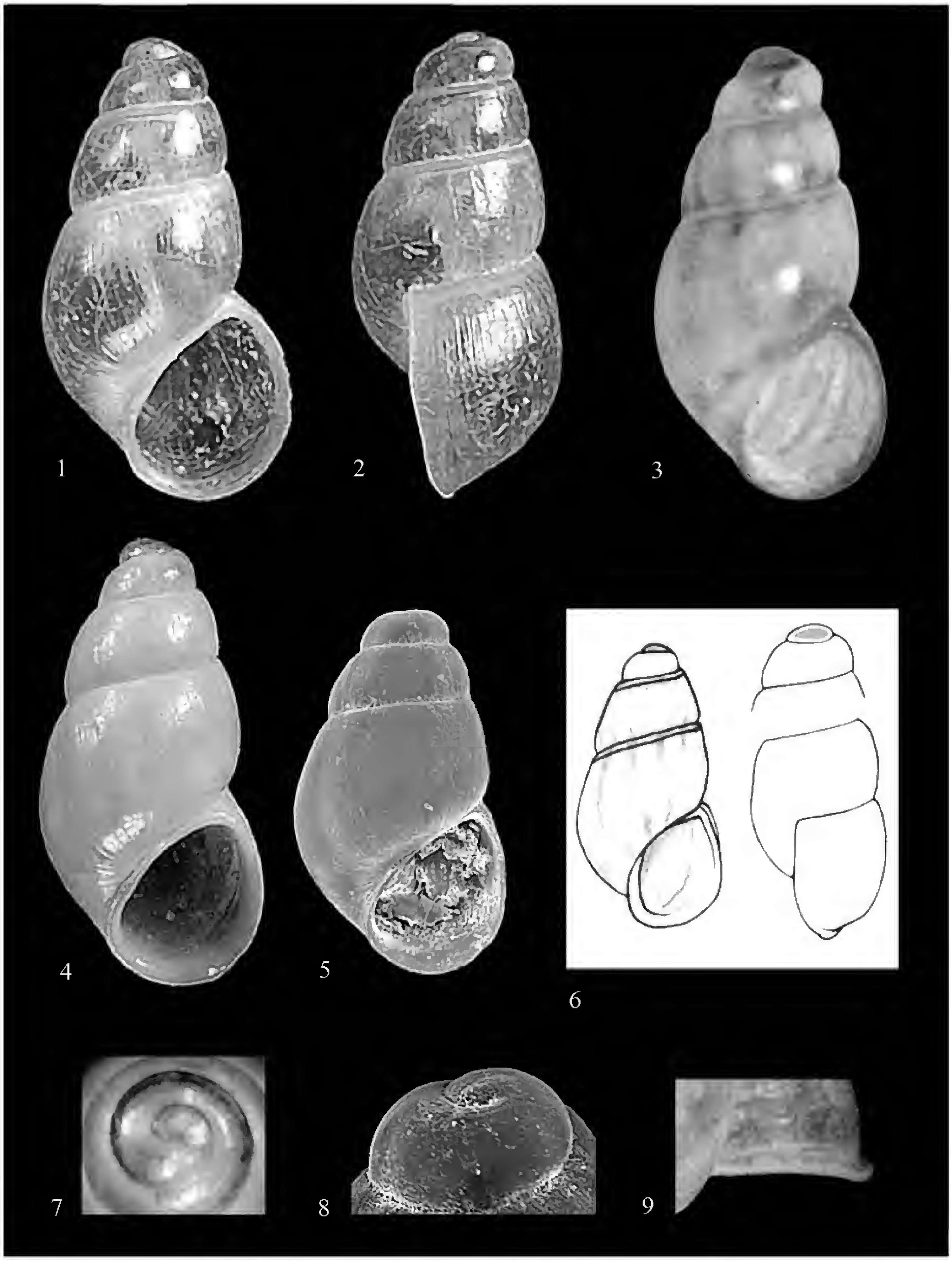
Setia fusca (Philippi, 1841) and *S. turriculata*, whose taxonomical status as separated species is also debated, share with the new species an oblique columella, but they have more turriculated shells with well-rounded whorls; the umbilicus is well developed; the colour pattern is very variable but never joins up that of *S. homerica* n. sp.; the aperture is less wide, squared; the protoconch is similar but is sculptured (van Aartsen & Verduin, 1978; Verduin, 1984; Gofas et al., 2011).

S. sciutiana (Aradas et Benoit, 1870) is currently placed among nomina dubia (CLEMAM), notwithstanding Gaglini (1994) redescribed and figured the type material demonstrating the validity of the species. However, according to the description and figure of this latter Author, this species is characterised by a shell with a different general outline, conical and not cylindrical, with more rounded whorls, a different set of stains and a protoconch less globose; mouth wide, not so inclined as *S. homerica* n. sp.; the umbilicus is almost lacking but a narrow chink is often present on a more rounded base of the shell; the colour pattern is different. Among Macaronesian and South Iberian species, *S. alboranensis* Peñas et Rolán, 2006 which seems to have a distribution restricted to Alboran, has a more conical outline, convex whorls, outer lip very flexuous and the protoconch is similar in shape and size but is sculptured by thin spiral lirae; the color is almost uniformly whitish (Peñas et al., 2006; Gofas et al., 2011).

Setia jansseni (Verduin, 1984) and *Setia lidyae* Verduin, 1988 are smaller and more ovoidal in outline, while *Setia nicoleae* Segers, Swinnen et De Prins, 2009 and *Setia subvaricosa* Gofas, 1990 are more conical. All these species have protoconchs sculptered with spiral threads, the color patterns are also different from *S. homerica* n. sp. (Verduin, 1984, 1988; Gofas, 1990; Segers et al., 2009; Rolán, 2011). Some few rissoids, different from *Setia*, could recall the new species for an almost smooth shell, the flattened whorls and the shape of mouth and are here compared. *Cingula nikolarianae* nowadays reported as a junior synonym of *Hyala vitrea* (Montagu, 1803) (WoRMS database: Rosenberg & Gofas, 2015), resemble the new species for the unsculptured surface of the shell and the oblique columella.

The examination of the lectotype (NHMB, NMBE21186) (Figs. 14, 15) revealed numerous differences: first of all its completely white colour, lacking both the apical and labial stains, a different general outline with more rounded whorl, and a larger protoconch. We have doubts concerning the correct collocation of this species in the genus *Onoba* by Moolenbeek et al. (1991). Some other species, which belong to the genera *Bothryphallus, Peringiella* and *Pseudosetia*, have smooth shells and could superficially recall the general shape of the new species, but they are all colourless and reveal important differences at a deeper examination of the shell morphology.

As concerns fossil species, *S. homerica* n. sp. at a preliminary exam has a superficial resemblance with *Rissostomia gravitellensis* Aradas, 1847 for the absence of sculpture and the internal lip slightly oblique, but the latter species is bigger and more solid, with a different protoconch. The new species could be more usefully compared with *Setia conoidea* (Seguenza L., 1903), a thin-shelled rissoid which has a more conical shape and well rounded whorls (Seguenza L., 1903).



Figures 1–9. *Setia homerica* n. sp., Scilla, Reggio Calabria, Italy. Figs. 1, 2: holotype, H 1.78 mm, (MNHN IM-2000-31233); Fig. 1: shell, frontal view; Fig. 2: shell, lateral view. Fig. 3: Paratype 12, H 1.68 mm, in DSC. Fig. 4: paratype 3, H 1.75 mm, in SBC. Figs. 5, 8: paratype 1, H 1.27 mm, in AM (C.474170). Fig. 6: schematic drawing of paratype 14, H 1.60 mm, in DSC. Figs. 7, 9: paratype 2, H 1.95 mm, in SBC; 9: outer lip in apical view.

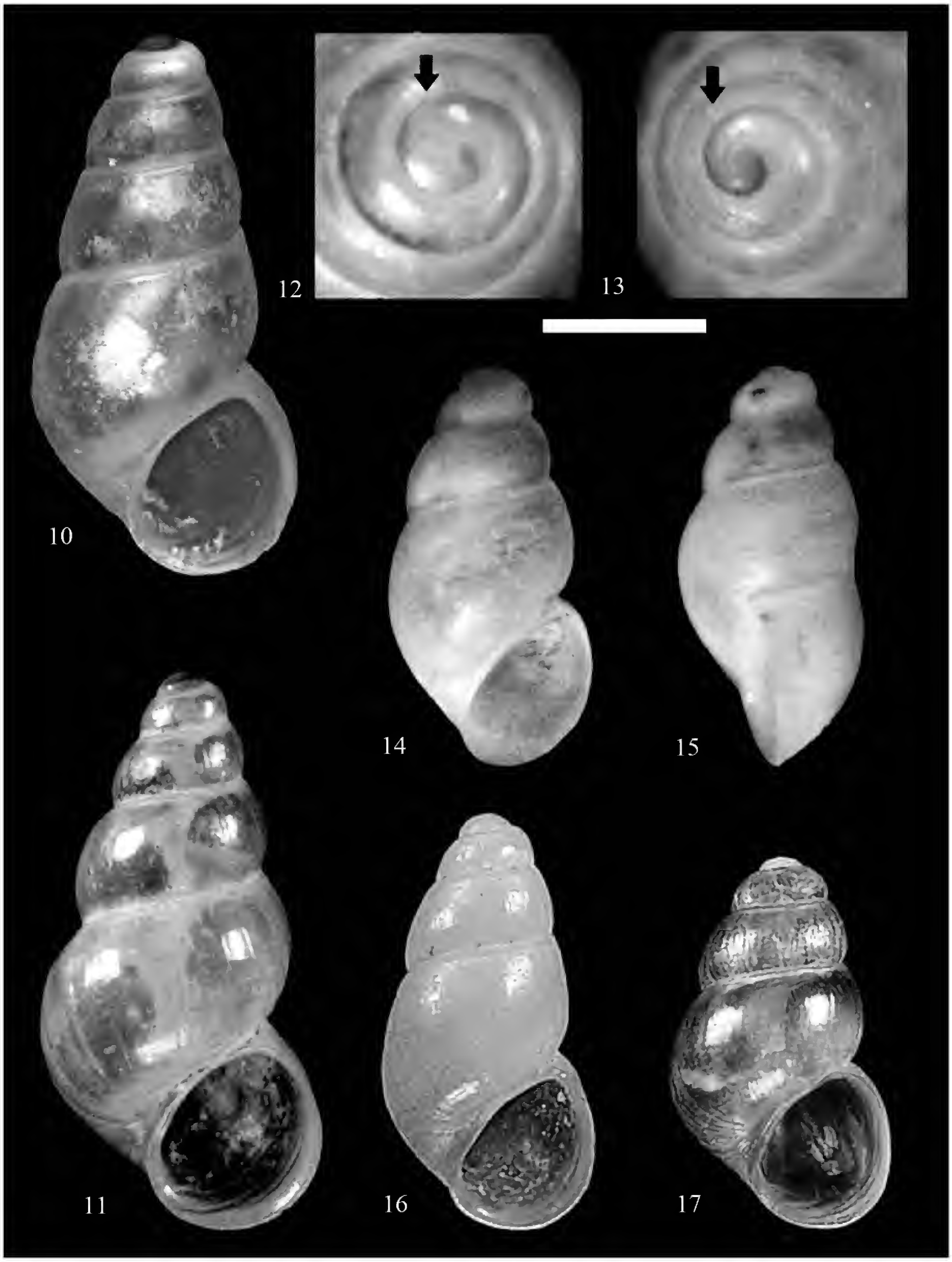


Figure 10: *Setia antipolitana* holotype, Antibes (France), H 2.05 mm. Fig. 11: *S. ambigua*, Scilla, Reggio Calabria, Italy, H 2.00 mm. 12: *S. homerica* n. sp., holotype, protoconch. Fig. 13: *S. antipolitana*,Toulon, France, H 1.83 mm, protoconch. (scale bar 200 µm, black arrow: protoconch-teleoconch border). Figs. 14, 15: *Cingula nikolarianae*, lectotype, H 1.70 mm (NMBE.21186). Fig. 16: *Setia homerica* n. sp., paratype 4, H 1.65 mm, in SBC. Fig. 17: *S. scillae*, Scilla, Reggio Calabria, Italy, H 1.30 mm.

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Reconciling the molecular clock and biogeography: an alternative view of the divergence process between *Allognathus* Pilsbry, 1888 and *Hemicycla* Swainson, 1840 (Pulmonata Helicidae)

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ABSTRACT The fragmentation of the Hercynian shield, which occurred between the Oligocene and Miocene explains satisfactorily the process of divergence between the Helicoidea genus *Allognathus* (endemic to the Balearic Islands) and *Hemicycla* Swainson, 1840 (endemic to the Canary Islands). The process of divergence of the common ancestor of *Allognathus* Pilsbry, 1888 and *Hemicycla* began with the separation of the Balearic islands and Kabylias. Our alternative biogeographic hypotheses suggest that the ancestor of *Hemicycla* colonized the Canary Islands from North Africa, once the Kabylias joined the African continent.

KEY WORDS Hercynian shield; Balearic and Canary Islands; Kabylias; North African malacofauna.

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INTRODUCTION

In a recent study on the Helicoidea of the western Palaearctic, Razkin et al. (2015) considered that extant genera *Allognathus* Pilsbry, 1888 (endemic to the Balearic Islands) and *Hemicycla* Swainson, 1840 (exclusive to the Canary Islands) are sister taxa and estimated their divergence age at 9.1 Ma. (Tortonian, late Miocene).

Based on the molecular clock, Chueca et al. (2015) considered that the divergence between these genera occurred somewhat earlier, during the Langhian-Serravalian (ie, in the middle Miocene, ca, 15.97-11.60 Ma), and they proposed that the Iberian Peninsula or the Balearic Islands were the geographical areas from which the ancestor of *Hemicycla* colonized the Canary Islands. The biogeographic hypothesis of Chueca et al. (2015) is based exclusively on the average divergence time estimated from the molecular clock, and hence it does not take into account the age uncertainty as defined by the maximum and minimum range of estimates. This may be correct from a methodological view point, but should not be taken as the exclusive basis for a biogeographical hypothesis on the origin of *Hemicycla*, especially since it contradicts currently available palaeogeographic data. Genetic changes do not necessarily accumulate steadily over time and at the same rate along various lineages depending on many factors and circumstances (Pulquério & Nichols, 2006). Thus, when evaluating alternative biogeographic hypotheses, the molecular clock should be considered as one among various sources of data. It needs to be reconciled with other data, as illustrated by the contrasting results obtained by Razkin et al. (2015) and Chueca et al. (2015). In particular, the events that define the palaeogeographic evolution of a given area must not be ignored, but rather taken as the reference starting point when proposing a biogeographic hypothesis.

In our opinion, the biogeographic hypothesis favored by Chueca et al. (2015) about the origin of *Hemicycla* relies on a too recent divergence time between *Allognathus* and *Hemicycla* and consequently, it does not adequately explain the area from which the ancestor of *Hemicycla* colonized the Canary Islands.

Here we propose an alternative biogeographic hypothesis on the origin of *Hemicycla* that is based on the previous works by Esu & Kotsakis (1983), Bourrouilh (1983), Gelabert et al. (2002), Rosenbaum et al. (2002) and Waldén (1984).

AN ALTERNATIVE BIOGEOGRAPHICAL HYPOTHESIS

The last common ancestor of *Allognathus*, *Hemicycla*, *Pseudotachea* Boettger, 1909 and *Iberus* Montfort, 1810 (Chueca et al., 2015: see Figure 4) would have inhabited the northern part of the western Mediterranean during the Oligocene, before fragmentation of the Hercynian shield (into the blocks corresponding to the Balearics, Kabylias, Rif-Betic cordillera, Corsica, Sardinia and Calabria) began (Esu & Kotsakis, 1983; Rosenbaum et al., 2002). This fragmentation, which occurred during the Oligocene and Miocene, would have resulted in the divergence of the clade including *Pseudotachea* and *Iberus* (inhabiting the Iberian Peninsula area) from that including *Allognathus* and *Hemicycla*, according with the molecular study of Chueca et al. (2015: see fig. 4). In accordance to this, the common ancestor of *Allognathus* and *Hemicycla* would

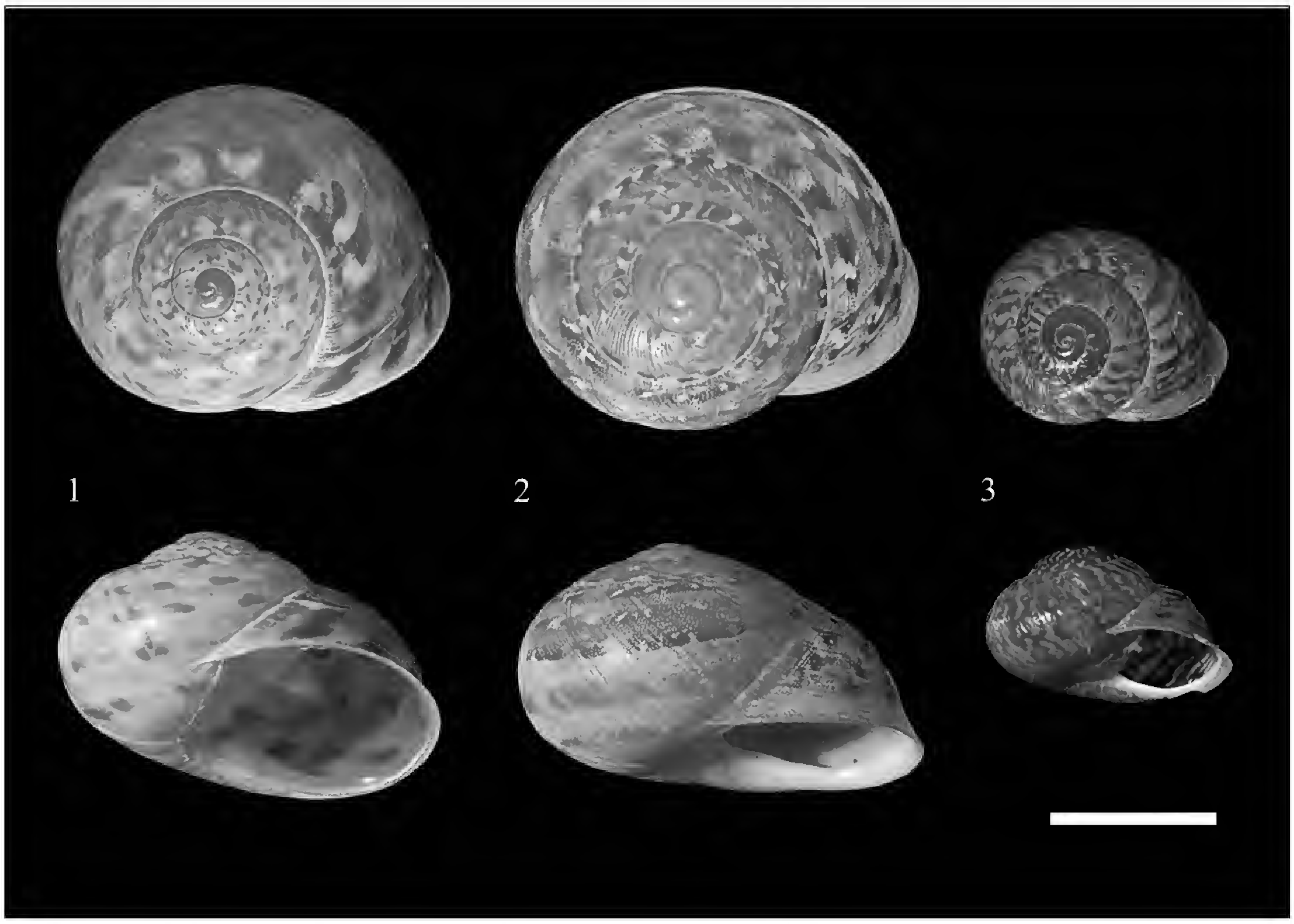

Figure1. *Allognathus* (*Allognathus*) *graellsianus* (Pfeiffer, 1848) from Pollença (Mallorca). Figure 2. *Alabastrina* (*Loxana*) *beaumieri* (Mousson, 1873) from Ait Atab (High Atlas, Morocco). Figure1. *Hemicycla laurijona* Alonso et Ibáñez, 2007 from La Gomera (Canary Islands). Scale: 10 mm.

have occupied the geographical area constituted by the Balearic Islands and the Kabylian block (see Esu & Kotsakis, 1983: fig. 2). The divergence between these genera would thus have resulted from the separation of these two blocks, which occurred in the early Miocene (Bourrouilh, 1983: p. 593). According to this scenario, the ancestor of *Hemicycla* would have colonized the Canary Islands from North Africa, once the Kabylian block joined the African continent during the early to middle Miocene (Esu & Kotsakis, 1983).

Unlike in other Macaronesian archipelagos, part of the Canary malacofauna (17%) shows affinities with the terrestrial molluscs of northwestern Africa (Waldén, 1984). According to this author, in the eastern Canary Islands there would have been an ancient continental malacofauna that was subsequently partly destroyed due to extensive volcanism during the late Tertiary (while the western islands were being formed). Many of the extant endemic species from the Canary Islands apparently evolved from immigrant species that dispersed from northwestern Africa and Madeira, during the late Tertiary. The colonization of Madeira by European Tertiary taxa (there are no fossil taxa of African origin in this archipelago) could have taken place during the middle Miocene, although an early colonization in the Oligocene, when the archipelago was considerably farther from Africa, seems more likely (Waldén, 1984). If correct, this conclusion is incompatible with the divergence time between *Allognathus* and *Hemicycla* proposed by Chueca et al. (2015).

CONCLUSIONS

According to Chueca et al. (2015): "*The position of* Hemicycla *as the sister group of* Allognathus *makes it difficult to pinpoint the colonization age of the Balearic Islands by* Allognathus. Hemicycla *is endemic to the Canary Islands, and there are no fossil records of* Hemicycla *in the Iberian Peninsula or the Balearic Islands*". Such claim is somewhat surprising, because Chueca et al. (2015) do not contemplate the possibility that *Hemicycla* diverged from a western Palaearctic helicid not included in their cladogram.

The alternative biogeographic hypothesis proposed here does not require this fossil record, since it is based on the progressive fragmentation of the Hercynian shield as the main event that determined the divergence between *Allognathus* and *Hemicycla*. According to our hypothesis, one may expect to find the common ancestors of *Pseudotachea+Iberus* as well as *Allognathus+Hemicycla* in the fossil record of the Iberian Peninsula and the Balearic Islands. In contrast, our hypothesis is incompatible with the presence of fossil *Hemicycla* in these two geographical areas.

Based on the palaeobiogeographical hypothesis proposed above, the divergence times proposed by Chueca et al. (2015: fig. 4) for *Allognathus* and *Hemicycla* (as well as the common ancestors of *Pseudotachea+Iberus* and *Allognathus+Hemicycla*) are too recent. Instead, the divergence between *Allognathus* and *Hemicycla*, and the arrival of the *Hemicycla* ancestor to the Canary Islands from northwest Africa would have occurred earlier, sometime between the late Oligocene and early to middle Miocene. The absence of the ancestor of *Hemicycla* from the North African fossil record might be attributed to an insufficient knowledge of the fossil land snails from this area, as suggested by Waldén (1984). This is supported by the anatomical similarities between *Allognathus* and some extant terrestrial molluscs from North Africa, such as *Alabastrina* (*Loxana*) *beaumieri* (Mousson, 1873) as already noted by Hesse (1931).

We therefore agree with Forés & Vilella (1993) that more in-depth studies on the phylogenetic relationships between North African genera would be required to shed more light on the biogeographic history of *Allognathus*, *Hemicycla* and the Canary Island's malacofauna.

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MONOGRAPH

Checklist of the littoral gastropods (Mollusca Gastropoda) from the Archipelago of the Azores (NE Atlantic)

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ABSTRACT The littoral gastropods (Mollusca Gastropoda) are probably the best known marine invertebrates in the Azores. Recently, this fauna has been studied by several authors, resulting in a regular increase of the knowledge of its biodiversity. However, the data are scattered by numerous publications, making it clear the need of an updated checklist of the littoral gastropods from the Azores. Our study presents a checklist of the littoral gastropods from the Azores, based on data from the literature and from new material examined. The occurrence of *Caecum gofasi*, *Cerithiopsis* cf. *nana*, *Curveulima dautzenbergi*, *Liostomia mamoi*, *Mangelia scabrida*, and *Rissoella contrerasi* is reported for the first time. Our findings expand the known regional biodiversity of littoral gastropods to 281 species. A list of dubious records and misidentifications is also presented, as well as the reasons for the exclusion of these species from the checklist.

KEY WORDS Azores; Gastropoda; littoral; Mollusca; NE Atlantic.

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INTRODUCTION

The marine molluscs (Mollusca Gastropoda) of the Archipelago of the Azores (located in the Northeast Atlantic Ocean, see Fig. 1) have received greater attention from the second half of the 19th century on, as a result of major scientific expeditions (see MacAndrew, 1857; Drouët, 1858; Watson, 1886; Simroth, 1888; Dautzenberg, 1889). During the 20th century a number of publications have also addressed this subject (see Ávila, 2000a, 2000b, 2005 and references therein). Ávila (2005; PhD thesis not published) summarized the knowledge about the marine molluscs of the Azores until that moment, counting 227 littoral gastropod species. The Azorean littoral gastropods have been addressed by several authors in the last years, with a regular increase of the knowledge of its biodiversity, as a result of new records and description of new species (Chan & Gosliner, 2007; Aartsen, 2008; Nolt, 2008; Malaquias et al., 2009; Martins et al., 2009; Ávila et al., 2011; Malaquias et al., 2011; Pedro et al., 2011; Cordeiro et al., 2013; Hart & Wirtz, 2013; Jensen, 2014; Malaquias et al., 2014). More recently, Cordeiro & Ávila (2015) described four new rissoid species, Rubio et al. (2015) described a new *Parviturbo* species and Ávila et al. (2015) reported the occurrence of a newly-established trochid in Santa Maria Island. Consequently, the littoral gastropods are probably the best known marine invertebrates in the Azores. However, as evidenced above, the data are scattered by numerous publications, making it clear the need of an updated checklist of the littoral gastropods from the Azores.

Up-to-date lists of species from a given geographic area are of primary importance for any study related with biodiversity, ecology, biogeography, and conservation management.

MATERIAL AND METHODS

The compilation of the checklist of the littoral gastropods from the Azores (here defined as the benthic gastropod species living from the intertidal down to 50 m depth) was carried out through a careful literature review. The references published since the first report on the Azorean marine molluscs written by MacAndrew (1857) were reviewed by Ávila et al. (1998), Ávila (2000b), Ávila et al. (2000a), Ávila et al. (2000b) and Ávila et al. (2004), and a preliminary checklist was assembled by Ávila (2005). This checklist was analysed and complemented with the following reports from 2006 on: Oliverio & Gofas (2006), Chan & Gosliner (2007), Aartsen (2008), Nolt (2008), Malaquias et al. (2009), Martins et al. (2009), Segers et al. (2009), Malaquias et al. (2011), Moreno (2011), Pedro et al. (2011), Geiger (2012), Cordeiro et al. (2013), Hart & Wirtz (2013), Jensen (2014), Malaquias et al. (2014), Cordeiro & Ávila (2015), and Rubio et al. (2015). An analysis of the marine mollusc collection held by the Department of Biology of the University of the Azores (DBUA) was also performed and a total of 1142 lots containing thousands of specimens were examined. DBUA specimens analysed in the present study were obtained from samples collected by about 850 dives and dredges in all islands and main seamounts of the Azores, between the years 1967 and 2015, from the intertidal down to 50 m depth. Additionally, the Natural History Museum of Rotterdam mollusc

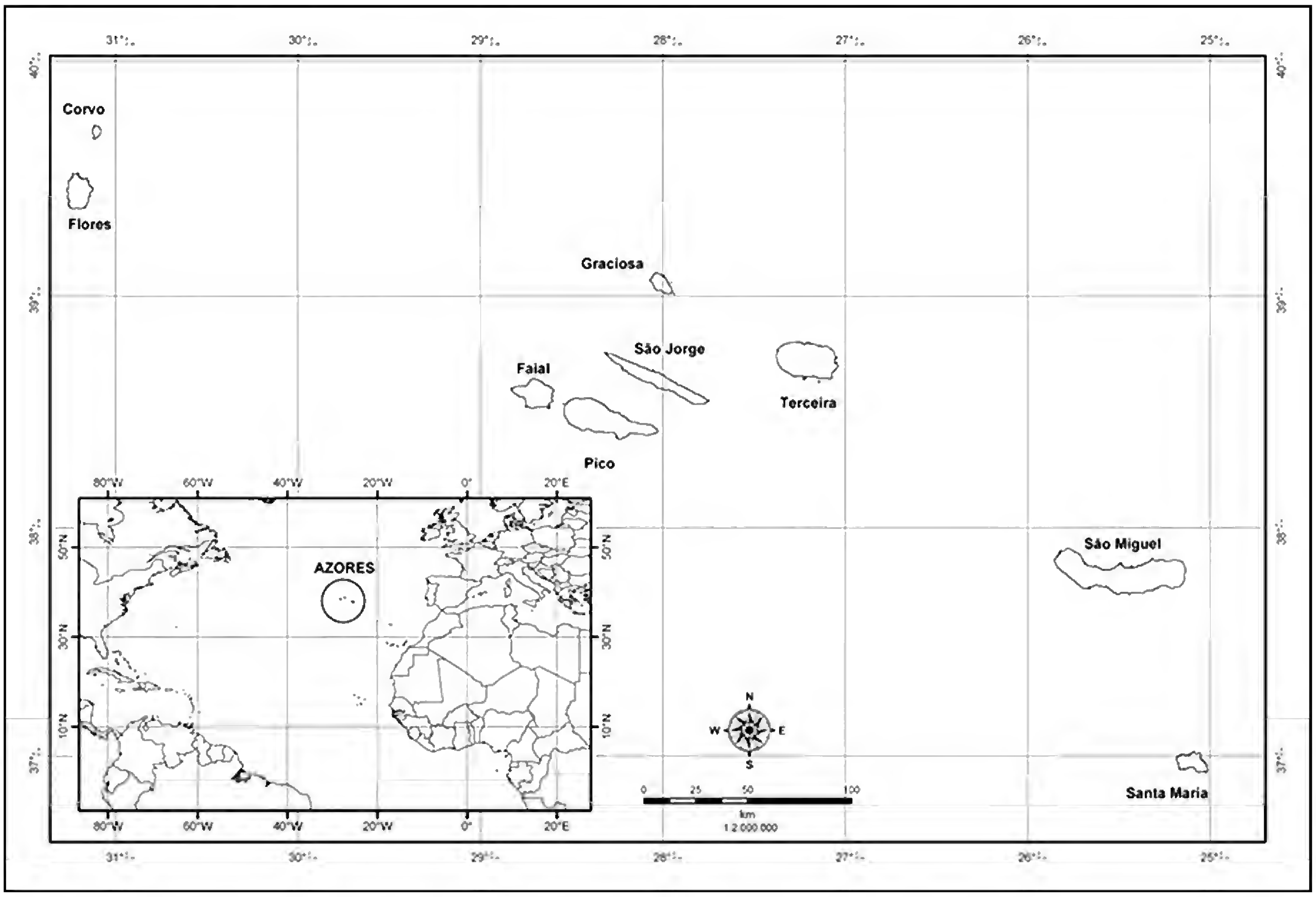


Figure 1. Archipelago of the Azores, located in the Northeast Atlantic Ocean.

collection (NMR) was consulted through its dedicated website at URL: www.nmr-pics.nl.

For confirmation of the identifications, and whenever possible, the shells of specimens believed to be new species' records were sonicated, coated with Au-Pd in a vacuum evaporator JEOL JEE 400, and then photographed with a JEOL JFM-5410 Scanning Electron Microscope (SEM) at the Department of Biologyof the University of the Azores. Alternatively, they were photographed using a Nikon SMZ1000 stereomicroscope with a Nikon D200 digital camera attached.

The systematic position of the families presented in the checklist follows Bouchet & Rocroi (2005). The taxonomy and nomenclature used follows World Register of Marine Species (WoRMS Editorial Board, 2015).

ABREVIATION AND ACRONYMS. Geographic range within the North-Atlantic Ocean and the Mediterranean Sea: GRE: Greenland; SCA: Scandinavia; BRI: British Isles; POR: mainland Portugal; MED: Mediterranean Sea; AZO: Archipelago of the Azores; MAD: Archipelago of Madeira; CAN: Canary Islands; CAP: Cape Verde; NWA: Northwest Africa; NSC: New Scotia, Canada; VIR: Virginia, USA; CRL: North and South Carolina, USA; GME: Gulf of Mexico; CAR: Caribbean Sea. Record type: LIT: Literature; VOU: Collection voucher.

RESULTS

A checklist of the littoral gastropods from the Azores is herein presented, based on data from the literature and from material examined (Table 1).

Our work documents for the first time the occurrence of six littoral gastropods in the Azores (Figs. 2–11):

i) *Caecum gofasi* Pizzini et Nofroni, 2001: DBUA 355/13 - Formigas Islets, 15 m depth, 03/07/1991; DBUA 662/19 - Lajes, Pico Island, 3 m depth, 07/08/1995; and DBUA 1096 - Angra do Heroísmo, Terceira Island, intertidal, 07/1967.

ii) *Cerithiopsis* cf. *nana* Jeffreys, 1867: DBUA 560/9 - Baixa do Porto, Flores Island, 10 m depth, 27/10/1990; DBUA 707/1 - Capelas, São Miguel Island, 3.5 m depth, 19/07/1996; and DBUA 748/12 - Capelas, São Miguel Island, 14 m depth, 07/10/1996.

iii) *Curveulima dautzenbergi* (Pallary, 1900): NMR 32213 - Lajes, Pico Island, intertidal, 07/2001.

iv) *Liostomia mamoi* Mifsud, 1993: DBUA 499/1 - Lajes, Pico Island, 1 m depth, 27/06/1991.

v) *Mangelia scabrida* Monterosato, 1890: NMR 34350 - Vila Franca do Campo Islet, São Miguel Island, 2 m depth, 08/2002.

vi) *Rissoella contrerasi* Rolán et Hernández, 2004 : DBUA 48/2 - Baía da Folga, Graciosa Island, 5 m depth, 06/1988; DBUA 195/8 - Santa Cruz, Flores Island, intertidal, 09/07/1989; DBUA 352/9 - Formigas Islets, intertidal, 05/06/1990; DBUA 730/18 - Baía de Belém, São Miguel Island, 8.6 m depth, 04/07/1990; DBUA 898/2 - Atalhada, São Miguel Island, 11.2 m depth, 10/10/1996; and DBUA 1018/4 - Vila do Porto Islet, Santa Maria Island, 17 m depth, 26/08/2004.

A thorough review of the literature allowed excluding from the checklist a total of 53 dubious records or misidentifications (Table 2).

CHECK LIST

Family PATELLIDAE Rafinesque, 1815

Patella aspera Röding, 1798

Geographic range. AZO, MAD, CAN, NWA.
Depth range. 0–15 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Patella nigrosquamosa* Dunker (Variet. *minor*).

Patella candei d'Orbigny, 1840

Geographic range. AZO, MAD, CAN.
Depth range. 0–5 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Patella vulgata* Linnaeus.

Family LOTTIIDAE Gray, 1840

Tectura virginea (O.F. Müller, 1776)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–100 m.
Record type. LIT/VOU.
First record. Jeffreys (1882)

Family LEPETIDAE Gray, 1850

Propilidium exiguum (W. Thompson, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 7–600 m.
Record type. LIT/VOU.
First record. Dautzenberg & Fischer (1896) as *Propilidium bavayi* Dautzenberg et H. Fischer.

Family HALIOTIDAE Rafinesque, 1815

Haliotis tuberculata Linnaeus, 1758
Geographic range. BRI, POR, MED, AZO, CAN, NWA.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. MacAndrew (1857).

Family SCISSURELLIDAE Gray, 1847

Scissurella azorensis Nolt, 2008

Geographic range. MED, AZO.
Depth range. 0–145 m.
Record type. LIT.
First record. Nolt (2008).

Scissurella lobini (Burnay et Rolán, 1990)

Geographic range. AZO, CAN, CAP.
Depth range. 32–785 m.
Record type. LIT.
First record. Geiger (2012).

Sinezona cingulata (O.G. Costa, 1861)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–60 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Schismope fayalensis* nov. sp.

Family ANATOMIDAE McLean, 1989

Anatoma aspera (Philippi, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA, CAR.
Depth range. 10–720 m.
Record type. LIT.
First record. Segers et al. (2009) as *Anatoma crispata* (Fleming, 1828).

Anatoma crispata (Fleming, 1828)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, NWA, NSC.
Depth range. 100–3000 m.
Record type. LIT.
First record. Jeffreys (1883) as *Scissurella crispata* Fleming.

Anatoma janusa Geiger, 2012

Geographic range. AZO, NWA.
Depth range. 0–1 m.
Record type. LIT.
First record. Geiger (2012).

Family TROCHIDAE Rafinesque, 1815

Clelandella azorica Gofas, 2005

Geographic range. Endemic AZO
Depth range. 30–360 m.
Record type. LIT.
First record. Dautzenberg (1927) as *Trochus miliaris* Brocchi.
Remarks. Described by Gofas (2005).

Gibbula delgadensis Nordsieck, 1982

Geographic range. Endemic AZO.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. Nordsieck (1982).

Gibbula magus (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 5–70 m.
Record type. LIT/VOU.
First record. Drouët (1858) as T*rochus magus* Linnaeus.

Jujubinus pseudogravinae Nordsieck, 1973

Geographic range. Endemic AZO.
Depth range. 0–80 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Trochus striatus* Linnaeus.
Remarks. Described by Nordsieck (1973).

Phorcus sauciatus (Koch, 1845)

Geographic range. Cryptogenic. POR, AZO, MAD, CAN.
Depth range. 0–1 m.
Record type. LIT/VOU.
First record. Ávila et al. (2015).

Family CALLIOSTOMATIDAE Thiele, 1924 (1847)

Calliostoma lividum (Dautzenberg, 1927)

Geographic range. Endemic AZO.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as T*rochus zizyphinus* Linnaeus.
Remarks. Described by Dautzenberg (1927), as *Calliostoma conulus* var. *livida*.

Family SKENEIDAE Clark W., 1851

Parviturbo azoricus Rubio, Rolán et Segers, 2015

Geographic range. Endemic AZO.
Depth range. 0–35 m.
Record type. LIT/VOU.
First record. Segers (2002) as *Parviturbo* cf. *rolani* Engl, 2001.
Remarks. Described by Rubio et al. (2015).

Family PHASIANELLIDAE Swainson, 1840

Tricolia pullus azorica (Dautzenberg, 1889)

Geographic range. Endemic AZO.
Depth range. 0–35 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Phasianella pullus* Linnaeus.
Remarks. Described by Dautzenberg (1889).

Family CERITHIIDAE Fleming, 1822

Bittium nanum (Mayer, 1864)

Geographic range. Endemic AZO.
Depth range. 0–50 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Cerithium reticulatum* Costa.
Remarks. Described by Mayer (1864) as *Cerithiopsis nana* (fossil). Restored as valid species and redescribed by Moreno (2011).

Family LITIOPIDAE Gray, 1847

Litiopa melanostoma Rang, 1829

Geographic range. AZO, CRL, GME, CAR.
Depth range. 0–32 m.
First record. Drouët (1858) as *Litiopa grateloupeana* nov. sp.

Family PLANAXIDAE Gray, 1850

Fossarus ambiguus (Linnaeus, 1758)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, CAR.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Fossarus adansoni* Philippi.

Family CYPRAEIDAE Rafinesque, 1815

Luria lurida (Linnaeus, 1758)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–60 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Cypraea lurida* Linnaeus.

Family LITTORINIDAE Children, 1834

Littorina saxatilis (Olivi, 1792)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, MAD, CAN, NWA, NSC, VIR.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Reid (1996) as *Littorina* (*Neritrema*) *saxatilis* (Olivi, 1792).

Melarhaphe neritoides (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Littorina caerulescens* Lamarck.

Tectarius striatus (King, 1832)

Geographic range. AZO, MAD, CAN, CAP.
Depth range. 0 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Littorina striata*.

Family SKENEOPSIDAE Iredale, 1915

Skeneopsis planorbis (O. Fabricius, 1780)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, MAD, CAN, NWA, NSC, VIR, CRL.
Depth range. 0–70 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Skeneia planorbis* O. Fabricius.

Family NATICIDAE Guilding, 1834

Natica prietoi Hidalgo, 1873

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–200 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Natica variabilis* Recluz.

Family RISSOIDAE Gray, 1847

Alvania abstersa van der Linden et van Aartsen, 1994

Geographic range. Endemic AZO.
Depth range. 5–35 m.
Record type. LIT/VOU.
First record. Linden (1993) as *Alvania obsoleta*.
Remarks. Redescribed by Linden & Aartsen (1994).

Alvania angioyi van Aartsen, 1982

Geographic range. Endemic AZO.
Depth range. 5–22 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Alvania* (*Alvinia*) *watsoni* Schwartz.
Remarks. Described by Aartsen (1982).

Alvania cancellata (da Costa, 1778)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 3–50 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Rissoa crenulata* Michaud, 1830.

Alvania formicarum Gofas, 1989

Geographic range. Endemic AZO.
Depth range. 0–142 m.
Record type. LIT/VOU.
First record. Gofas (1989a).

Alvania internodula Hoenselaar et Goud, 1998

Geographic range. Endemic AZO.
Depth range. 0–300 m.
Record type. LIT/VOU.
First record. Hoenselaar & Goud (1998)

Alvania mediolittoralis Gofas, 1989

Geographic range. Endemic AZO.
Depth range. 0–24 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Alvania mariae* d'Orbigny.
Remarks. Described by Gofas (1989b) and redescribed by Gofas (1990).

Alvania poucheti Dautzenberg, 1889

Geographic range. Endemic AZO.
Depth range. 1–20 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889).

Alvania sleursi (Amati, 1987)

Geographic range. AZO, MAD.
Depth range. 0–45 m.
Record type. LIT/VOU.
First record. Watson (1886) as *Rissoa* (*Alvania*) *hispidula* (Monterosato).
Remarks. Described by Amati (1987) as *Manzonia* (*Alvinia*) *sleursi* and redescribed by Gofas (1990).

Alvania tarsodes (Watson, 1886)

Geographic range. Endemic AZO.
Depth range. 8–57 m.
Record type. LIT/VOU.
First record. Watson (1886) as *Rissoa* (*Alvania*) *tarsodes*.

Botryphallus ovummuscae (Gofas, 1990)

Geographic range. Endemic AZO.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Peringiella nitida* Brusina.
Remarks. Described by Gofas (1990) as *Peringiella ovummuscae*.

Cingula trifasciata (J. Adams, 1800)

Geographic range. SCA, BRI, POR, MED, AZO.
Depth range. 0–2 m.
Record type. LIT/VOU.
First record. MacAndrew (1857), as *Rissoa cingillus* Montagu.

Crisilla iunoniae (Palazzi, 1988)

Geographic range. AZO, MAD, CAN.
Depth range. 0–60 m.
Record type. LIT.
First record. Ávila (2005; Hoenselaar & Goud, in litt.).

Crisilla postrema (Gofas, 1990)

Geographic range. AZO, MAD.
Depth range. 0–29 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Setia abjecta* Watson.
Remarks. Described by Gofas (1990) as *Alvania* (*Crisilla*) *postrema*.

Manzonia martinsi Ávila et Cordeiro, 2015

Geographic range. Endemic AZO.
Depth range. 1–5 m.
Record type. LIT/VOU.
First record. Cordeiro & Ávila (2015)

Manzonia unifasciata Dautzenberg, 1889

Geographic range. Endemic AZO.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Manzonia costata* J. Adams, var. ex colore *unifasciata* nov. var., *Manzonia costata* J. Adams, var. ex colore *bifasciata* nov. var., *Manzonia costata* J. Adams, var. ex colore *luteola* nov. var., and *Manzonia aurantiaca* Watson.
Remarks. Raised to species status by Moolenbeek & Faber (1987). Redescribed by Gofas (1990).

Obtusella intersecta (S. Wood, 1857)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 15–620 m.
Record type. LIT.
First record. Ávila (2005; Hoenselaar & Goud, in litt.).

Onoba moreleti Dautzenberg, 1889

Geographic range. Endemic AZO.
Depth range. 14–234 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889)

Pusillina inconspicua (Alder, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 0–100 m.
Record type. LIT.
First record. Martins (2004).

Rissoa guernei Dautzenberg, 1889

Geographic range. Endemic AZO.
Depth range. 14–30 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Rissoia guernei* nov. sp. and *Rissoia obesula* nov. sp.
Remarks. Redescribed by Gofas (1990).

Rissoa mirabilis Manzoni, 1868

Geographic range. AZO, MAD, CAN.
Depth range. 35–55 m.
Record type. LIT.
First record. Ávila (2005; Hoenselaar & Goud, in litt.)

Setia alexandrae Ávila et Cordeiro, 2015

Geographic range. Endemic AZO.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Ávila et al. (1998) as *Setia* sp.
Remarks. Described by Cordeiro & Ávila (2015).

Setia ambigua (Brugnone, 1873)

Geographic range. MED, AZO, CAN.
Depth range. 0–12 m.
Record type. LIT.
First record. Ávila (2005; Hoenselaar & Goud, in litt.)

Setia ermelindoi Ávila et Cordeiro, 2015

Geographic range. Endemic AZO.
Depth range. 0–25 m.
Record type. LIT/VOU.
First record. Segers (2002) as *Setia* cf. *lacourti* (Verduin, 1984).
Remarks. Described by Cordeiro & Ávila (2015).

Setia netoae Ávila et Cordeiro, 2015

Geographic range. Endemic AZO.
Depth range. 0–10 m.
Record type. LIT/VOU.
First record. Cordeiro & Ávila (2015)

Setia quisquiliarum (Watson, 1886)

Geographic range. AZO, CAN.
Depth range. 15–914 m.
Record type. LIT.
First record. Watson (1886) as *Rissoa* (*Setia*) *quisquiliarum*.

Setia subvaricosa Gofas, 1990

Geographic range. Endemic AZO.
Depth range. 0–22 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Setia abjecta* Watson.
Remarks. Described by Gofas (1990).

Family ANABATHRIDAE Keen, 1971

Pisinna glabrata (Megerle von Mühlfeld, 1824)

Geographic range. MED, AZO, MAD, CAN, NWA.
Depth range. 0–1 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Pisinna punctulum* Philippi.

Family ASSIMINEIDAE H. Adams et A. Adams, 1856

Assiminea avilai van Aartsen, 2008
Geographic range. Endemic AZO.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Aartsen (2008).

Paludinella globularis (Hanley in Thorpe, 1844)

Geographic range. MED, AZO, MAD, CAN, NWA.
Depth range. 0–15 m.
Record type. LIT/VOU.
First record. Morton et al. (1998) as *Paludinella littorina*.

Family CAECIDAE Gray, 1850

Caecum armoricum de Folin, 1869

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 6–50 m.
Record type. LIT.
First record. Hoeksema & Segers (1993)

Caecum clarkii Carpenter, 1859

Geographic range. BRI, POR, MED, AZO, MAD, CAN.
Depth range. 10–30 m.
Record type. LIT.
First record. Aartsen & Fehr-de-Wal (1975).

Caecum gofasi Pizzini et Nofroni, 2001

Geographic range. AZO.
Depth range. 3–280 m.
Record type. VOU.
First record. This work.

Caecum wayae Pizzini et Nofroni, 2001

Geographic range. Endemic AZO.
Depth range. 2–6 m.
Record type. LIT/VOU.
First record. Pizzini & Nofroni (2001)

Family ELACHISINIDAE Ponder, 1985

Elachisina azoreana Rolán et Gofas, 2003

Geographic range. Endemic AZO.
Depth range. 6–9 m.

Record type. LIT.
First record. Rolán & Gofas (2003).

Family TORNIDAE Sacco, 1896 (1884)

Teinostoma azoricum (Dautzenberg et H. Fischer, 1896)

Geographic range. Endemic AZO.
Depth range. 5–1000 m.
Record type. LIT.
First record. Dautzenberg & Fischer (1896) as *Tinostoma azorica* nov. sp.

Family TRUNCATELLIDAE Gray, 1840

Truncatella subcylindrica (Linnaeus, 1767)

Geographic range. Introduced. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 1–5 m.
Record type. LIT/VOU.
First record. Martins (1980) as *Truncatella* (*Truncatella*) *subcylindrica* (Linnaeus).

Family TONNIDAE Suter, 1913 (1825)

Eudolium bairdii (Verrill et S. Smith, 1881)

Geographic range. POR, MED, AZO, CAN, NWA, GME, CAR.
Depth range. 17–823 m.
Record type. LIT.
First record. Poppe & Goto (1991) as *Eudolium crosseanum* (Monterosato 1869).

Tonna galea (Linnaeus, 1758)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, CRL, GME, CAR.
Depth range. 9–30 m.
Record type. LIT.
First record. Ávila (2005).

Family BURSIDAE Thiele, 1925

Bursa scrobilator (Linnaeus, 1758)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 5–1000 m.
Record type. LIT/VOU.
First record. MacAndrew (1857), as *Triton scrobiculatus* Lamark.

Family CASSIDAE Latreille, 1825

Galeodea rugosa (Linnaeus, 1771)

Geographic range. BRI, POR, MED, AZO, NWA.
Depth range. 40–350 m.
Record type. LIT.
First record. Ávila (2005).

Semicassis granulata undulata (Gmelin, 1791)

Geographic range. Introduced. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 8–80 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Cassis sulcosa* Lamarck.

Family RANELLIDAE Gray, 1854

Charonia lampas (Linnaeus, 1758)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 5–50 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Triton nodiferus* Lamark.

Charonia variegata (Lamarck, 1816)

Geographic range. MED, AZO, MAD, CAN, CAP, NWA, CRL, GME, CAR.
Depth range. 0–110 m.
Record type. LIT/VOU.
First record. Ávila (2005).

Monoplex corrugatus (Lamarck, 1816)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 10–200 m.
Record type. LIT/VOU.
First record. Simroth (1888) as *Tritonium corrugatum* Lamark.

Monoplex krebsii (Mörch, 1877)

Geographic range. AZO, CAN, CRL, GME, CAR.
Depth range. 2–150 m.

Record type. LIT.
First record. Gofas & Beu (2002) as *Cymatium krebsii* (Mörch, 1877).

Monoplex parthenopeus (Salis Marschlins, 1793)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, CRL, GME, CAR.
Depth range. 0–75 m.
Record type. LIT/VOU.
First record. Nobre (1924) as *Triton partenopeum* von Salis.

Ranella olearium (Linnaeus, 1758)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA, CAR.
Depth range. 20–400 m.
Record type. LIT/VOU.
First record. Ávila (2000a) as *Ranella olearia* (Linnaeus, 1758).

Family VELUTINIDAE Gray, 1840

Lamellaria latens (O.F. Müller, 1776)

Geographic range. SCA, BRI, POR, MED, AZO, CAP.
Depth range. 10–1200 m.
Record type. LIT/VOU.
First record. Ávila (2000a).

Lamellaria perspicua (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA, GME, CAR.
Depth range. 0–200 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Lamellaria perspicua* Linnaeus, var. *lata* Jeffreys.

Family TRIVIIDAE Troschel, 1863

Trivia candidula (Gaskoin, 1836)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, CRL, GME, CAR.
Depth range. 3–780 m.
Record type. LIT/VOU.
First record. Watson (1886) as *Cypraea* (*Trivia*) *candidula* Gaskoin.

Trivia mediterranea (Risso, 1826)

Geographic range. POR, MED, AZO, CAN.
Depth range. 5–30 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Cypraea pulex* Solander.

Family VERMETIDAE Rafinesque, 1815

Thylaeodus cf. ***rugulosus*** (Monterosato, 1878)

Geographic range. POR, MED, AZO, MAD, CAN.
Depth range. 1–10 m.
Record type. LIT/VOU.
First record. Bieler (1995).

Vermetus triquetrus Bivona Ant., 1832

Geographic range. POR, MED, AZO, CAN, NWA.
Depth range. 1–20 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Vermetus* (*Dofania*) *triqueter* Bivona.

Family EPITONIIDAE Berry, 1910 (1812)

Acirsa subdecussata (Cantraine, 1835)

Geographic range. POR, MED, AZO, MAD, CAN.
Depth range. 12–500 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Cirsotrema cochlea (G.B. Sowerby II, 1844)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–60 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000b).

Epitonium algerianum (Weinkauff, 1866)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 40–500 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Scalaria algeriana* Weinkauff.

Epitonium celesti (Aradas, 1854)

Geographic range. POR, MED, AZO, MAD, CAN,

CAP, CRL, GME, CAR.
Depth range. 30–640 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Epitonium clathratulum (Kanmacher, 1798)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 30–100 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Scalaria clathratula* Montagu.

Epitonium clathrus (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 5–70 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Epitonium jani Segers, Swinnen et de Prins, 2009

Geographic range. AZO, MAD, CAN.
Depth range. 0–10 m.
Record type. LIT.
First record. Segers et al. (2009).

Epitonium pulchellum (Bivona, 1832)

Geographic range. POR, MED, AZO, CAN, CAP.
Depth range. 20–40 m.
Record type. LIT/VOU.
First record. Martins et al. (2009)

Epitonium turtonis (Turton, 1819)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 5–70 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Gyroscala lamellosa (Lamarck, 1822)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA, CRL, GME, CAR.
Depth range. 0–60 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Scalaria pseudoscalaris* Risso.

Opalia coronata (Philippi et Scacchi, 1840)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 20–80 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000b) as *Opalia hellenica* (Forbes, 1844).

Opalia crenata (Linnaeus, 1758)

Geographic range. POR, MED, AZO, CAN, CAP, NWA, GME, CAR.
Depth range. 0–82 m.
Record type. LIT.
First record. Nobre (1924) as *Scalaria crenata* Linnaeus.

Family EULIMIDAE Philippi, 1853

Crinophtheiros collinsi (Sykes, 1903)

Geographic range. BRI, AZO, MAD, CAN.
Depth range. 5–200 m.
Record type. LIT/VOU.
First record. Segers (2002)

Curveulima dautzenbergi (Pallary, 1900)

Geographic range. BRI, MED, AZO, MAD, CAN.
Depth range. 15–80 m.
Record type. VOU.
First record. This work.

Melanella boscii (Payraudeau, 1826)

Geographic range. MED, AZO.
Depth range. 0–150 m.
Record type. LIT/VOU.
First record.

Melanella* cf. *trunca (Watson, 1897)

Geographic range. AZO, MAD, CAN.
Depth range. 50–40 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Parvioris ibizenca (Nordsieck, 1968)

Geographic range. MED, AZO, MAD, CAN, CAP.
Depth range. 3–50 m.
Record type. LIT/VOU.

First record. Dautzenberg (1889), as *Eulima microstoma* Brusina.
Remarks. Described by Nordsieck (1968) as *Eulima microstoma ibizenca*.

Vitreolina curva (Monterosato, 1874)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 5–70 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000a).

Vitreolina incurva (Bucquoy, Dautzenberg et Dollfus, 1883)

Geographic range. POR, MED, AZO, CAN, NWA.
Depth range. 3–52 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Eulima incurva* Renieri.

Vitreolina philippi (de Rayneval et Ponzi, 1854)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 10–30 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Eulima incurva* Renieri.

Family TRIPHORIDAE Gray, 1847

Cheirodonta pallescens (Jeffreys, 1867)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP.
Depth range. 1–100 m.
Record type. LIT/VOU.
First record. Ávila & Azevedo (1997).

Marshallora adversa (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–100 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Triforis perversa* Montagu.

Metaxia abrupta (Watson, 1880)

Geographic range. Endemic AZO.
Depth range. 20–200 m.
Record type. LIT/VOU.
First record. Ávila (2000a).

Monophorus erythrosoma (Bouchet et Guillemot, 1978)

Geographic range. MED, AZO, MAD, CAN, CAP.
Depth range. 1–50 m.
Record type. LIT/VOU.
First record. Ávila (2000a).

Monophorus thiriotae Bouchet, 1985

Geographic range. MED, AZO, MAD, CAN, CAP.
Depth range. 20–400 m.
Record type. LIT/VOU.
First record. Bouchet (1985).

Pogonodon pseudocanaricus (Bouchet, 1985)

Geographic range. MED, AZO, CAN, CAP.
Depth range. 25–100 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Similiphora similior (Bouchet et Guillemot, 1978)

Geographic range. SCA, BRI, POR, MED, AZO, CAP.
Depth range. 0–70 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000b).

Similiphora cf. ***triclotae*** Bouchet, 1997

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 35–60 m.
Record type. LIT.
First record. Segers et al. (2009) as *Similiphora* cf. *triclothae* Bouchet, 1996.

Family CERITHIOPSIDAE H. Adams et A. Adams, 1853

Cerithiopsis barleei Jeffreys, 1867

Geographic range. SCA, BRI, POR, MED, AZO, CAN, CAP.
Depth range. 5–30 m.
Record type. LIT/VOU.
First record. Ávila & Azevedo (1997).

Cerithiopsis diadema Monterosato, 1874

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 10–125 m.
Record type. LIT.
First record. Macedo et al. (1999).

Cerithiopsis fayalensis Watson, 1880

Geographic range. POR, MED, AZO, MAD.
Depth range. 20–120 m.
Record type. LIT/VOU.
First record. Watson (1880).

Cerithiopsis jeffreysi Watson, 1885

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CRL, CAR.
Depth range. 1–200 m.
Record type. LIT/VOU.
First record. Azevedo & Gofas (1990) as *Cerithiopsis pulchella* (Jeffreys, 1858).

Cerithiopsis minima (Brusina, 1865)

Geographic range. POR, MED, AZO, CAN, CAP, NWA.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889).

Cerithiopsis cf. ***nana*** Jeffreys, 1867

Geographic range. MED, AZO.
Depth range. 5–50 m.
Record type. LIT/VOU.
First record. This work.

Cerithiopsis scalaris Locard, 1892

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 10–200 m.
Record type. LIT/VOU.
First record. Segers (2002).

Cerithiopsis tubercularis (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP.
Depth range. 0–100 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Cerithium tuberculare* Montagu.

Family BUCCINIDAE Rafinesque, 1815

Pollia dorbignyi (Payraudeau, 1826)

Geographic range. Introduced. POR, MED, AZO, NWA.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Morton et al. (1998) as *Engina turbinella*.

Family COLUMBELLIDAE Swainson, 1840

Anachis avaroides Nordsieck, 1975

Geographic range. POR, AZO, MAD, CAN.
Depth range. 0–60 m.
Record type. LIT/VOU.
First record. Ávila & Azevedo (1997) as *Raphitoma carnosula* (Jeffreys, 1869).

Columbella adansoni Menke, 1853

Geographic range. AZO, MAD, CAN, CAP.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Columbella rustica* Linnaeus.

Family NASSARIIDAE Iredale, 1916 (1835)

Nassarius corniculum (Olivi, 1792)

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–50 m.
Record type. LIT/VOU.
First record. Nobre (1924) as *Nassa corniculum* (Olivi, 1792).

Nassarius cuvierii (Payraudeau, 1826)

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Nobre (1924) as *Nassa costulata* Brocchi.

Nassarius incrassatus (Strøm, 1768)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.

Depth range. 0–200 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Nassa incrassata* Müller.

Family MURICIDAE Rafinesque, 1815

Coralliophila guancha Smriglio, Mariottini et Engl, 2003

Geographic range. AZO, MAD, CAN.
Depth range. 18–50 m.
Record type. LIT.
First record. Oliverio & Gofas (2006).

Coralliophila meyendorffii (Calcara, 1845)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Murex imbricatus* Brocchi.

Hexaplex trunculus (Linnaeus, 1758)

Geographic range. Introduced. POR, MED, AZO, MAD, CAN.
Depth range. 1–100 m.
Record type. LIT/VOU.
First record. Nobre (1924) as *Murex trunculus* Linnaeus.

Ocenebra chavesi Houart, 1996

Geographic range. Endemic AZO.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Houart (1996) as *Ocenebra* (*Ocenebra*) *chavesi* nov. sp.

Ocenebra erinaceus (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–150 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Murex erinaceus* Linnaeus.

Ocinebrina aciculata (Lamarck, 1822)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–100 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Murex corallinus* Scacchi.

Orania fusulus (Brocchi, 1814)

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 30–150 m.
Record type. LIT/VOU.
First record. Poppe & Goto (1991)

Stramonita haemastoma (Linnaeus, 1767)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, VIR, CRL, GME, CAR.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Purpura haemastoma* Linnaeus.

Trophonopsis barvicensis (Johnston, 1825)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, NWA.
Depth range. 32–100 m.
Record type. LIT/VOU.
First record. Martins et al. (2009).

Family CYSTISCIDAE Stimpson, 1865

Gibberula lazaroi Contreras, 1992

Geographic range. Endemic AZO.
Depth range. 0–1 m.
Record type. LIT.
First record. Contreras (1992).

Family MARGINELLIDAE Fleming, 1828

Volvarina oceanica Gofas, 1989

Geographic range. Endemic AZO.
Depth range. 12–90 m.
Record type. LIT/VOU.
First record. Gofas (1989b).

Family MITRIDAE Swainson, 1831

Mitra cornea Lamarck, 1811

Geographic range. MED, AZO, MAD, CAN, CAP, NWA.

Depth range. 0–40 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Mitra fusca* Swainson.

Mitra zonata Marryat, 1819

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 30–150 m.
Record type. LIT/VOU.
First record. Burnay & Martins (1988).

Family MITROMORPHIDAE Casey, 1904

Mitromorpha azorensis Mifsud, 2001

Geographic range. Endemic AZO.
Depth range. 30–200 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Mitrolumna olivoidea* Cantraine.
Remarks. Described by Mifsud (2001) as *Mitromorpha* (*Mitrolumna*) *azorensis*.

Mitromorpha crenipicta (Dautzenberg, 1889)

Geographic range. AZO, CAN.
Depth range. 10–145 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889), as *Mitrolumna olivoidea* Cantraine, var. *crenipicta* nov. var.

Family MANGELIIDAE P. Fischer, 1883

Bela nebula (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 10–30 m.
Record type. LIT/VOU.
First record. Simroth (1888) as *Mangelia nebula* Montagu.

Mangelia costata (Pennant, 1777)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 1–40 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000a) as *Mangelia coarctata* (Forbes, 1840).

Mangelia scabrida Monterosato, 1890

Geographic range. POR, MED, AZO.
Depth range. 1–80 m.
Record type. VOU.
First record. This work.

Family RAPHITOMIDAE Bellardi, 1875

Raphitoma aequalis (Jeffreys, 1867)

Geographic range. BRI, POR, MED, AZO.
Depth range. 0–200 m.
Record type. LIT/VOU.
First record. Martins et al. (2009) as *Raphitoma* cf. *aequalis* (Jeffreys, 1867).

Raphitoma leufroyi (Michaud, 1828)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 5–150 m.
Record type. LIT/VOU.
First record. Ávila et al. (2000b).

Raphitoma linearis (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–60 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Clathurella linearis* Montagu.

Raphitoma purpurea (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–100 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Clathurella purpurea* Montagu.

Teretia teres (Reeve, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 30–900 m.
Record type. LIT/VOU.
First record. Dautzenberg & Fischer (1896) as *Pleurotoma anceps* Eichwald.

Family DRILLIIDAE Olsson, 1964

Crassopleura maravignae (Bivona Ant. in Bivona And., 1838)

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 15–250 m.
Record type. LIT/VOU.
First record. Ávila (2000a) as *Crassopleura incrassata* (Dujardin, 1837).

Family HORAICLAVIDAE Bouchet, Kantor, Sysoev et Puillandre, 2011

Haedropleura septangularis (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 7–251 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Bela septangularis* Montagu.

Family CANCELLARIIDAE Forbes et Hanley, 1851

Brocchinia clenchi Petit, 1986

Geographic range. POR, AZO, CAN, NWA.
Depth range. 15–80 m.
Record type. LIT/VOU.
First record. Ávila (2000a) as *Odostomia conoidea* (Brocchi, 1814).

Family CIMIDAE Warén, 1993

Cima cylindrica (Jeffreys, 1856)

Geographic range. MED, AZO, CAN.
Depth range. 5–60 m.
Record type. LIT/VOU.
First record. Segers (2002).

Cima cf. **minima** (Jeffreys, 1858)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. Ávila (2000a)

Family APLUSTRIDAE Gray, 1847

Hydatina physis (Linnaeus, 1758)

Geographic range. POR, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–5 m.
Record type. LIT.
First record. Wirtz (1999).

Micromelo undatus (Bruguière, 1792)

Geographic range. AZO, CAN, CAP, NWA, GME, CAR.
Depth range. 1–5 m.
Record type. LIT.
First record. Nordsieck (1972).

Family ARCHITECTONICIDAE Gray, 1850

Philippia hybrida (Linnaeus, 1758)

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 1–100 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Solarium luteum* Lamarck.

Pseudotorinia architae (O.G. Costa, 1841)

Geographic range. POR, MED, AZO, MAD, CAN, CRL, GME, CAR.
Depth range. 30–180 m.
Record type. LIT/VOU.
First record. Ávila (2000a) as *Heliacus architae* (O. G. Costa, 1841).

Family TOFANELLIDAE Bandel, 1995

Graphis albida (Kanmacher, 1798)

Geographic range. SCA, BRI, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–30 m.
Record type. LIT/VOU.
First record. Segers (2002) as *Graphis albidus* (Kanmacher, 1798).

Family OMALOGYRIDAE G.O. Sars, 1878

Ammonicera fischeriana (Monterosato, 1869)

Geographic range. MED, AZO, CAN, NWA.
Depth range. 0–25 m.

Record type. LIT/VOU.
First record. Ávila & Azevedo (1996).

Ammonicera rota (Forbes et Hanley, 1850)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 0–25 m.
Record type. LIT/VOU.
First record. Ávila & Azevedo (1996).

Omalogyra atomus (Philippi, 1841)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, CAN, CAP, NWA, NSC, VIR.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Homalogyra atomus* Philippi.

Family PYRAMIDELLIDAE Gray, 1840

Brachystomia eulimoides (Hanley, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, CAN, NWA.
Depth range. 10–120 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998) as *Odostomia* (*Odostomia*) *eulimoides* Hanley, 1844.

Brachystomia scalaris (MacGillivray, 1843)

Geographic range. SCA, BRI, POR, MED, AZO, CAN, NWA.
Depth range. 3–20 m.
Record type. LIT.
First record. Dautzenberg (1889) as *Odostomia rissoides* Hanley, var. *alba* Jeffreys.

Chrysallida stefanisi (Jeffreys, 1869)

Geographic range. MED, AZO, CAN, NWA.
Depth range. 30–1000 m.
Record type. LIT.
First record. Linden & Eikenboom (1992).

Liostomia mamoi Mifsud, 1993

Geographic range. MED, AZO, MAD, CAN.
Depth range. 2–75 m.
Record type. VOU.
First record. This work.

Odostomella doliolum (Philippi, 1844)

Geographic range. MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 10–800 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889), as *Odostomia* (*Odostomia*) *doliolum* Philippi.

Odostomia acuta Jeffreys, 1848

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 10–100 m.
Record type. LIT.
First record. Nordsieck & Talavera (1979).

Odostomia bernardi van Aartsen, Gittenberger et Goud, 1998

Geographic range. Endemic AZO.
Depth range. 0–300 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998).

Odostomia duureni van Aartsen, Gittenberger et Goud, 1998

Geographic range. Endemic AZO.
Depth range. 0–125 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998).

Odostomia kuiperi van Aartsen, Gittenberger et Goud, 1998

Geographic range. AZO, CAN.
Depth range. 0–150 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998).

Odostomia lukisii Jeffreys, 1859

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–150 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998) as *Odostomia* (*Odostomia*) *lukisii* Jeffreys, 1859.

Odostomia striolata Forbes et Hanley, 1850

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.

Depth range. 0–400 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998) as *Odostomia* (*Odostomia*) *striolata* Forbes et Hanley, 1850.

Odostomia turrita Hanley, 1844

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–250 m.
Record type. LIT/VOU.
First record. Aartsen et al. (1998) as *Odostomia* (*Odostomia*) *turrita* Hanley, 1844.

Odostomia unidentata (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA, CRL.
Depth range. 0–200 m.
Record type. LIT.
First record. Dautzenberg (1889).

Ondina diaphana (Jeffreys, 1848)

Geographic range. SCA, BRI, POR, MED, AZO, CAN, NWA.
Depth range. 9–54 m.
Record type. LIT/VOU.
First record. Ávila (2000a).

Pyrgiscus rufus (Philippi, 1836)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 15–3500 m.
Record type. LIT/VOU.
First record. Martins et al. (2009) as *Turbonilla rufa* (Philippi, 1836).

Turbonilla lactea (Linnaeus, 1758)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 5–95 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Chemnitzia elegantissima* Montagu, 1803.

Family MURCHISONELLIDAE Casey, 1904

Ebala nitidissima (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 15–150 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Aclis nitidissima* Montagu.

Family RISSOELLIDAE Gray, 1850

Rissoella contrerasi Rolán et Hernández, 2004

Geographic range. AZO, MAD, CAN.
Depth range. 0–50 m.
Record type. VOU.
First record. This work.

Rissoella diaphana (Alder, 1848)

Geographic range. SCA, BRI, MED, AZO, MAD, CAN.
Depth range. 1–150 m.
Record type. LIT/VOU.
First record. Ávila & Azevedo (1996).

Family DIAPHANIDAE Odhner, 1914 (1857)

Diaphana globosa (Lovén, 1846)

Geographic range. SCA, BRI, POR, AZO.
Depth range. 25–2644 m.
Record type. LIT/VOU.
First record. Cordeiro et al. (2013).

Family HAMINOEIDAE Pilsbry, 1895

Atys macandrewii E.A. Smith, 1872

Geographic range. MED, AZO, MAD, CAN, CAP, GME, CAR.
Depth range. 0–75 m.
Record type. LIT/VOU.
First record. Nordsieck (1972) as *Atys* (*Limulatys*) *macandrewi* Smith, 1872.

Haminoea orteai Talavera, Murillo et Templado, 1987

Geographic range. MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–30 m.
Record type. LIT/VOU.
First record. Mikkelsen (1995).

Family PHILINIDAE Gray, 1850 (1815)

Philine intricata Monterosato, 1884

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP.
Depth range. 10–620 m.
Record type. LIT.
First record. Linden (1994).

Philine lima (Brown, 1827)

Geographic range. GRE, SCA, BRI, MED, AZO, NSC.
Depth range 20–150 m.
Record type. LIT.
First record. Dautzenberg (1889).

Family AGLAJIDAE Pilsbry, 1895 (1847)

Chelidonura africana Pruvot-Fol, 1953

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range 2–8 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Odontoglaja sabadiega (Ortea, Moro et Espinosa, 1997)

Geographic range. AZO, MAD, CAN.
Depth range. 2–8 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Family CYLICHNIDAE H. Adams et A. Adams, 1854

Cylichna alba (Brown, 1827)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, NSC, VIR.
Depth range. 6–2700 m.
Record type. LIT.
First record. Watson (1886).

Family SCAPHANDRIDAE G.O. Sars, 1878

Scaphander punctostriatus (Mighels et Adams, 1842)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, CAN, NSC, GME, CAR.
Depth range. 20–2700 m.
Record type. LIT.
First record. Watson (1886).

Family RETUSIDAE Thiele, 1925

Pyrunculus hoernesii (Weinkauff, 1866)

Geographic range. MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 7–300 m.
Record type. LIT.
First record. Segers (2002).

Retusa multiquadrata Oberling, 1970

Geographic range. MED, AZO, MAD.
Depth range. 1–14 m.
Record type. LIT/VOU.
First record. Mikkelsen (1995).

Retusa truncatula (Bruguière, 1792)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–200 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Tornatina truncatula* Bruguière and *Tornatina mariei* nov. sp.

Family RUNCINIDAE H. Adams et A. Adams, 1854

Runcina adriatica T. Thompson, 1980

Geographic range. AZO, CAN.
Depth range. 0–18 m.
Record type. LIT/VOU.
First record. Gosliner (1990).

Runcina coronata (de Quatrefages, 1844)

Geographic range. SCA, BRI, POR, AZO.
Depth range. 1–6 m.
Record type. LIT.
First record. Gosliner (1990) as *Runcina aurata* García-Gómez, Lopez, Luque et Cervera, 1986.

Runcina hidalgoensis Ortea et Moro, 1999

Geographic range. SCA, BRI, POR, AZO.
Depth range. 1–12 m.
Record type. LIT.
First record. Ortea & Moro (1999).

Runcina ornata (de Quatrefages, 1844)

Geographic range. MED, AZO, MAD.
Depth range 1–5 m.
Record type. LIT.
First record. Malaquias et al. (2014)

Family APLYSIIDAE Lamarck, 1809

Aplysia depilans Gmelin, 1791

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–40 m.
Record type. LIT/VOU.
First record. Wirtz (1995).

Aplysia fasciata Poiret, 1789

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA, NSC, VIR, GME, CAR.
Depth range. 0–15 m.
Record type. LIT/VOU.
First record. Wirtz & Martins (1993).

Aplysia juliana Quoy et Gaimard, 1832

Geographic range. AZO, CAN, GME, CAR.
Depth range. 0–10 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Aplysia parvula Mörch, 1863

Geographic range. BRI, POR, MED, AZO, MAD, CAN, NWA, GME, CAR.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Eales (1960).

Aplysia punctata (Cuvier, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Simroth (1888).

Stylocheilus striatus (Quoy et Gaimard, 1832)

Geographic range. AZO, MAD, CAN, CAP, CAR.
Depth range. 1–30 m.
Record type. LIT.
First record. Wirtz & Debelius (2003).

Family AKERIDAE Mazzarelli, 1891

Akera bullata O.F. Müller, 1776

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 1–370 m.
Record type. LIT.
First record. Nobre (1924) as *Acera bullata* Müller.

Family PLAKOBRANCHIDAE Gray, 1840

Elysia flava Verrill, 1901

Geographic range. MED, AZO, MAD, CAN, CAP, CAR.
Depth range. 1–30 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Elysia gordanae Thompson et Jaklin, 1988

Geographic range. POR, MED, AZO, CAN.
Depth range. 2–6 m.
Record type. LIT.
First record. Wirtz & Debelius (2003) as *Elysia margaritae* Fez, 1962.

Elysia ornata (Swainson, 1840)

Geographic range. AZO, MAD, CAN, GME, CAR.
Depth range. 1–45 m.
Record type. LIT/VOU.
First record. Wirtz (1995).

Elysia viridis (Montagu, 1804)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 1–10 m.
Record type. LIT/VOU.
First record. Azevedo (1991).

Thuridilla hopei (Vérany, 1853)

Geographic range. MED, AZO.
Depth range. 1–30 m.
Record type. LIT.
First record.

Thuridilla mazda Ortea et Espinosa, 2000

Geographic range. AZO, GME, CAR.

Depth range. 1–20 m.
Record type. LIT.
First record. Malaquias et al. (2009) as *Thuridilla picta* (Verrill, 1901).

Family LIMAPONTIIDAE Gray, 1847

Ercolania coerulea Trinchese, 1892

Geographic range. MED, AZO, MAD, GME, CAR.
Depth range. 0–1 m.
Record type. LIT.
First record. Wirtz & Debelius (2003).

Ercolania lozanoi Ortea, 1982

Geographic range. AZO, CAN, CAP.
Depth range. 0–2 m.
Record type. LIT.
First record. Jensen (2014) and Malaquias et al. (2014).

Placida cremoniana (Trinchese, 1892)

Geographic range. POR, MED, AZO, CAN.
Depth range. 2–28 m.
Record type. LIT.
First record. Ortea et al. (1998).

Placida verticilata Ortea, 1982

Geographic range. POR, MED, AZO, MAD, CAN, CAR.
Depth range. 1–5 m.
Record type. LIT.
First record. Ávila (2000a).

Family CALIPHYLLIDAE Tiberi, 1881

Caliphylla mediterranea A. Costa, 1867

Geographic range. MED, AZO, CAN, GME, CAR.
Depth range. 1–5 m.
Record type. LIT.
First record. Jensen (2014).

Cyerce antillensis Engel, 1927

Geographic range. AZO, MAD, GME, CAR.
Depth range. 1–5 m.
Record type. LIT.
First record. Wirtz & Debelius (2003).

Family HERMAEIDAE H. Adams et A. Adams, 1854

Aplysiopsis formosa Pruvot-Fol, 1953

Geographic range. AZO, CAN, NWA.
Depth range. 0–12 m.
Record type. LIT.
First record. Jensen (1995).

Hermaea variopicta (A. Costa, 1869)

Geographic range. BRI, POR, MED, AZO, CAN.
Depth range. 1–15 m.
Record type. LIT.
First record. Cordeiro et al. (2013) as *Hermaeopsis variopicta* A. Costa, 1869.

Family UMBRACULIDAE Dall, 1889 (1827)

Umbraculum umbraculum (Lightfoot, 1786)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, GME, CAR.
Depth range. 0–85 m.
Record type. LIT/VOU.
First record. Menezes (1991) as *Umbraculum mediterraneum* (Lamarck, 1819).

Family TYLODINIDAE Gray, 1847

Tylodina perversa (Gmelin, 1791)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–15 m.
Record type. LIT/VOU.
First record. Dautzenberg (1889) as *Tylodina citrina* de Joannis.

Family PLEUROBRANCHIDAE Gray, 1827

Berthella aurantiaca (Risso, 1818)

Geographic range. MED, AZO.
Depth range. 1–20 m.
Record type. LIT.
First record. Bergh (1892) as *Pleurobranchus aurantiacus* Risso.

Berthella plumula (Montagu, 1803)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.

Depth range. 1–10 m.
Record type. LIT.
First record. Bergh (1892) as *Pleurobranchus plumula* Montagu.

Berthella stellata (Risso, 1826)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, CAR.
Depth range. 2–10 m.
Record type. LIT.
First record. Wirtz & Debelius (2003).

Berthellina edwardsii (Vayssière, 1897)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 5–30 m.
Record type. LIT/VOU.
First record. Vayssière (1896) as *Berthella edwardsii* nov. sp.

Pleurobranchus reticulatus Rang, 1832

Geographic range. AZO, MAD, CAN, CAP.
Depth range. 5–30 m.
Record type. LIT.
First record. Cervera et al. (2004) as *Pleurobranchus garciagomezi* Cervera, Cattaneo-Vietti et Edmunds, 1996.

Pleurobranchus testudinarius Cantraine, 1835

Geographic range. MED, AZO, MAD, CAN.
Depth range. 5–80 m.
Record type. LIT/VOU.
First record. Wirtz & Martins (1993).

Family PLEUROBRANCHAEIDAE Pilsbry, 1896

Pleurobranchaea meckeli (Blainville, 1825)

Geographic range. POR, MED, AZO, MAD, CAN, CAP.
Depth range. 8–100 m.
Record type. LIT.
First record. Bergh (1899).

Family DORIDIDAE Rafinesque, 1815

Doris bertheloti (d'Orbigny, 1839)

Geographic range. MED, AZO, MAD, CAN.
Depth range. 0–5 m.
Record type. LIT/VOU.
First record. Cordeiro et al. (2013).

Doris ocelligera (Bergh, 1881)

Geographic range. POR, MED, AZO.
Depth range. 3–12 m.
Record type. LIT/VOU.
First record. Azevedo & Gofas (1990).

Doris sticta (Iredale et O'Donoghue, 1923)

Geographic range. BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 3–6 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Family CADLINIDAE Bergh, 1891

Aldisa smaragdina Ortea, Pérez et Llera, 1982

Geographic range. POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0–20 m.
Record type. LIT/VOU.
First record. Wirtz (1998).

Aldisa zetlandica (Alder et Hancock, 1854)

Geographic range. SCA, BRI, POR, AZO.
Depth range. 10–1900 m.
Record type. LIT.
First record. Bergh (1899).

Family CHROMODORIDIDAE Bergh, 1891

Felimare fontandraui (Pruvot-Fol, 1951)

Geographic range. POR, MED, AZO, CAN.
Depth range. 5–40 m.
Record type. LIT.
First record. Wirtz (1995) as *Hypselodoris fontandraui* (Pruvot-Fol, 1951).

Felimare picta (Schultz in Philippi, 1836)

Geographic range. POR, MED, AZO, MAD, CAN, NWA, GME.
Depth range. 0–55 m.
Record type. LIT/VOU.

First record. Bergh (1899) as *Chromodoris cantrainei* Bergh.

Felimare tricolor (Cantraine, 1835)

Geographic range. POR, MED, AZO, MAD, CAN.
Depth range. 2–40 m.
Record type. LIT/VOU.
First record. Gosliner (1990) as *Hypselodoris midatlantica* Gosliner, 1990.

Felimida britoi (Ortea et Pérez, 1983)

Geographic range. MED, AZO, MAD, CAN.
Depth range. 0–18 m.
Record type. LIT/VOU.
First record. Gosliner (1990) as *Chromodoris clenchi* (Russell, 1935).

Felimida edmundsi (Cervera, García-Gómez et Ortea, 1989)

Geographic range. MED, AZO, MAD, CAN.
Depth range. 1–25 m.
Record type. LIT/VOU.
First record. Gosliner (1990) as *Glossodoris edmundsi* Cervera, García-Gómez et Ortea, 1989.

Felimida goslineri (Ortea et Valdés, 1996)

Geographic range. Endemic AZO.
Depth range. 5 m.
Record type. LIT.
First record. Ortea et al. (1996) as *Chromodoris goslineri* sp. nov.

Felimida purpurea (Risso in Guérin, 1831)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 3–28 m.
Record type. LIT/VOU.
First record. Gosliner (1990) as *Chromodoris purpurea* (Laurillard, 1831).

Family DISCODORIDIDAE Bergh, 1891

Geitodoris planata (Alder et Hancock, 1846)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, VIR.
Depth range. 2–15 m.
Record type. LIT.
First record. Azevedo & Gofas (1990) as *Geitodoris* cf. *planata* (Alder et Hancock, 1846).

Jorunna tomentosa (Cuvier, 1804)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 2–400 m.
Record type. LIT.
First record. Morton et al. (1998).

Peltodoris atromaculata Bergh, 1880

Geographic range. POR, MED, AZO, MAD, CAN.
Depth range. 10–100 m.
Record type. LIT/VOU.
First record. Wirtz & Martins (1993) as *Discodoris atromaculata* (Bergh, 1880).

Platydoris argo (Linnaeus, 1767)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 2–25 m.
Record type. LIT/VOU.
First record. Bergh (1899).

Rostanga rubra (Risso, 1818)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 4–60 m.
Record type. LIT.
First record. Cordeiro et al. (2013).

Taringa armata Swennen, 1961

Geographic range. MED, AZO, MAD.
Depth range. 1–10 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Thordisa azmanii Cervera et García-Gómez, 1989

Geographic range. POR, AZO.
Depth range. 6–25 m.
Record type. LIT.
First record. Chan & Gosliner (2007).

Family PHYLLIDIIDAE Rafinesque, 1814

Phyllidia flava Aradas, 1847

Geographic range. MED, AZO, MAD, CAN, CAP.
Depth range. 6–30 m.
Record type. LIT.
First record. Hart & Wirtz (2013).

Family DENDRODORIDIDAE O'Donoghue, 1924 (1864)

Dendrodoris herytra Valdés et Ortea, 1996

Geographic range. POR, AZO, MAD, CAN, NWA.
Depth range. 4–15 m.
Record type. LIT/VOU.
First record. Bergh (1892) as *Doriopsis limbata* Cuvier.

Family ONCHIDORIDIDAE Gray, 1827

Diaphorodoris luteocincta (M. Sars, 1870)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 1–25 m.
Record type. LIT.
First record. Wirtz & Martins (1993).

Family POLYCERIDAE Alder et Hancock, 1845

Crimora papillata Alder et Hancock, 1862

Geographic range. BRI, POR, MED, AZO, CAN.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Pedro et al. (2011).

Kaloplocamus ramosus (Cantraine, 1835)

Geographic range. BRI, MED, AZO, MAD, CAN, NWA.
Depth range. 4–100.
Record type. LIT/VOU.
First record. Wirtz (1998).

Limacia clavigera (O.F. Müller, 1776)

Geographic range. SCA, BRI, POR, MED, AZO, CAN, CAP, NWA.
Depth range. 4–20 m.
Record type. LIT/VOU.
First record. Wirtz (1998).

Polycera elegans (Bergh, 1894)

Geographic range. BRI, POR, MED, AZO, CAN.
Depth range. 5–25 m.
Record type. LIT.
First record. Wirtz & Martins (1993).

Polycera quadrilineata (O.F. Müller, 1776)

Geographic range. GRE, SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 2–60 m.
Record type. LIT/VOU.
First record. Wirtz (1998).

Tambja ceutae García J.C. et Ortea, 1988

Geographic range. POR, MED, AZO, MAD, CAN, CAP.
Depth range. 4–15 m.
Record type. LIT/VOU.
First record. Wirtz & Martins (1993).

Family AEGIRIDAE P. Fischer, 1883

Aegires sublaevis Odhner, 1932

Geographic range. MED, AZO, MAD, CAN, GME, CAR.
Depth range. 0–30 m.
Record type. LIT/VOU.
First record. Calado (2002).

Family DOTIDAE Gray, 1853

Doto floridicola Simroth, 1888

Geographic range. BRI, POR, MED, AZO, MAD, CAN.
Depth range. 4–35 m.
Record type. LIT.
First record. Simroth (1888)

Doto furva García J.C. et Ortea, 1984

Geographic range. MED, AZO, CAN.
Depth range. 25–140 m.
Record type. LIT.
First record. Calado (2002).

Doto koenneckeri Lemche, 1976

Geographic range. SCA, BRI, POR, MED, AZO.
Depth range. 1–8 m.
Record type. LIT.
First record. Calado (2002).

Family PROCTONOTIDAE Gray, 1853

Janolus cristatus (delle Chiaje, 1841)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 3–18 m.
Record type. LIT.
First record. Cordeiro et al. (2013).

Family TRITONIIDAE Lamarck, 1809

Marionia blainvillea (Risso, 1818)

Geographic range. POR, MED, AZO, MAD, CAN.
Depth range. 4–40 m.
Record type. LIT/VOU.
First record. Wirtz (1995).

Family FLABELLINIDAE Bergh, 1889

Flabellina bulbosa Ortea et Espinosa, 1998

Geographic range. AZO, CAP.
Depth range. 2–10 m.
Record type. LIT.
First record. Cordeiro et al. (2013).

Flabellina pedata (Montagu, 1816)

Geographic range. SCA, BRI, POR, MED, AZO.
Depth range. 6–35 m.
Record type. LIT.
First record. Gosliner (1994).

Family EUBRANCHIDAE Odhner, 1934

Eubranchus farrani (Alder et Hancock, 1844)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 6–40 m.
Record type. LIT.
First record. Fontes et al. (2001).

Eubranchus vascoi Ortea, Caballer et Moro, 2002

Geographic range. AZO, CAN.
Depth range. 2–4 m.
Record type. LIT.
First record. Ortea et al. (2002).

Family TERGIPEDIDAE Bergh, 1889

Catriona maua Ev. Marcus et Er. Marcus, 1960

Geographic range. MED, AZO, CAN, CAR.
Depth range. 1–8 m.
Record type. LIT.
First record. Malaquias et al. (2009).

Cuthona caerulea (Montagu, 1804)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 2–25 m.
Record type. LIT.
First record. Calado (2002).

Cuthona fidenciae (Ortea, Moro et Espinosa, 1999)

Geographic range. AZO, CAN.
Depth range. 5–15 m.
Record type. LIT.
First record. Ortea et al. (2001).

Cuthona foliata (Forbes et Goodsir, 1839)

Geographic range. SCA, BRI, POR, MED, AZO, CAN.
Depth range. 2–25 m.
Record type. LIT.
First record. Calado (2002).

Family AEOLIDIIDAE Gray, 1827

Aeolidiella sanguinea (Norman, 1877)

Geographic range. BRI, POR, AZO, MAD.
Depth range. 0–18 m.
Record type. LIT
First record. Morton et al. (1998).

Spurilla neapolitana (delle Chiaje, 1841)

Geographic range. POR, MED, AZO, MAD, CAN, CAP, NWA, GME, CAR.
Depth range. 0–10 m.
Record type. LIT/VOU.
First record. Simroth (1888) as *Spurilla sargassicola* Bergh.

Family FACELINIDAE Bergh, 1889

Caloria elegans (Alder et Hancock, 1845)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN.
Depth range. 6–30 m.
Record type. LIT.
First record. Wirtz (1995).

Dicata odhneri Schmekel, 1967

Geographic range. BRI, POR, MED, AZO.
Depth range. 1–45 m.
Record type. LIT/VOU.
First record. Cervera et al. (2004; Gosliner, pers. comm.).

Facelina annulicornis (Chamisso et Eysenhardt, 1821)

Geographic range. BRI, POR, MED, AZO, MAD, CAN.
Depth range. 0–6 m.
Record type. LIT/VOU.
First record. Calado (2002).

Favorinus branchialis (Rathke, 1806)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 2–30 m.
Record type. LIT.
First record. Calado (2002).

Learchis poica Ev. Marcus et Er. Marcus, 1960

Geographic range. AZO, CRL, GME, CAR.
Depth range. 0–5 m.
Record type. LIT.
First record. Cervera et al. (2004; Moro, pers. comm.).

Family SIPHONARIIDAE Gray, 1827

Williamia gussoni (O.G. Costa, 1829)

Geographic range. MED, AZO, MAD, CAN, CAP, NWA.
Depth range. 1–100 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Patella gussonii* Costa.

Family ELLOBIIDAE L. Pfeiffer, 1854 (1822)

Auriculinella bidentata (Montagu, 1808)
Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA.
Depth range. 0 m.
Record type. LIT/VOU.
First record. MacAndrew (1857) as *Auricula alba* Jeffreys.

Myosotella myosotis (Draparnaud, 1801)

Geographic range. SCA, BRI, POR, MED, AZO, MAD, CAN, NWA, NSC, VIR, CRL, CAR.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Morelet (1860) as *Auricula vespertina* nov. sp.

Ovatella vulcani (Morelet, 1860)

Geographic range. Endemic AZO.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Morelet (1860) as *Auricula vulcani* nov. sp.

Pedipes pedipes (Bruguière, 1789)

Geographic range. POR, AZO, MAD, CAN, CAP, NWA.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Drouët (1858) as *Pedipes afra* Férussac.

Pseudomelampus exiguus (Lowe, 1832)

Geographic range. POR, AZO, MAD, CAN, CAP, NWA.
Depth range. 0 m.
Record type. LIT/VOU.
First record. Martins (1980).

Family ONCHIDIIDAE Rafinesque, 1815

Onchidella celtica (Cuvier, 1816)

Geographic range. BRI, POR, AZO, MAD, CAN, CAP, NWA.
Depth range. 0–1 m.
Record type. LIT/VOU.
First record. Martins (1980).

Table 1. Material examined from the Department of Biology of the University of the Azores (DBUA) and Natural History Museum of Rotterdam (NMR) mollusc collections.

FAMILY - SPECIES	MATERIAL EXAMINED
PATELLIDAE	
Patella aspera Röding, 1798	DBUA 179, 190/1, 240/3, 264/2, 265, 271, 458/4, 496/1, 499/9, 554/2, 562/1, 579/2, 638/1, 669/1, 670/15, 672/1, 677/1, 678/1, 713/1, 714, 715/1, 717/1, 740/1, 743/1
Patella candei d'Orbigny, 1840	DBUA 234, 638/2, 647, 667/1, 668/1, 713/2, 715/2, 717/2, 750/1
LOTTIIDAE	
Tectura virginea (O.F. Müller, 1776)	DBUA 182, 197/6, 240/5, 274/1, 278/4, 398/1, 410/1, 420, 433/1, 434/3, 457/1, 558/1, 560/1, 561/1, 562/2, 570, 609/1, 616/1, 626/1, 666/1, 667/2, 668/2, 670/1, 672/2, 677/2, 687/1, 695/1, 709/1, 713/3, 715/3, 717/3, 718, 719/1, 726/1, 730/1, 732/1, 733/1, 739/1, 742/1, 748/1, 753/1, 755/1, 766/1, 769/1, 788/1, 791/1
LEPETIDAE	
Propilidium exiguum (W. Thompson, 1844)	DBUA 1097
HALIOTIDAE	
Haliotis tuberculata Linnaeus, 1758	DBUA 193/1, 197/3, 233/1, 240/7, 263, 392, 433/2, 460/1, 496/2, 498/1, 499/6, 565/1, 566/1, 621/1, 662/1, 668/3, 670/2, 672/3, 677/3, 696/1, 713/4, 717/4, 719/2, 724/1, 726/2, 730/2, 733/2, 738/1, 756, 760/1, 766/2, 807/1
SCISSURELLIDAE	
Sinezona cingulata (O.G. Costa, 1861)	DBUA 144, 204, 268/1, 274/2, 276/1, 277/1, 446/1, 465/1, 466/1, 467/1, 468/1, 470/1, 471/13, 472/1, 475/1, 481/1, 492/1, 493/1, 496/3, 499/10, 500/1, 545/1, 564/1, 662/2, 663/1, 669/2, 745/1, 772/1, 787/2
TROCHIDAE	
Clelandella azorica Gofas, 2005	DBUA 1106
Gibbula delgadensis Nordsieck, 1982	DBUA 57, 102, 117/1, 167/1, 320, 332, 335/1, 340/1, 342/5, 343/2, 345/1, 350/1, 353/8, 355/1, 568/1, 695/2, 702/D1, 703/B, 703/C1, 708/I, 715/4, 733/3, 735/1, 740/2, 741/1, 766/3, 769/2, 772/2, 782/1, 784/1, 788/2, 789/1, 791/2
Gibbula magus (Linnaeus, 1758)	DBUA 21, 117/2, 167/2, 168/3, 169/1, 170, 410/2, 421/1, 422/1, 424/5, 604, 605/1, 607, 608/1, 609/2, 614/1, 616/2, 618/1, 621/2, 624/1, 655/1, 661/1, 670/3, 676/1, 696/2, 709/2, 717/5, 719/3, 731/1, 732/2, 734/1, 735/2, 737/1, 739/2, 784/2, 807/2
Jujubinus pseudogravinae Nordsieck, 1973	DBUA 103, 125, 168/5, 173/1, 176/1, 193/2, 195/1, 233/2, 238, 240/6, 249, 267, 274/3, 278/2, 281/1, 330/2, 340/2, 341/1, 345/2, 350/2, 353/7, 355/2, 362/4, 371/3, 372/1, 378/1, 387/1, 388/2, 390/1, 394/1, 395/1, 396/1, 400/1, 405/1, 407/1, 408/1, 415/1, 418/1, 421/2, 422/2, 424/3, 429/1, 432, 438/1, 441/1, 460/2, 462/1, 481/2, 486/1, 499/11, 550, 553/1, 555/1, 556/1, 557/1, 558/2, 560/2, 561/2, 563/1, 565/2, 567/1, 568/2, 569/1, 570/2, 575/1, 576/1, 577/1, 579/3, 605/2, 608/2, 609/3, 614/2, 616/3, 624/2, 626/2, 655/2, 656/1, 657/1, 660/1, 661/2, 662/3, 667/3, 669/3, 670/4, 671/1, 672/4, 673/1, 675/1, 677/4, 683/1, 686, 687/2, 688/1, 689/1, 692, 695/3, 696/3, 698/1, 703/C2, 707/G, 709/3, 715/5, 719/4, 721/1, 726/3, 728/1, 730/3, 731/2, 732/3, 733/4, 735/3, 739/3, 742/2, 746/1, 748/2, 749, 754/1, 755/2, 762/1, 764/1, 766/4, 767/1, 768/1, 769/3, 771/1, 772/3, 773/1, 774/1, 776/1, 777/1, 779/1, 780/1, 783/1, 788/3, 789/2, 791/3, 814/1
Phorcus sauciatus (Koch, 1845)	DBUA 1067, 1068, 1069
CALLIOSTOMATIDAE	
Calliostoma lividum (Dautzenberg, 1927)	DBUA 330/1, 338/1, 339, 355/3, 356/2, 362, 365, 433/3, 557/2, 565/3, 579/4, 605/3, 634, 651/1, 652/1, 654/1, 657/2, 668/4, 670/5, 672/5, 675/2, 676/2, 677/5, 682/1, 683/2, 688/2, 695/4, 696/4, 697/1, 699, 712, 719/5, 724/2, 732/4, 738/2, 748/3, 755/3, 758/1, 766/5, 767/2, 773/2, 776/2, 777/2, 779/2, 780/2, 782/2, 783/2, 789/3, 796, 813/1, 814/2, 838, 839

FAMILY - SPECIES	MATERIAL EXAMINED
SKENEIDAE	
Parviturbo azoricus Rubio, Rolán et Segers, 2015	DBUA 1103
PHASIANELLIDAE	
Tricolia pullus azorica (Dautzenberg, 1889)	DBUA 127/1, 145, 168/6, 173/2, 176/2, 188/2, 190/2, 193/4, 195/2, 197/7, 208, 240/4, 266/1, 270, 274/4, 278/3, 281/2, 286/1, 368/1, 374/1, 376/2, 377/1, 378/2, 380/1, 381/1, 382/1, 384/2, 387/2, 388/1, 391/1, 393/3, 394/2, 395/2, 396/2, 398/2, 400/2, 403/1, 405/2, 408/2, 409/1, 410/3, 428/1, 429/2, 438/2, 440, 441/2, 452/1, 453/1, 459/1, 460/3, 462/2, 465/2, 468/2, 471/12, 492/2, 493/2, 496/4, 499/12, 500/2, 545/2, 551/1, 553/2, 554/3, 555/2, 556/2, 557/3, 558/3, 560/3, 561/3, 563/2, 564/2, 566/2, 568/3, 569/2, 570/3, 571/1, 574/1, 575/2, 579/6, 609/4, 614/3, 626/3, 636, 662/4, 666/2, 667/4, 668/5, 670/6, 672/6, 676/3, 677/6, 695/5, 696/5, 709/4, 713/5, 715/6, 719/6, 726/4, 728/2, 730/4, 731/3, 732/5, 733/5, 735/4, 740/3, 741/2, 742/3, 743/2, 744/1, 745/2, 746/2, 748/4, 750/2, 754/2, 755/4, 760/2, 762/2, 764/2, 765/1, 766/6, 767/3, 768/2, 769/4, 770/1, 771/2, 772/4, 773/3, 774/2, 775/1, 776/3, 777/3, 779/3, 780/3, 782/3, 783/3, 784/3, 788/4, 789/4, 791/4, 806/1
CERITHIIDAE	
Bittium nanum (Mayer, 1864)	DBUA 167/3, 169/2, 173/4, 176/3, 181, 182/3, 188/5, 190/3, 193/5, 196/1, 197/8, 206, 240/8, 266/2, 274/5, 276/2, 278/5, 281/3, 286/2, 368/2, 369/1, 370/2, 371/2, 372/2, 373/1, 374/2, 375, 376/1, 377/2, 378/3, 379/1, 380/2, 381/2, 382/2, 384/3, 385, 386, 387/3, 390/2, 391/2, 393/2, 394/3, 395/3, 396/3, 397/1, 398/3, 399, 400/3, 403/2, 405/3, 407/2, 408/2, 409/2, 410/4, 412/1, 414/1, 415/2, 416/1, 417, 418/2, 422/3, 424/4, 427/2, 428/2, 430/1, 434/1, 435, 436, 437/1, 438/3, 439/1, 441/3, 442/1, 443/4, 445/1, 446/2, 447/1, 448/1, 449/1, 450/1, 452/2, 453/2, 456/1, 457/2, 458/2, 459/2, 460/4, 462/3, 463, 465/3, 466/2, 467/2, 468/3, 469/1, 470/2, 471/11, 472/2, 474/1, 475/2, 476/1, 478/1, 480/1, 481/3, 483/1, 486/2, 489/1, 492/3, 493/3, 496/4, 499/13, 500/3, 545/3, 546, 551/2, 553/3, 555/3, 556/3, 557/4, 558/4, 560/4, 561/4, 563/3, 564/3, 565/4, 567/2, 568/4, 569/3, 570/4, 571/2, 572, 574/2, 575/3, 576/2, 579/11, 605/4, 608/3, 609/5, 610/1, 614/4, 621/3, 623, 624/3, 626/4, 631/1, 657/3, 658/1, 659/1, 661/3, 662/5, 665/1, 666/3, 668/6, 670/7, 672/7, 675/3, 676/4, 677/7, 678/2, 695/6, 696/6, 709/5, 715/7, 716, 717/6, 719/7, 721/2, 726/5, 727/1, 728/3, 730/5, 731/4, 732/6, 733/6, 735/5, 736/1, 737/2, 739/4, 742/4, 744/2, 748/5, 750/3, 753/2, 755/5, 758/2, 760/3, 762/3, 763/1, 764/3, 765/2, 766/7, 767/4, 768/3, 769/5, 770/2, 771/3, 772/5, 773/4, 774/3, 775/2, 776/4, 777/4, 778/1, 779/4, 780/4, 782/4, 783/4, 784/4, 786/5, 788/5, 789/5, 791/5, 806/2, 807/3
PLANAXIDAE	
Fossarus ambiguus (Linnaeus, 1758)	DBUA 136, 182, 228, 286/3, 387/4, 448/2, 458/5, 459/3, 465/4, 471/10, 472/3, 475/3, 489/2, 492/4, 496/6, 500/4, 614/5, 658/2, 661/4, 662/6, 665/2, 666/4, 677/8, 695/7, 727/2, 728/4, 743/3, 750/4
CYPRAEIDAE	
Luria lurida (Linnaeus, 1758)	DBUA 362, 640, 649/1, 696/7, 715/8, 810, 835/1, 1059/1
LITTORINIDAE	
Littorina saxatilis (Olivi, 1792)	DBUA 22/1, 29/1, 61, 191, 193/6, 348/1, 626/5, 629, 743/4
Melarhaphe neritoides (Linnaeus, 1758)	DBUA 149, 171, 215/1, 235, 415/3, 430/2, 438/4, 444/1, 445/2, 448/3, 452/3, 457/3, 458/1, 459/4, 460/5, 496/7, 500/5, 659/2, 660/2, 661/5, 662/7, 663/2, 665/3, 666/5, 667/5, 672/8, 713/6, 727/3, 739/5, 806/3
Tectarius striatus (King, 1832)	DBUA 163, 215/2, 221, 282, 438/5, 471/9, 661/6, 662/8, 663/3, 665/4, 667/6, 668/7, 713/7, 727/4, 728/5, 743/5
SKENEOPSIDAE	
Skeneopsis planorbis (O. Fabricius, 1780)	DBUA 9, 117/3, 173/5, 188/7, 189, 194/2, 195/3, 196/2, 217, 268/2, 269/1, 272/1, 274/6, 277/2, 280/1, 281/4, 442/2, 444/2, 446/3, 449/2, 452/4, 456/2, 460/6, 462/4, 466/3, 467/3, 468/4, 469/2, 471/8, 475/4, 477, 478/2, 492/5, 493/4, 496/8, 499/2, 500/6, 564/4, 632/1, 661/7, 662/9, 663/4, 674/1, 719/8, 726/6, 735/6, 743/6, 744/3, 768/4

FAMILY - SPECIES	MATERIAL EXAMINED
NATICIDAE	
Natica prietoi Hidalgo, 1873	DBUA 2, 108, 410/5, 422/4, 605/5, 676/5, 697/2, 717/7, 721/3, 724/3, 734/2, 737/3, 757, 804, 807/4, 825, 835/2, 837/1, 1060/1
RISSOIDAE	
Alvania abstersa van der Linden et van Aartsen, 1994	DBUA 411/1, 726/7
Alvania angioyi van Aartsen, 1982	DBUA 119/1, 173/6, 188/8, 227, 274/7, 277/3, 281/5, 335/2, 340/3, 343/1, 350/3, 352/1, 353/6, 355/4, 372/3, 374/3, 379/8, 394/4, 398/4, 400/4, 407/3, 410/6, 412/2, 462/5, 493/5, 496/9, 499/14, 556/4, 560/5, 564/5, 568/5, 571/3, 574/3, 579/13, 666/6, 675/4, 687/3, 695/8, 709/6, 715/9, 719/9, 727/5, 730/6, 731/5, 732/7, 733/7, 735/7, 736/2, 741/3, 742/5, 748/6, 753/3, 764/4, 766/8, 767/5, 768/5, 769/6, 772/6, 773/5, 788/6, 789/6, 811/1, 813/2
Alvania cancellata (da Costa, 1778)	DBUA 127/2, 168/2, 173/6, 176/4, 197/2, 240/9, 274/8, 281/6, 341/2, 350/4, 379/9, 394/5, 395/4, 405/4, 408/3, 410/7, 411/2, 415/4, 421/3, 422/5, 438/6, 441/4, 446/4, 448/4, 459/5, 489/3, 493/6, 496/10, 499/16, 500/7, 555/4, 558/5, 561/5, 569/4, 570/5, 574/4, 579/9, 605/6, 608/4, 609/6, 614/6, 621/4, 626/6, 658/3, 659/3, 660/3, 661/8, 662/10, 665/5, 666/7, 667/7, 670/8, 672/9, 675/5, 676/6, 677/9, 687/4, 695/9, 696/8, 697/3, 709/7, 719/10, 726/8, 727/6, 731/6, 732/8, 733/8, 735/8, 740/4, 742/6, 760/4, 767/6, 773/6, 789/7, 806/4, 816/1
Alvania formicarum Gofas, 1989	DBUA 332/4, 335/3, 338/2, 340/4, 341/3, 342/4, 343/3, 345/3, 348/2, 350/5, 352/2, 353/1, 355/5, 359/1
Alvania internodula Hoenselaar et Goud, 1998	DBUA 336/4, 338/9
Alvania mediolittoralis Gofas, 1989	DBUA 124, 188/9, 193/7, 197/5, 229, 240/15, 274/9, 409/3, 410/8, 411/3, 421/4, 428/3, 434/2, 438/7, 441/5, 442/3, 444/3, 445/3, 446/5, 448/5, 449/3, 450/2, 451/1, 452/5, 453/3, 455, 456/3, 457/4, 458/6, 459/6, 460/7, 461/1, 462/6, 471/7, 473/1, 474/2, 475/5, 476/2, 483/2, 486/3, 489/4, 490/1, 492/6, 493/7, 496/11, 499/8, 500/8, 551/3, 553/4, 558/6, 560/6, 561/6, 564/6, 565/5, 566/3, 568/6, 570/6, 571/4, 574/5, 579/7, 614/7, 632/2, 659/4, 661/9, 662/11, 663/5, 665/6, 666/8, 667/8, 715/10, 719/11, 727/7
Alvania poucheti Dautzenberg, 1889	DBUA 4, 119/2, 143, 173/7, 240/17, 350/6, 352/3, 353/2, 355/6, 368/3, 369/2, 370/1, 371/1, 372/4, 373/2, 377/3, 378/4, 379/2, 380/3, 384, 387/5, 393/1, 394/6, 395/5, 397/2, 398/5, 400/5, 405/5, 407/4, 409/4, 410/9, 411/4, 427/1, 447/2, 457/5, 465/5, 493/8, 499/3, 500/9, 556/5, 563/4, 570/7, 631/2, 666/9, 687/5, 695/10, 709/8, 748/7, 767/7, 773/7, 788/7, 806/5
Alvania sleursi (Amati, 1987)	DBUA 173/8, 335/4, 340/5, 341/4, 342/1, 343/4, 350/7, 352/4, 353/4, 355/7, 446/6, 448/6, 458/7, 459/7, 493/9, 496/12, 499/17, 500/10, 626/7, 666/10, 667/9, 687/6, 695/11, 709/9, 719/12, 727/8, 731/7, 735/9, 746/3, 748/8, 750/5, 755/6, 766/9, 767/8, 769/7, 772/7, 773/8, 780/5, 786/4, 788/8, 789/8, 791/6, 806/6, 811/2
Alvania tarsodes (Watson, 1886)	DBUA 703/E
Botryphallus ovummuscae (Gofas, 1990)	DBUA 209, 493/10, 499/7, 500/11, 659/5, 661/10, 662/12, 665/7, 666/11, 715/11, 750/6
Cingula trifasciata (J. Adams, 1800)	DBUA 128, 205, 240/2, 352/5, 442/4, 445/4, 448/7, 449/4, 457/6, 460/8, 461/2, 470/3, 474/3, 475/6, 489/5, 490/2, 496/13, 499/5, 500/12, 632/3, 659/6, 660/4, 661/11, 662/13, 663/6, 665/8, 666/12, 667/10, 695/12, 696/9, 726/9, 732/9, 744/4, 750/7, 755/7, 806/7
Crisilla postrema (Gofas, 1990)	DBUA 121/1, 173/9, 188/3, 198, 274/10, 277/4, 340/6, 350/8, 351, 352/6, 353/3, 355/8, 359/2, 447/3, 462/7, 465/6, 470/4, 472/4, 492/7, 496/14, 499/18, 500/13, 545/4, 564/7, 632/4, 670/9, 730/7, 731/8, 733/9, 741/4, 745/3, 746/4, 768/6
Manzonia martinsi Ávila et Cordeiro, 2015	DBUA 788/9, 1092, 1093, 1094, 1095
Manzonia unifasciata Dautzenberg, 1889	DBUA 129, 173/10, 188/1, 266/3, 273, 274/11, 281/7, 332, 338/3, 340/7, 341/5, 346, 350/9, 352/7, 353/5, 355/9, 380/4, 381/3, 395/6, 397/3, 398/6, 403/3, 409/5, 410/10, 442/5, 443/3, 445/5, 446/7, 449/5, 451/2, 452/6, 462/8, 470/5, 471/6, 475/7, 476/3, 486/4, 492/8, 493/11, 496/15, 499/20, 500/14, 556/6, 571/5, 574/6, 579/14, 657/4, 660/5, 661/12, 662/14, 665/9, 666/13, 667/11, 670/11, 687/7, 695/13, 697/4, 709/10, 715/12, 719/13, 726/10, 727/9, 728/6, 730/8, 731/9, 733/10, 748/9, 755/8, 766/10, 767/9, 773/9, 789/9, 806/8

FAMILY - SPECIES	MATERIAL EXAMINED
RISSOIDAE	
Onoba moreleti Dautzenberg, 1889	DBUA 24/1, 181/2, 410/11, 411/5, 500/15, 556/7, 666/14, 726/11, 748/10
Rissoa guernei Dautzenberg, 1889	DBUA 132, 188/10, 190/4, 193/8, 195/4, 220, 240/18, 274/12, 281/8, 372/5, 381/4, 382/3, 387/6, 397/4, 398/7, 400/6, 442/6, 443/2, 448/8, 451/3, 452/7, 459/8, 460/9, 462/9, 468/5, 470/6, 471/5, 472/5, 473/2, 475/8, 492/9, 493/12, 496/16, 499/22, 500/16, 551/4, 554/1, 556/8, 565/6, 566/4, 568/7, 570/8, 571/6, 574/7, 579/5, 632/5, 661/13, 662/15, 666/15, 667/12, 695/14, 719/14, 726/12, 735/10, 736/3, 741/5, 746/5, 748/11, 755/9, 764/5, 766/11
Setia alexandrae Ávila et Cordeiro, 2015	DBUA 35/1, 37/1, 40, 48/1, 50, 336/3, 355/10, 449/6, 468/6, 471/4, 478/3, 496/17, 662/16, 704/A1, 898/1, 901, 920, 963/1, 1018/1, 1019/1, 1051, 1070, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078
Setia ermelindoi Ávila et Cordeiro, 2015	DBUA 137, 467/4, 689/2, 899, 957, 1058/1, 1079, 1080, 1081, 1082, 1083, 1084, 1085
Setia netoae Ávila et Cordeiro, 2015	DBUA 264/1, 745/4, 1086, 1087, 1088, 1089, 1090, 1091
Setia subvaricosa Gofas, 1990	DBUA 121/2, 176/5, 188/11, 193/9, 195/5, 223, 274/13, 281/9, 332, 335/5, 336/1, 338/4, 343/5, 345/4, 350/10, 352/8, 355/11, 447/4, 451/4, 462/10, 465/7, 467/5, 471/3, 481/4, 496/18, 499/23, 500/17, 545/5, 557/5, 564/8, 571/7, 574/8, 660/6, 662/17, 666/16, 730/9, 731/10, 733/11, 735/11, 741/6, 742/7, 744/5, 745/5, 746/6, 754/3, 755/10, 764/6, 766/12, 773/10, 782/5, 784/5, 788/10
ANABATHRIDAE	
Pisinna glabrata (Megerle von Mühlfeld, 1824)	DBUA 187, 189/2, 194, 195/6, 269/2, 272/2, 277/5, 280/2, 442/7, 443/1, 444/4, 446/8, 447/5, 448/9, 449/7, 450/3, 451/5, 452/8, 456/4, 457/7, 458/3, 459/9, 460/10, 462/11, 465/8, 466/4, 467/6, 468/7, 469/3, 470/7, 471/2, 472/6, 474/4, 475/9, 476/4, 478/4, 480/2, 481/5, 492/10, 493/13, 496/19, 499/19, 500/18, 554/4, 661/14, 662/18, 663/7, 665/10, 666/17, 669/4, 726/13, 727/10, 743/7, 744/6, 755/11
ASSIMINEIDAE	
Assiminea avilai van Aartsen, 2008	DBUA 687/8
Paludinella globularis (Hanley in Thorpe, 1844)	DBUA 355/12, 449/8, 466/5, 470/8, 660/7, 661/15, 665/11, 666/18, 715/13, 726/14
CAECIDAE	
Caecum gofasi Pizzini et Nofroni, 2001	DBUA 355/13, 662/19, 1096
Caecum wayae Pizzini et Nofroni, 2001	DBUA 355/14, 1107
TRUNCATELLIDAE	
Truncatella subcylindrica (Linnaeus, 1767)	DBUA 1
BURSIDAE	
Bursa scrobilator (Linnaeus, 1758)	DBUA 359/3, 495/1, 498/2, 639/1, 643, 672/10, 1059/2
CASSIDAE	
Semicassis granulata undulata (Gmelin, 1791)	DBUA 719/15, 807/5
RANELLIDAE	
Charonia lampas (Linnaeus, 1758)	DBUA 648, 668/8, 672/11, 685/1
Charonia variegata (Lamarck, 1816)	DBUA 672/12
Monoplex corrugatus (Lamarck, 1816)	DBUA 652/2, 668/9, 738/3, 807/6
VELUTINIDAE	
Lamellaria latens (O.F. Müller, 1776)	DBUA 22/2, 410/12, 666/19

FAMILY - SPECIES	MATERIAL EXAMINED
VELUTINIDAE	
Lamellaria perspicua (Linnaeus, 1758)	DBUA 29/2, 731/11, 788/11, 842
TRIVIIDAE	
Trivia candidula (Gaskoin, 1836)	DBUA 6, 624/4, 668/10, 677/10, 696/10, 717/8, 721/4, 732/10, 737/4, 739/6, 750/8, 835/3.
Trivia mediterranea (Risso, 1826)	DBUA 33, 169/3, 486/5, 608/5, 609/7, 610/2, 614/8, 620, 649/2, 651/2, 666/20, 677/11, 696/11, 715/14, 726/15, 730/10, 733/12, 739/7, 758/4, 760/5, 837/2
VERMETIDAE	
Thylaeodus cf. *rugulosus* (Monterosato, 1878)	DBUA 1108
Vermetus triquetrus Bivona Ant., 1832	DBUA 214, 445/6, 456/5, 470/9, 474/5, 674/2.
EPITONIIDAE	
Acirsa subdecussata (Cantraine, 1835)	DBUA 1117
Cirsotrema cochlea (G.B. Sowerby II, 1844)	DBUA 738/4
Epitonium algerianum (Weinkauff, 1866)	DBUA 69, 72
Epitonium celesti (Aradas, 1854)	DBUA 1118
Epitonium clathratulum (Kanmacher, 1798)	DBUA 614/9, 715/15
Epitonium clathrus (Linnaeus, 1758)	DBUA 1119
Epitonium pulchellum (Bivona, 1832)	DBUA 1120
Epitonium turtonis (Turton, 1819)	DBUA 1121
Gyroscala lamellosa (Lamarck, 1822)	DBUA 24/2, 93, 105, 695/15, 777/5, 1058/2
Opalia coronata (Philippi et Scacchi, 1840)	DBUA 614/10
EULIMIDAE	
Crinophtheiros collinsi (Sykes, 1903)	DBUA 1122
Curveulima dautzenbergi (Pallary, 1900)	NMR 32213
Melanella boscii (Payraudeau, 1826)	DBUA 1123
Melanella cf. trunca (Watson, 1897)	DBUA 1124
Parvioris ibizenca (Nordsieck, 1968)	DBUA 224
Vitreolina curva (Monterosato, 1874)	DBUA 133/1, 338/5, 343/6, 355/15
Vitreolina incurva (Bucquoy, Dautzenberg et Dollfus, 1883)	DBUA 115, 133/2, 134, 281/10, 379/3, 407/5
Vitreolina philippi (de Rayneval et Ponzi, 1854)	DBUA 16, 19, 1017, 1058/3
TRIPHORIDAE	
Cheirodonta pallescens (Jeffreys, 1867)	DBUA 240/14, 722/1, 769/8, 781, 784/6
Marshallora adversa (Montagu, 1803)	DBUA 116, 186, 193/10, 197/9, 240/16, 281/11, 373/3, 374/4, 379/4, 380/5, 407/6, 428/4, 441/6, 493/14, 560/7, 563/5, 574/9, 662/20, 665/12, 666/21, 672/14, 675/6, 715/16, 722/2, 765/3, 768/7, 770/3, 771/4, 773/11, 774/4, 775/3, 776/5, 777/6, 778/2, 789/10, 791/7

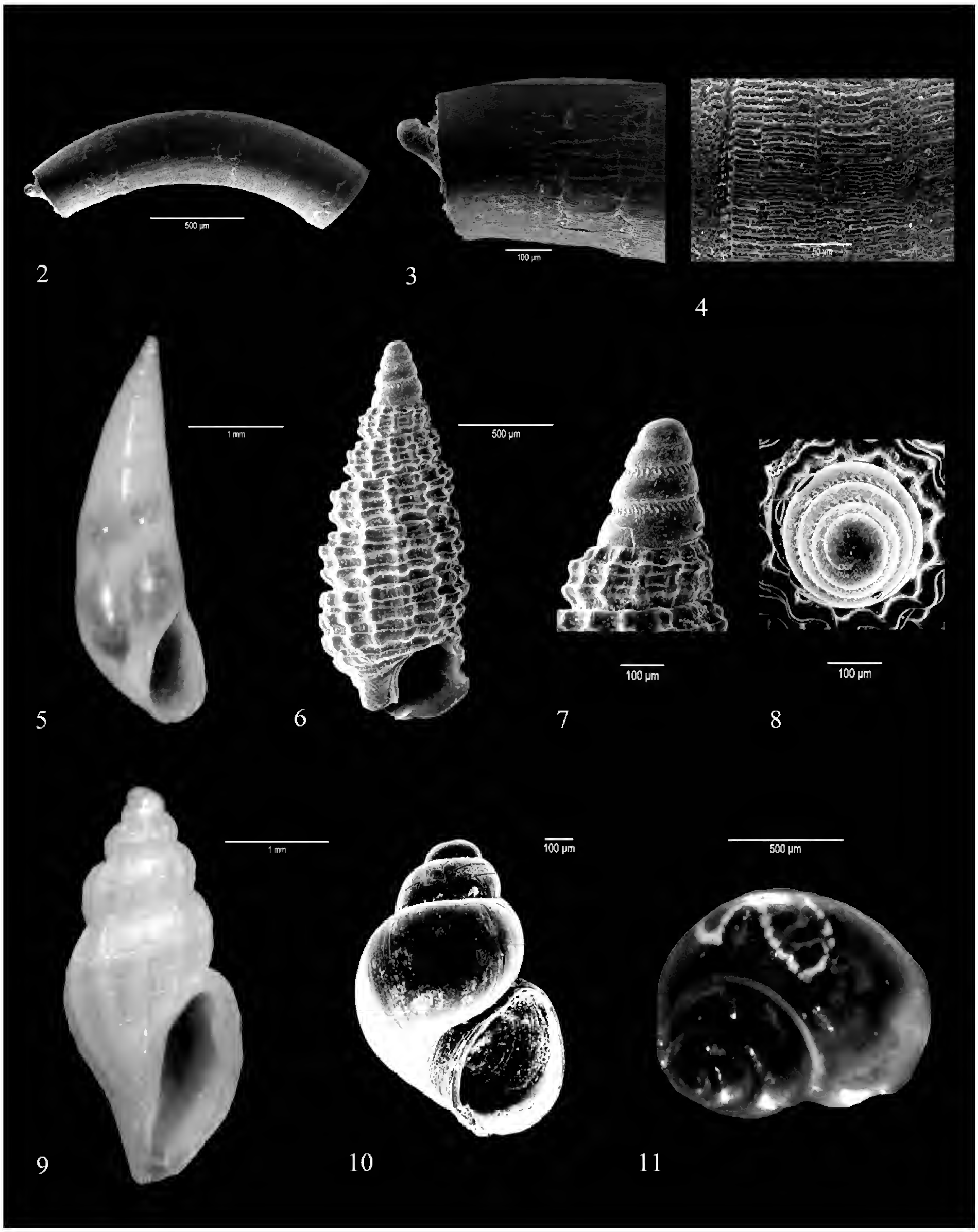
FAMILY - SPECIES	MATERIAL EXAMINED
TRIPHORIDAE	
Metaxia abrupta (Watson, 1880)	DBUA 73/1, 76/1
Monophorus erythrosoma (Bouchet et Guillemot, 1978)	DBUA 421/5, 574/10, 722/3, 723, 727/11, 762/4, 767/10, 768/8, 773/12, 774/5, 778/3, 782/6, 789/11, 790
Monophorus thiriotae Bouchet, 1985	DBUA 768/9
Pogonodon pseudocanaricus (Bouchet, 1985)	DBUA 1141
Similiphora similior (Bouchet et Guillemot, 1978)	DBUA 727/12, 730/11, 732/11, 767/11, 787, 788/12
CERITHIOPSIDAE	
Cerithiopsis barleei Jeffreys, 1867	DBUA 197/10, 240/11, 412/3, 560/8, 567/3
Cerithiopsis fayalensis Watson, 1880	DBUA 1142
Cerithiopsis jeffreysi Watson, 1885	DBUA 12, 73/2, 274/14, 574/11, 695/16, 702/4, 731/12, 785/1
Cerithiopsis minima (Brusina, 1865)	DBUA 150, 188/4, 213, 695/17, 777/7
Cerithiopsis cf. *nana* Jeffreys, 1867	DBUA 560/9, 707/1, 748/12
Cerithiopsis scalaris Locard, 1892	DBUA 1128
Cerithiopsis tubercularis (Montagu, 1803)	DBUA 76/2, 188/6, 379/5, 409/6, 660/8, 662/21, 666/22, 742/8
BUCCINIDAE	DBUA 1121
Pollia dorbignyi (Payraudeau, 1826)	DBUA 175, 410/13, 627, 657/5, 676/8, 721/5, 731/13, 733/13, 738/5, 754/4, 767/12, 807/7, 835/4
COLUMBELLIDAE	
Anachis avaroides Nordsieck, 1975	DBUA 155, 168/7, 173/11, 176/6, 195/7, 216, 240/12, 274/15, 278/6, 281/12, 368/4, 372/6, 378/5, 379/6, 381/5, 387/7, 391/3, 394/7, 395/7, 397/5, 398/8, 405/6, 407/7, 408/4, 409/7, 410/14, 428/5, 438/8, 441/7, 456/6, 496/20, 553/5, 555/5, 556/9, 561/7, 565/7, 571/8, 574/12, 579/12, 614/11, 621/5, 626/8, 662/22, 666/23, 672/15, 675/7, 676/9, 677/12, 695/18, 696/12, 707/2, 709/11, 715/17, 719/16, 726/16, 727/13, 732/12, 733/14, 739/8, 741/7, 742/9, 745/6, 748/13, 764/7, 766/13, 767/13, 768/10, 772/8, 773/13, 775/4, 777/8, 779/5, 783/5, 784/7, 788/13, 789/12, 791/8, 807/8
Columbella adansoni Menke, 1853	DBUA 166, 176/7, 184, 193/11, 197/4, 233/3, 240/13, 278/1, 377/4, 404, 405/7, 425/1, 433/4, 553/6, 556/10, 557/6, 561/8, 563/6, 565/8, 567/4, 569/5, 570/9, 574/13, 576/3, 578/1, 579/1, 621/6, 646/1, 658/4, 662/23, 668/11, 670/12, 671/2, 672/16, 676/10, 677/13, 696/13, 709/12, 713/8, 715/18, 719/17, 721/6, 727/14, 728/7, 729/1, 731/14, 733/15, 738/6, 758/5, 759/1, 760/6, 761/1, 766/14, 773/14, 776/6, 778/4, 783/6, 791/9, 807/9, 835/5, 837/3
NASSARIIDAE	
Nassarius corniculum (Olivi, 1792)	DBUA 418/3
Nassarius cuvierii (Payraudeau, 1826)	DBUA 340/8, 673/2, 676/11, 711, 730/12, 731/15, 732/13, 734/3, 735/12, 736/4, 807/10
Nassarius incrassatus (Strøm, 1768)	DBUA 164, 167/4, 169/4, 176/8, 193/12, 201, 233/4, 240/10, 368/5, 414/2, 416/2, 418/4, 422/6, 424/1, 430/3, 437/2, 439/2, 553/7, 555/6, 558/7, 560/10, 563/7, 568/8, 569/6, 576/4, 578/2, 579/15, 612/2, 614/12, 616/4, 621/7, 624/5, 646/2, 657/6, 668/12, 672/17, 675/8, 676/13, 677/14, 676, 696/14, 704/A2, 709/13, 717/9, 719/19, 721/7, 729/2, 730/13, 731/16, 732/14, 733/16, 734/4, 735/14, 737/5, 738/7, 758/6, 760/7, 761/2, 764/8, 766/15, 767/14, 768/11, 769/9, 772/9, 773/15, 774/6, 776/7, 777/9, 779/6, 780/6, 782/7, 784/8, 786/3, 788/14, 789/13, 791/10, 807/11, 835/6, 837/4

FAMILY - SPECIES	MATERIAL EXAMINED
MURICIDAE	
Coralliophila meyendorffii (Calcara, 1845)	DBUA 37/2, 38/1, 345/5, 350/11, 695/19, 728/8
Hexaplex trunculus (Linnaeus, 1758)	DBUA 425/2, 645/1, 646/3, 649/3, 652/4, 656/2, 676/14, 758/7, 760/8
Ocenebra chavesi Houart, 1996	DBUA 38/2, 414/3, 612/3, 651/3, 676/15, 724/4, 760/9, 761/3, 807/12
Ocenebra erinaceus (Linnaeus, 1758)	DBUA 123/2, 424/2, 645/2, 651/4, 652/5, 657/7, 672/18, 676/16, 695/20, 719/20, 754/5, 760/10, 807/13
Ocinebrina aciculata (Lamarck, 1822)	DBUA 123/1, 167/5, 168/1, 173/12, 176/9, 379/7, 394/8, 395/8, 400/7, 408/5, 409/8, 410/15, 411/6, 605/7, 608/6, 612/4, 614/13, 616/5, 618/2, 621/8, 626/9, 672/19, 675/9, 676/17, 677/15, 695/21, 696/15, 709/14, 719/21, 721/8, 726/17, 730/14, 731/17, 732/15, 733/17, 742/10, 754/6, 760/11, 761/4, 764/9, 765/4, 766/16, 767/15, 770/4, 772/10, 773/16, 774/7, 776/8, 778/5, 779/7, 782/8, 783/7, 784/9, 786/2, 788/15, 789/14, 791/11, 807/14, 837/5
Orania fusulus (Brocchi, 1814)	DBUA 612/5
Stramonita haemastoma (Linnaeus, 1767)	DBUA 18, 174, 193/3, 233/5, 239, 372/7, 410/16, 422/7, 425/3, 433/5, 487, 576/5, 579/10, 609/8, 644, 650, 657/8, 662/24, 666/24, 668/13, 670/13, 671/3, 672/20, 676/18, 677/16, 696/16, 717/10, 719/22, 729/3, 731/18, 733/18, 737/6, 759/2, 760/12, 761/5, 764/10, 766/17, 767/16, 807/15, 835/7
Trophonopsis barvicensis (Johnston, 1825)	DBUA 151, 605/8, 608/7, 616/6
MARGINELLIDAE	
Volvarina oceanica Gofas, 1989	DBUA 338/6, 342/3
MITRIDAE	
Mitra cornea Lamarck, 1811	DBUA 172, 197/1, 233/6, 378/6, 397/6, 400/8, 401, 402, 405/8, 409/9, 433/6, 495/3, 573, 579/8, 612/6, 624/6, 662/25, 670/14, 671/4, 672/21, 674/3, 677/17, 696/17, 715/19, 717/11, 719/23, 727/15, 729/4, 733/19, 738/8, 740/5, 741/8, 759/3, 761/6, 763/2, 765/5, 767/17, 786/1, 835/8, 1018/2
Mitra zonata Marryat, 1819	DBUA 356/3, 419, 495/4, 724/5
MANGELIIDAE	
Bela nebula (Montagu, 1803)	DBUA 135, 167/6, 169/5, 605/9, 608/8, 614/14, 616/7, 676/19, 732/17, 739/9, 807/16
Mangelia costata (Pennant, 1777)	DBUA 338/10
Mangelia scabrida Monterosato, 1890	NMR 34350
RAPHITOMIDAE	
Raphitoma aequalis (Jeffreys, 1867)	DBUA 605/10, 609/9
Raphitoma leufroyi (Michaud, 1828)	DBUA 338/7, 343/7, 614/15, 698/2, 701/G
Raphitoma linearis (Montagu, 1803)	DBUA 122, 176/11, 253, 418/6, 558/8, 574/14, 624/7, 626/11, 666/25, 675/11, 695/23, 696/19, 721/9, 732/18, 764/11, 767/19, 770/5, 773/18, 774/8, 775/5, 789/16
Raphitoma purpurea (Montagu, 1803)	DBUA 410/17, 666/26, 670/10, 702/H, 709/16, 762/5, 785/2, 1058/5
Teretia teres (Reeve, 1844)	DBUA 1116
DRILLIIDAE	
Crassopleura maravignae (Bivona Ant. in Bivona And., 1838)	DBUA 154, 169/6, 608/9, 614/16, 616/8, 696/20
HORAICLAVIDAE	DBUA 338/10
Haedropleura septangularis (Montagu, 1803)	DBUA 240/1, 338/8, 605/11, 675/12, 682/2, 683/3, 695/24, 696/21, 704/A3, 709/17

FAMILY - SPECIES	MATERIAL EXAMINED
CANCELLARIIDAE	
Brocchinia clenchi Petit, 1986	DBUA 146, 169/7, 605/12, 608/10, 609/10, 614/17
CIMIDAE	
Cima cylindrica (Jeffreys, 1856)	DBUA 1125, 1126
Cima cf. *minima* (Jeffreys, 1858)	DBUA 147
ARCHITECTONICIDAE	
Philippia hybrida (Linnaeus, 1758)	DBUA 17, 35/2
Pseudotorinia architae (O.G. Costa, 1841)	DBUA 605/13
TOFANELLIDAE	
Graphis albida (Kanmacher, 1798)	DBUA 1127
OMALOGYRIDAE	
Ammonicera fischeriana (Monterosato, 1869)	DBUA 338/6, 342/3
Ammonicera rota (Forbes et Hanley, 1850)	DBUA 1058/6
Omalogyra atomus (Philippi, 1841)	DBUA 35/3, 77, 87, 118/2, 173/13, 188/12, 277/6, 280/3, 336/2, 446/9, 449/9, 452/9, 465/9, 467/7, 468/8, 469/4, 470/10, 471/1, 474/6, 475/10, 496/21, 499/15, 564/9, 571/9, 614/18, 631/3, 632/6, 662/26, 663/8, 665/13, 666/27, 715/21, 726/18, 730/15, 731/19, 755/13, 768/12, 773/19, 1058/7
PYRAMIDELLIDAE	
Brachystomia eulimoides (Hanley, 1844)	DBUA 1114
Liostomia mamoi Mifsud, 1993	DBUA 499/1
Odostomella doliolum (Philippi, 1844)	DBUA 5, 22/3, 355/16, 574/15, 687/9, 695/25, 707/C, 709/18, 735/15, 755/14, 767/10, 1014, 1018/3, 1058/8
Odostomia bernardi van Aartsen, Gittenberger et Goud, 1998	DBUA 719/25, 731/20, 1115
Odostomia duureni van Aartsen, Gittenberger et Goud, 1998	DBUA 1113
Odostomia kuiperi van Aartsen, Gittenberger et Goud, 1998	DBUA 719/26, 1111
Odostomia lukisii Jeffreys, 1859	DBUA 730/16, 731/21, 733/21, 1110
Odostomia striolata Forbes et Hanley, 1850	DBUA 1109
Odostomia turrita Hanley, 1844	DBUA 1112
Ondina diaphana (Jeffreys, 1848)	DBUA 719/27
Pyrgiscus rufus (Philippi, 1836)	DBUA 1129
Turbonilla lactea (Linnaeus, 1758)	DBUA 22/4, 130, 493/15, 499/21, 695/26, 702/1, 703/G, 709/19, 727/17, 728/9, 730/17, 731/22, 735, 767/21
Cima cf. *minima* (Jeffreys, 1858)	DBUA 147
MURCHISONELLIDAE	
Ebala nitidissima (Montagu, 1803)	DBUA 1130
RISSOELLIDAE	
Rissoella contrerasi Rolán et Hernández, 2004	DBUA 48/2, 195/8, 352/9, 730/18, 898/2, 1018/4

FAMILY - SPECIES	MATERIAL EXAMINED
RISSOELLIDAE	
Rissoella diaphana (Alder, 1848)	DBUA 466/6, 662/27, 665/14
DIAPHANIDAE	
Diaphana globosa (Lovén, 1846)	DBUA 1062
HAMINOEIDAE	
Atysma candrewii E.A. Smith, 1872	DBUA 738/9, 1131, 1132, 1133
Haminoea orteai Talavera, Murillo et Templado, 1987	DBUA 702/2, 738/10, 1334, 1335
RETUSIDAE	
Retusa multiquadrata Oberling, 1970	DBUA 733/22
Retusa truncatula (Bruguière, 1792)	DBUA 22/5, 493/16, 499/4, 731/23, 746/7
RUNCINIDAE	
Runcina adriatica T. Thompson, 1980	DBUA 1137, 1139
APLYSIIDAE	
Aplysia depilans (Gmelin 1791)	DBUA 80, 835/9
Aplysia fasciata Poiret, 1789	DBUA 360
Aplysia parvula Mörch, 1863	DBUA 45/1, 662/28, 667/13, 704/D1, 704/H, 762/6
Aplysia punctata (Cuvier, 1803)	DBUA 354/1, 748/14, 759/4, 766/19, 776/10, 778/6, 780/9, 785/2, 788/16, 1058/9
PLAKOBRANCHIDAE	
Elysia ornata (Swainson, 1840)	DBUA 577/2
Elysia viridis (Montagu, 1804)	DBUA 729/5
UMBRACULIDAE	
Umbraculum umbraculum (Lightfoot, 1786)	DBUA 26, 35/4, 638/3, 753/4, 760/13, 874
TYLODINIDAE	
Tylodina perversa (Gmelin, 1791)	DBUA 861
PLEUROBRANCHIDAE	
Berthellina edwardsii (Vayssière, 1896)	DBUA 185/1, 362, 423, 642/1, 719/28, 748/15
Pleurobranchus testudinarius Cantraine, 1835	DBUA 185/2, 759/5, 761/7
DORIDIDAE	
Doris bertheloti (d'Orbigny, 1839)	DBUA 1063
Doris ocelligera (Bergh, 1881)	DBUA 778/7
CADLINIDAE	
Aldisa smaragdina Ortea, Pérez et Llera, 1982	DBUA 809/1
CHROMODORIDIDAE	
Felimare picta (Schultz in Philippi, 1836)	DBUA 354/2, 685/2, 687/11, 759/6, 761/8, 809/2
Felimare tricolor (Cantraine, 1835)	DBUA 760/14, 1038

FAMILY - SPECIES	MATERIAL EXAMINED
CHROMODORIDIDAE	
Felimida britoi (Ortea et Pérez, 1983)	DBUA 722/4, 760/15
Felimida edmundsi (Cervera, García-Gómez et Ortea, 1989)	DBUA 1034/1
Felimida purpurea (Risso in Guérin, 1831)	DBUA 722/5, 759/7, 760/16, 1036
DISCODORIDIDAE	
Peltodoris atromaculata Bergh, 1880	DBUA 726/19, 761/9, 840, 1034/2, 1035
Platydoris argo (Linnaeus, 1767)	DBUA 345/6, 356/1, 642/2, 835/10, 864, 1040/1
DENDRODORIDIDAE	
Dendrodoris herytra Valdés et Ortea, 1996	DBUA 726/20, 760/17
POLYCERIDAE	
Crimora papillata Alder et Hancock, 1862	DBUA 1039, 1040/2
Kaloplocamus ramosus (Cantraine, 1835)	DBUA 610/3, 835/11
Limacia clavigera (O.F. Müller, 1776)	DBUA 837/6
Polycera quadrilineata (O.F. Müller, 1776)	DBUA 1138, 1140
Tambja ceutae García-Gómez et Ortea, 1988	DBUA 798, 1037, 1041/1, 1059/3
AEGIRIDAE	
Aegires sublaevis Odhner, 1932	DBUA 767/22, 1136
TRITONIIDAE	
Marionia blainvillea (Risso, 1818)	DBUA 331
AEOLIDIIDAE	
Spurilla neapolitana (delle Chiaje, 1841)	DBUA 45/2
FACELINIDAE	
Dicata odhneri Schmekel, 1967	DBUA 1041/2
SIPHONARIIDAE	
Williamia gussoni (O.G. Costa, 1829)	DBUA 260, 342/2, 703/D, 704/D2, 1058/10
ELLOBIIDAE	
Auriculinella bidentata (Montagu, 1808)	DBUA 659/7, 660/9, 661/16, 665/15, 666/28
Myosotella myosotis (Draparnaud, 1801)	DBUA 490/3, 500/19
Ovatella vulcani (Morelet, 1860)	DBUA 490/4, 659/9, 660/10, 661/17, 665/16, 666/29, 677/18, 726/21, 750/9
Pedipes pedipes (Bruguière, 1789)	DBUA 490/5, 626/12, 660/11, 665/17, 677/19, 694, 696/22, 726/22, 743/8, 750/10, 1056/1, 1060/2
Pseudomelampus exiguus (Lowe, 1832)	DBUA 659/8, 661/18, 665/18, 677/20, 696/23, 750/11, 1060/3
ONCHIDIIDAE	
Onchidella celtica (Cuvier, 1817)	DBUA 490/6, 491, 659/10, 660/12, 661/19, 665/19, 1056/2, 1066



Figures 2–11. New records for the littoral gastropoda fauna of the Azores. Figs. 2–4. *Caecum gofasi* Pizzini et Nofroni, 2001; DBUA 355/13. Fig. 2: shell; Fig. 3: septum, lateral view; Fig. 4: microsculpture of the shell. Fig. 5. *Curveulima dautzenbergi* (Pallary, 1900), shell, NMR 32213, credit: J. Trausel, Natural History Museum of Rotterdam. Figs. 6–8. *Cerithiopsis* cf. *nana* Jeffreys, 1867, DBUA 748/12: Fig. 6: shell; Fig. 7: protoconch, lateral view; Fig. 8: protoconch, apical view. Fig. 9. *Mangelia scabrida* Monterosato, 1890; shell, NMR 34350, credit: J. Trausel, Natural History Museum of Rotterdam). Fig. 10. *Liostomia mamoi* Mifsud, 1993, shell, DBUA 499/1. Fig. 11. *Rissoella contrerasi* Rolán et Hernández, 2004, shell, DBUA 1018/4.

Table 2. Species excluded from the checklist of the littoral gastropods of the Azores.

FAMILY	SPECIES	FIRST RECORD AND REMARKS
HALIOTIDAE	*Haliotis tuberculata coccinea* Reeve, 1846	Drouët (1858) as *Haliotis coccinea* Reeve. Dubious record (see Ávila et al., 1998).
TROCHIDAE	*Clanculus berthelotii* (d'Orbigny, 1840)	MacAndrew (1857), as *Trochus* (*Monodonta*) *bertheloti* d'Orbigny. Dubious record (see Ávila et al., 2011).
	Jujubinus exasperatus (Pennant, 1777)	MacAndrew (1857) as *Trochus striatus* Linnaeus. Misidentification of *Jujubinus pseudogravinae* Nordsieck, 1973 (see Ávila et al., 2011).
	Jujubinus striatus (Linnaeus, 1758)	MacAndrew (1857) as *Trochus striatus* Linnaeus. Misidentification of *Jujubinus pseudogravinae* Nordsieck, 1973 (see Ávila et al., 2011).
CALLIOSTOMATIDAE	*Calliostoma conulus* (Linnaeus, 1758)	Drouët (1858) as *Trochus conulus* Linnaeus. Misidentification of *Calliostoma lividum* Dautzenberg, 1927 (see Ávila et al., 2011).
	Calliostoma laugieri (Payraudeau, 1826)	MacAndrew (1857) as *Trochus laugieri* Payraudeau. Misidentification of *Calliostoma lividum* Dautzenberg, 1927 (see Ávila et al., 2011).
	Calliostoma zizyphinum (Linnaeus, 1758)	MacAndrew (1857) as *Trochus zizyphinus* Linnaeus. Misidentification of *Calliostoma lividum* Dautzenberg, 1927 (see Ávila et al., 2011).
TURBINIDAE	*Bolma rugosa* (Linnaeus, 1767)	MacAndrew (1857) as *Turbo rugosus* Linnaeus. Dubious record (see Ávila et al., 1998).
SKENEIDAE	*Dikoleps* cf. *cutleriana* (Clark, 1849)	Ávila et al. (2000b). Dubious record. The specimen was not found in the DBUA marine mollusc collection.
	Parviturbo cf. *rolani* Engl, 2001	Segers (2002). Misidentification of *Parviturbo azoricus* Rubio, Rolán et Segers, 2015.
CERITHIIDAE	*Cerithium zebrum* Kiener, 1841	Drouët (1858). Dubious record (see Ávila et al., 1998).
LITTORINIDAE	*Littorina compressa* Jeffreys, 1865	Jeffreys (1883) as *Littorina rudis* Maton. Misidentification of *Littorina saxatilis* (Olivi, 1792) (see Ávila et al., 1998).
	Littorina obtusata (Linnaeus, 1758)	Jeffreys (1883). Dubious record (see Ávila et al., 1998).
NATICIDAE	*Euspira intricata* (Donovan, 1804)	MacAndrew (1857) as *Natica intricata* Donovan. Misidentification of *Natica prietoi* Hidalgo, 1873.
	Euspira nitida (Donovan, 1804)	Morton et al. (1998) as *Lunatia alderi*. Misidentification of *Natica prietoi* Hidalgo, 1873.
	Naticarius stercusmuscarum (Gmelin, 1791)	Morton et al. (1998) as *Natica canrena*. Misidentification of *Natica prietoi* Hidalgo, 1873.
	Notocochlis dillwynii (Payraudeau, 1826)	Simroth (1888) as *Natica dillwyni* Payraudeau. Misidentification of *Natica prietoi* Hidalgo, 1873, see Ávila et al. (2000b).
	Polinices lacteus (Guilding, 1834)	Laursen (1981). Dubious record. Specimens of this species sometimes arrive by rafting to the Azores from the western Atlantic, but so far have not been able to maintain viable populations in the archipelago.
RISSOIDAE	*Alvania beanii* (Hanley in Thorpe, 1844)	MacAndrew (1857) as *Rissoa calathus* Forbes et Hanley. Dubious record (see Ávila, 2000b).
	Alvania cimex (Linnaeus, 1758)	MacAndrew (1857) as *Rissoa granulata* Philippi. Dubious record (see Ávila, 2000b).
	Cingula ordinaria Smith, 1890	Chapman (1955). Misidentification of *Cingula trifasciata* (J. Adams, 1800) (see Ávila et al., 1998).

FAMILY	SPECIES	FIRST RECORD AND REMARKS
RISSOIDAE	*Manzonia crassa* (Kanmacher, 1798)	Morton et al. (1998). Misidentification of *Manzonia unifasciata* Dautzenberg, 1889 (see Ávila, 2000b).
	Rissoa guerinii Récluz, 1843	Chapman (1955) as *Cingula costulata* Alder. Misidentification of *Rissoa guernei* Dautzenberg, 1889 (see Ávila, 2000b).
	Setia pulcherrima (Jeffreys, 1848)	Bullock et al. (1990) as *Cingula pulcherrima* (Jeffreys, 1848). Misidentification of *Setia subvaricosa* Gofas, 1990 (see Ávila, 2000b).
ASSIMINEIDAE	*Assiminea eliae* Paladilhe, 1875	Ávila & Azevedo (1996). Misidentification of *Paludinella globularis* (Hanley in Thorpe, 1844) (see Aartsen, 2008).
CAECIDAE	*Caecum glabellum* (A. Adams, 1868)	Morton et al. (1998). Dubious record. Probably misidentified, since it was only recorded by Morton et al. (1998) and was not found in the DBUA marine mollusc collection.
	Caecum vitreum Carpenter, 1859	Dautzenberg (1889). Dubious record. Probably misidentified, since it was only recorded by Dautzenberg (1889) and was not found in the DBUA marine mollusc collection.
TORNIDAE	*Tornus subcarinatus* (Montagu, 1803)	Borges et al. (2010). Misidentification of *Parviturbo azoricus* Rubio, Rolán et Segers, 2015.
RANELLIDAE	*Gutturnium muricinum* (Röding, 1798)	MacAndrew (1857) as *Triton tuberosus* Lamarck. Dubious record, (see Ávila et al., 1998).
EULIMIDAE	*Eulima glabra* (da Costa, 1778)	Jeffreys (1884) as *Eulima subulata* Donovan. Dubious record (see Ávila et al., 1998).
	Vitreolina antiflexa (Monterosato, 1884)	MacAndrew (1857) as *Eulima distorta* Deshayes. Dubious record (see Ávila et al., 1998).
TRIPHORIDAE	*Monophorus perversus* (Linnaeus, 1758)	Jeffreys (1885) as *Triforis perversa* Linnaeus. Dubious record. Jeffreys identified virtually all European Triphoridae with this name (see Bouchet, 1985).
BUCCINIDAE	*Engina turbinella* (Kiener, 1836)	Morton et al. (1998). Misidentification of *Pollia dorbignyi* (Payraudeau, 1826) (see Ávila et al., 2000b).
	Pisania striata (Gmelin, 1791)	MacAndrew (1857) as *Pisania maculosa* Lamarck. Dubious record (see Ávila et al., 1998).
NASSARIIDAE	*Nassarius* cf. *ovoideus* (Locard, 1886)	Ávila et al. (2000a). Misidentification of *Nassarius cuvierii* (Payraudeau, 1826).
MURICIDAE	*Ocinebrina edwardsii* (Payraudeau, 1826)	Ávila et al. (1998). Misidentification of *Ocenebra chavesi* Houart, 1996.
	Trophonopsis muricata (Montagu, 1803)	Poppe & Goto (1991) as *Trophon muricatus* (Montagu, 1803). Misidentification of *Trophonopsis barvicensis* (Johnston, 1825).
COSTELLARIIDAE	*Vexillum zebrinum* (d'Orbigny, 1840)	MacAndrew (1857) as *Mitra zebrina* d'Orbigny. Dubious record (see Ávila et al., 1998).
MITRIDAE	*Mitra cornicula* (Linnaeus, 1758)	Simroth (1888) as *Mitra corniculum* Linnaeus. Misidentification of *Mitra cornea* Lamarck, 1811 (see Ávila et al., 2000b).
MANGELIIDAE	*Bela menkhorsti* van Aartsen, 1988	Dautzenberg (1889) as *Raphitoma turgidum* Forbes. Dubious record. Probably misidentified, since it was only recorded by Dautzenberg (1889) and was not found in the DBUA marine mollusc collection.
	Trophonopsis muricata (Montagu, 1803)	Poppe & Goto (1991) as *Trophon muricatus* (Montagu, 1803). Misidentification of *Trophonopsis barvicensis* (Johnston, 1825).

FAMILY	SPECIES	FIRST RECORD AND REMARKS
COSTELLARIIDAE	*Vexillum zebrinum* (d'Orbigny, 1840)	MacAndrew (1857) as *Mitra zebrina* d'Orbigny. Dubious record (see Ávila et al., 1998).
MITRIDAE	*Mitra cornicula* (Linnaeus, 1758)	Simroth (1888) as *Mitra corniculum* Linnaeus. Misidentification of *Mitra cornea* Lamarck, 1811 (see Ávila et al., 2000b).
MANGELIIDAE	*Bela menkhorsti* van Aartsen, 1988	Dautzenberg (1889) as *Raphitoma turgidum* Forbes. Dubious record. Probably misidentified, since it was only recorded by Dautzenberg (1889) and was not found in the DBUA marine mollusc collection.
	Bela zonata (Locard, 1892)	Ávila et al. (2000b), as *Bela laevigata* (Philippi, 1836). Misidentification of *B. nebula* (Montagu, 1803).
ACTEONIDAE	*Acteon incisus* Dall, 1881	Dautzenberg & Fischer (1896). Dubious record. Probably misidentified, since it was only recorded by Dautzenberg & Fischer (1896) and was not found in the DBUA marine mollusc collection.
RINGICULIDAE	*Ringicula semistriata* d'Orbigny, 1842	Nordsieck (1972). Dubious record. Nordsieck (1972) merely speculates about the presence of this species in the Azores. It was not found in the DBUA marine mollusc collection.
RISSOELLIDAE	*Rissoella globularis* (Forbes et Hanley, 1853)	Segers (2002). Misidentification of *Rissoella contrerasi* Rolán et Hernández, 2004.
BULLIDAE	*Bulla striata* Bruguière, 1792	Drouët (1858). Dubious record (see Malaquias & Reid, 2008).
HAMINOEIDAE	*Haminoea hydatis* (Linnaeus, 1758)	García-Talavera (1983). Dubious record. Probably misidentified, since it was only recorded by García-Talavera (1983) and was not found in the DBUA marine mollusc collection.
PHILINIDAE	*Philine quadrata* (S. Wood, 1839)	Watson (1886). Dubious record (see Ávila et al., 1998).
CYLICHNIDAE	*Cylichna cylindracea* (Pennant, 1777)	Pilsbry (1893). Dubious record (see Ávila et al., 1998).
RETUSIDAE	*Retusa umbilicata* (Montagu, 1803)	Ávila & Azevedo (1996). Misidentification of *Retusa truncatula* (Bruguière, 1792).
RUNCINIDAE	*Runcina africana* Pruvot-Fol, 1953	Malaquias et al. (2009). Misidentification of *Runcina coronata* (de Quatrefages, 1844).
CHROMODORIDIDAE	*Felimida krohni* (Vérany, 1846)	Ávila et al. (1998) as *Chromodoris krohni* (Vérany, 1846). Misidentification of *Felimida britoi* (Ortea et Pérez, 1983).
DISCODORIDIDAE	*Discodoris* cf. *millegrana* (Alder et Hancock, 1854)	Ávila & Azevedo (1997). Misidentification of *Platydoris argo* (Linnaeus, 1767) (see Ávila et al., 2000a).
FACELINIDAE	*Phidiana lynceus* Bergh, 1867	Borges et al. (2010). Dubious record (Manuel António E. Malaquias, pers. comm. 2013).

DISCUSSION

The total number of littoral gastropods now validly reported for the Azores is 281 species, belonging to 178 genera and 94 families. Since the last account by Ávila (2005), who counted 227 littoral gastropods, this new checklist represents an increase of 23.8% (54 species). With 26 species (9.3%), Rissoidae is the most species-rich littoral gastropod family in the archipelago, followed by Pyramidellidae and Epitoniidae with 16 (5.7%) and 12 species (4.3%), respectively. There is a total of 36 endemic species (12.8%), belonging to 18 families, of which 16 (44.4%) belong to Rissoidae. Three gastropod species (1.1%) are considered as introduced (Cardigos et al., 2006).

The presence of the newly recorded littoral gastropods *Caecum gofasi*, *Cerithiopsis* cf. *nana*, *Curveulima dautzenbergi*, *Liostomia mamoi*, *Mangelia scabrida*, and *Rissoella contrerasi* in the Archipelago of the Azores is not unexpected since these species are known from the northern European coasts, the Mediterranean Sea, northeast Atlantic seamounts, and from other Macaronesian archipelagos. Our findings expand their known geographical distribution in the northeast Atlantic Ocean.

Accurate checklists are of crucial importance for biodiversity, ecology and biogeography studies. All Macaronesian archipelagos have recent checklists on the marine molluscs: Madeira (Segers et al., 2009), Selvagens (Albuquerque et al., 2009), Canaries (Rolán, 2011) and Cape Verde (Rolán, 2005). For the Azores, a checklist of the marine molluscs reporting 236 littoral gastropods was published in a book edited by Borges et al. (2010), intended to cover the terrestrial and marine fauna and flora of the Azores. This comprehensive list was later made available in the web as a species searchable database (Portal da Biodiversidade dos Açores). As stated in the homepage, the aim of this "Azorean Biodiversity Portal" is to provide "a unique resource for fundamental research in systematics, biodiversity, education and conservation management in the Azores (Portugal). It also provides an original platform for biogeographical and macroecological research on islands."

More recently, an updated version of this database was made available as well, and called "ATLANTIS" (Base de Dados da Biodiversidade dos Açores). At the time of our consultancy, both databases were online, yielding quite different results. Both data bases were accessed and all marine gastropods reported for the Azores by the "Azorean Biodiversity Portal" and the "ATLANTIS" databases were downloaded. Deep-water and pelagic species were excluded from the following analysis.

From a total of 417 littoral gastropod species reported by the "Azorean Biodiversity Portal", 153 species proved to be wrong citations, as they were either dubious records (mostly misidentifications) or outdated synonymies already cited (e.g., *Thais haemastoma* and *Stramonita haemastoma*). From a total of 270 records provided by the"ATLANTIS" database, 49 species were wrong citations. As both databases yielded a significant amount of wrong citations, in our opinion, they must be used with precaution and, in their present status, clearly do not meet the stated aims.

Despite more than 150 years of scientific research, our knowledge on the diversity of the Azorean littoral gastropods seems to be still incomplete. In fact, the scientific campaigns made in recent years have resulted in new records or species for the region. A clear example of this is the continuing increase in new records of opisthobranch species (Malaquias et al., 2009; Malaquias et al., 2011; Pedro et al., 2011; Cordeiro et al., 2013; Malaquias et al., 2014) or the rissoid and *Parviturbo* species recently described (Cordeiro & Ávila, 2015; Rubio et al., 2015), which demonstrates the need for further biodiversity surveys.

In our opinion, future fieldwork efforts should be focused on islands poorly studied and geographically closer to the colonization sources (i.e. Santa Maria, Flores and Corvo Islands), in order to enhance the potential discovery of new records or species.

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Biodiversity in the era of the market globalization: some cases from the marine realm

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ABSTRACT The globalization of markets and te growing scarcity of te mediterranea fishery products caused by the over-exploitation of the most consumed species has determined an increase in demand of frozen or trasformed fishery products importated from different countries. This caused an increase of food fraud represented by the substitution of a species with another with less economical value but which presents similar morphological characeristics. The use of modern tools as the DNA barcoding is crucial for traceability of such products and provides the consumer the necessary information about the exact identification of the species and their origin. The Italia and European Union food stuff are controlled thanks to laws, while for many non UE products are not expected any control inspection.

KEY WORDS DNA barcoding; food fraud; marine species; free markets.

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INTRODUCTION

In recent years, biologists have been involved in studying the changes of the marine biodiversity taking into account the global climate change and the advanced tropicalization of the Mediterranean Sea. Particular attention has been paid to the Indo-Pacific species that due to the opening of the Suez Canal have increasingly colonised Mediterranean waters and, for some of these, now can be considered as "established", in the sense of CIESM Atlas series (2002, 2004) or "invasive"sensu Zenetos et al. (2010); in addition it has also been registered an increase of thermophilic species of Atlantic origin (Golani et al., 2002; Galil et al., 2002; Zenetos et al., 2004). These changes, however, did not take into account how the natural diversity has, in some way, influenced also the diversity of the Italian fish markets in terms of availability or supply of new species that came from other parts of the world.

In the European Union, the Regulation (EC) 854/04 refers to the official control of foodstuffs and highlights how the controls are also to be based on the inspection of these products. Any inspections to be carried out on the fish or fishery products presuppose the correct identification of the species to which they belong. The food fraud, for example, is represented by the substitution of a food with another with less economical value but which presents similar macroscopic morphological characteristics that can easily mislead the buyer. This fraud can occur through the use of names and trademarks of local products or trademarks of some companies. These substitutions are carried out with the purpose of making a profit, and occur when the seller trust on consumers ignorance due to their inability to properly identify the product they are interested in.

The morphological identification of invertebrate and vertebrate marine species of commercial interest (crustaceans, molluscs, fish) in some cases can be difficult especially when these products are marketed or sold already portioned or in the form of pulp (crabs) or cut into small pieces or slices (squid, cuttlefish, octopus, fish, etc.) or without shell or carapace (decapod crustaceans, molluscs bivalves or gastropods). The classical approaches of identification are not useful in many cases because during the processing, most of the morphological characteristics of the product are often lost, making it difficult to identify.

The globalization of markets and the growing scarcity of the Mediterranean fishery products caused by the over-exploitation of the most consumed species (Tsikliras et al., 2015), determined an increase in demand and a higher exchange capacity of fishery products, especially in those countries where requests for frozen or transformed products are still rising. The use of modern tools for the traceability of such products on one side provides the consumer with the necessary information enabling him to know the "history" of the food and on the other give the authorities a valuable support in case of food emergency or in the identification of food fraud.

For these reasons it is essential to find appropriate and easy technologies that increase food security and enable it to monitor effectively the food fraud and illegal trade of organisms potentially dangerous to human health, or rare and threatened species.

One of the most commonly used techniques for its low costs and the effectiveness of the produced results is the DNA barcoding. This technique was proposed for the first time by Hebert et al. (2003) as universal tool for the Barcoding of Life; it is a simple method that use, as marker, a fragment of about 655-bp of the 5' region of the mitochondrial cytochrome c oxidase I (COI) gene. To date, few studies are available on the application of this technique that allows us to have good results both as a support to the classical taxonomy and as a tools of food control. This is unfortunate, as recognition of genetic fishery products through the DNA barcoding provides a reliable and safe identification system.

While for some groups of organisms, such as fish, there is a database of reference (Landi et al., 2014; and references therein), in the case of other groups as invertebrate the available databases of sequences has to be improved.

The aim of this report is to highlight some critical issues that can be encountered at the Italian "free fish market" (single shop outside the supermarket, then referred to the small distribution of fish products) where normally fishmonger uses a simple label where only the local or the Italian name of the species is reported. Conversely, according to the European Union Regulation (EC) 854/04, the buyers should find in all the products a label where is reported the name of species (both the latin name and the Italian vernacular one), tool used for the capture, area FAO of origin/catch, possible conservation treatments, etc... This means that the "free fish market" does not currently comply with the law and that the fish seller may sell all he/she wants without any control. In fact, most of the food fraud and/or substitutions of species occurred mainly in the free fish markets. Although supermarkets show complete labels they can not give to the consumer, unless they certify them through their own laboratories, a 100% guarantee of products declared.

CRUSTACEANS

Referring to some examples, there are groups of crustaceans with high economic value that can be subject to fraud through the exchange with other economically less-valuable species. This is the case of the European spiny lobster *Palinurus elephas* Fabricius, 1787 (Decapoda Palinuridae) a coastal species that lives on rocky and coralligenous substrates that can be replaced with the pink spiny lobster *Palinurus mauritanicus* Gruvel, 1911 a deeper-living species that inhabits the edge of the continental shelf. Most of the quantities of this species that are found on the Italian free fish markets comes from the Atlantic Ocean. *Palinurus elephas* has, in the European free fish markets and supermarkets, a price which is higher than that of *P. mauritanicus* and can be easily confused by consumers with this last. Recently, appears in the supermarkets another species of lobster, *P. regius* De Brito Capello, 1864 that may be also confused with *P. elephas*. *Panulirus regius* is an Atlantic thermophilic species that has first colonised the north-western Mediterranean along the coasts of France and Spain and which recently seems to have shifted towards the Italian coasts even if catches remain extremely low (Froglia et al., 2012). All these lobsters species are generally sold without carapace and with a label indicating generically "lobsters".

A more serius problem is when the free fish markets trying to sell the species *Polycheles typhlops* C. Heller, 1862 (Decapoda Polychelidae), a species without commercial value, as "minor lobster". This Polychelidae is sold some times under the generic Italian name of "aragostella" (i.e.: "little lobster") indicating a species similar to the lobster but with a lower economic value. More frequently, and more correctly, free fish markets indicated with the generic name of "aragostella"the Indo-Pacific species *Puerulus* spp. (Decapoda Palinuridae). They genus comprise about 10 species and are sold also in the supermarkets in plastic box and with a label indicating only the name of the genus *Puerulus* Ortmann, 1897, and the origin of catch.

Other case concerns *Homarus americanus* H. Milne-Edwards, 1837 (Decapoda Nephropidae), American lobster, species imported mainly from the USA and sold instead of *Homarus gammarus* Linnaeus, 1758, European lobster, a Mediterranean species; this substitution is widespread especially in restaurants as well as in the free fish markets.

Recently, appeared in the fridges of the supermarkets an Indo-Pacific crustacean species sold with a label indicating the italian name "mazzancolla" and the scientific name *Penaeus vannamei* (Boone, 1931) (Decapoda Penaeidae). This species in nature has a more or less greyish colour, but it is sold cooked because after cooking it assumes a orange colour, which looks more pleasing to the eyes of the consumer. In Italy, usually, the name "mazzancolla" is used to indicate another crustacean species, *Melicertus kerathurus*, with a very high economical value. *Melicertus kerathurus* (Forskål, 1775) is another crustacean case of possible replacement with the very similar species *Marsupenaeus japonicus* (Spence Bate, 1888), a Lessepsian species very invasive which replaced, in the eastern sector of the Mediterranean Sea, the endemic species *M. kerathurus*. Today, *M. japonicus* can be considered in Mediterranean Sea as an established species (Zenotos et al., 2010).

Another possible replacement or fraud is between the *Aristaeopsis edwardsiana* (Johnson, 1868) (Decapoda Aristeidae), an Atlantic species which is not present in the Mediterranean and is imported and sold as defrosted product, and the giant red shrimp *Aristeomorpha foliacea* (Risso, 1897), the commercially most important deep-water shrimp in the Mediterranean Sea. The two species might be easily confused by consumers when buying them in the free fish markets.

The last new entry in the free fish market and supermarkets refers to the *Pleoticus muelleri* (Bate, 1888) (Decapoda Penaidae), a very abundant species along the coasts of Argentine, which is sold as defrosted or "fresh" pink shrimp. This specie is sold defrosted in the free fish market as the Mediterranean deep-water rose shrimp *Parapenaeus longirostris* Lucas, 1847 a species with higher economic value.

MOLLUSCS

As regards molluscs, cases of food fraud are mainly linked to the commercialization of *Ruditapes phylippinarum* (Adams et Reeve, 1850) (Bivalvia Veneridae) a clam species native of the Pacific Ocean introduced in the Mediterranean Sea (Adriatic Sea) for commercial purposes in the 80s and that now can be considered as an established species (Zenetos et al., 2010). This species is confused with the endemic (Mediterranean) bivalve *Ruditapes decussatus* (Linnaeus, 1758), especially when it is sold fresh or frozen without the shell. The biggest problem occurs when consumers buy products stored in jars with a generic label of clams. These jars may contain different species from *Ruditapes* Chiamenti, 1900 as *Polititapes aureus* (Gmelin, 1791) or *Chamelea gallina* (Linnaeus, 1758) or with the *Meretrix* Lamarck, 1799, a species native from the Indian Ocean.

Another important fraud is connected with the cephalopods like *Todarodes sagittatus* Lamarck, 1798 (Teuthida Ommastrephidae), European flying squid, that sometimes is sold in the free fish market as *Loligo vulgaris* Lamarck, 1798 (Teuthida Loliginidae), European squid. One of the most blatant fraud regards the Mediterranean squid *Loligo vulgaris* that can be replaced by the defrosted *Uroteuthis chinensis* (Gray, 1849), Mitre squid, or *U. duvauceli* (Orbigny,1848), Indian squid, species that come from the Indian and the Pacific Ocean, respectively.

The Argentinean short-finned squid, *Illex argentinus* (Castellanos, 1960) (Teuthida Ommastrephidae) a species distributed along the western South Atlantic and imported frozen from Argentine, is sold defrosted instead of our common Mediterranean *Illex coindetii* (Vérany, 1837), broadtail short-finned squid.

Regarding cuttlefish, a common replacement is that between *Sepia pharaonis* Ehrenberg, 1831 (Sepiida Sepiidae), pharaoh cuttlefish, an Indo-Pacific species with the Atlanto-Mediterranean *Sepia officinalis* Linnaeus, 1758, common cuttlefish.

Among the octopus, species of the genus *Eledone* Leach, 1817 (Octopoda Octopodidae) are sometimes sold instead of *Octopus vulgaris* Cuvier, 1797. Others octopus species like *O. maya* Voss et Solis Ramirez, 1966 or *O. cyaneus* Gray, 1849 (which are Lessepssian specis and are considered as occasional in the western Mediterranean, see Zenetos et al., 2010) can be sold instead of the Mediterranean *O. vulgaris*. In all cases, fraud occurs when these products are sold fresh or frozen cut into small pieces.

FISH

Regarding fish species, there are some important example of commercial fraud. This is the case of the juvenile of sardines or anchovies (“bianchetto”) that are replaced by the species *Neosalanx tangkahkeii* (Wu, 1931) (Osmeriformes Salangidae), known as “ice fish”, species that comes from China and that is sold in the free fish markets and restaurants. Sometimes also juvenile of “rossetto” *Aphia minuta* Risso, 1810 (Perciformes Gobiidae), a small fish that reaches the maximum length of 6 cm, can be sold as “bianchetto”.

If we look to the flat fish, there are many cases of replacement. This occur between “zanchette”, i.e. fish of the genera *Lepidorhombus* Günther, 1862 (Pleuronectiformes Scophthalmidae) or *Arnoglossus* Bleeker, 1862 (Pleuronectiformes Bothidae) instead of the “sogliole”, fish of the genera *Solea*. In some cases, consumers can buy instead of the *Solea solea* Quensel, 1806 (Pleuronectiformes Soleidae), two Atlantic specie the *Synaptura cadenati* Cantor, 1849, Guinean sole, or the Senegalese tongue sole *Cynoglossus senegalensis* (Kaup, 1858) (Pleuronectiformes Cynoglossidae).

Other very curios replacement of species concerns the “pangasio”, *Pangasianodon hypophthalmus* (Sauvage, 1878) (Siluriformes Pangasiidae) imported from Asia (Vietnam), which is bred mainly in the Mekong basin and then sold in the markets as fillets of perch, *Perca fluviatilis* Linnaeus, 1758 (Perciformes Percidae). The “pangasio” has very little economical and nutritional value (it contains a lot of water, low protein and low amount of polyunsaturated fat). Another species that can be sold instead of the European perch, *Perca fluviatilis* is the Nile perch, *Lates niloticus* (Linnaeus, 1758) (Perciformes Latidae).

Among the Tunnidae family we have the difficulty to understand what species of tuna we are buying especially when this is sold in tins or jars; often companies reported in the pack the general label “tuna fish”. Substitutions of species concern also the cartilaginous fish. This is the case of the blue shark, *Prionace glauca* (Linnaeus, 1758) (Carchariniformes Carcharhinidae) species subjected to the pressure of commercial fishing and sold some times for swordfish, *Xiphias gladius* Linnaeus, 1758 (Perciformes Xiphiidae).

FINAL REMARKS

It is important to be able to recognize the species, especially when these are considered over exploited or endangered or threatened and included in the Red List of the IUCN. This is the case, for example, of the shark *Prionace glauca*, a “near threatened species” (http://www.iucnredlist.org/details/39381/). The specific knowledge also allows us to properly estimate actual catches and then to adopt appropriate strategies for conservation.

For expert people, on the banks of the free fish markets it is easy to take a rip: a fish similar but of lower value can be sold for one more precious and of greater nutritional value. But if the fish is cleaned and filleted, even for experts recognize fraud is impossible.

In addition to the consequences of fraud, these “alien” fish create unfair competition against our national product. Moreover, if the fish of Italian origin are controlled thanks to laws and the "traceability" from the producer (fisheries, aquaculture, companies, etc.), for non-European Union controls are more difficult; lots from Vietnam or Africa could come from any control inspection.

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