Naturalista sicil., S. IV, XLIII (2), 2019, pp. 239-252

Mirko Wölfling, Britta Uhl, Arnold Sciberras & Alan Deidun

MARINE SHELLED MOLLUSCS FROM TWO LOCATIONS IN THE MALTESE ISLANDS – A CHECKLIST

SUMMARY

Climate change and manifold other anthropogenic influences are the main driving factors for changes in marine ecosystems. Characterising these changes is of great interest and can be made possible through the adoption of marine shelled mollusca as bioindicators. Malta is renowned for its rich diversity of mollusc species, including rare and endemic ones. So, we analysed mollusc shell grit from two locations (St. Pauls Island/Selmunett Island and Marsaxlokk) to provide a species baseline list for future investigations. We identified a total of 7662 parts of marine shelled mollusca. 115 species were found at St. Pauls Island and 45 species at Marsaxlokk, belonging to a total of 60 families (16 at both locations). To make both samples comparable, despite differences in sampling efforts, we formulated an individual-based species extrapolation curve for each location. With this, we calculated an estimated total species number of 134 at St. Pauls Island and of 49 at Marsaxlokk, for a set threshold of 6000 individuals, indicating a considerably lower mollusc diversity at the second location, putatively the result of higher human disturbance levels at the same location. The substantial differences in mollusc species composition between the two localities, despite the small geographical distance between the two, further underscores the importance of further related research.

Key words: Biodiversity, community composition, Mediterranean sea, microshells, species inventory, species richness

RIASSUNTO

Molluschi marini provvisti di conchiglia in due siti delle isole Maltesi – Una checklist. I cambiamenti climatici e un numero di altre influenze antropogeniche sono i principali fattori principali dei cambiamenti osservati recentemente negli ecosistemi marini. Caratterizzare questi cambiamenti è di grande interesse e può essere reso possibile attraverso l'uso di molluschi marini provvisti di conchiglia come bioindicatori. Un numero elevato di specie di molluschi è noto di Malta, comprese specie rare ed endemiche. Abbiamo analizzato individui di micro-molluschi spiaggiati in due località (isola di San Paulo/Selmunett Island e Marsaxlokk) per fornire una lista di riferimento per le ricerche future. Abbiamo identificato un totale di 7662 frammenti di molluschi marini da questi due siti, equivalente a 115 specie nell'isola di San Paulo e 45 specie a Marsaxlokk, appartenenti a un totale di 60 famiglie (16 in entrambe le località). Per rendere entrambi i campioni confrontabili, nonostante le differenze negli sforzi di campionamento, abbiamo formulato una curva di estrapolazione del numero massimo di specie presenti ad ogni sito basata sul numero di individui campionati. Con questo, abbiamo calcolato un numero totale di specie stimato a 134 e 49 per l'isola di Sa Paolo e per Marsaxlokk, rispettivamente, calcolato su un campionamento ipotetico di 6000 individui di molluschi. Questo indica una diversità di molluschi notevolmente inferiore nel secondo sito, probabilmente il risultato di un livello di disturbo umano più elevato in tale sito. Le differenze sostanziali nella composizione delle specie di molluschi tra le due località, nonostante la modesta distanza geografica, sottolinea ulteriormente l'importanza di ulteriori ricerche in tale campo.

Parole chiave: Biodiversità, ricchezza di specie, Mediterraneo, composizione comunitaria, micro-molluschi, inventario di specie

INTRODUCTION

Climate change, microplastic and coastal transformation are some of the myriad anthropogenic impacts bring exerted on marine habitats worldwide (HOEGH-GULDBERG & BRUNO, 2010; ANDRADY, 2011; ROMANO & ZULLO, 2014). Impacts from these drivers are especially visible in shallow waters (GORMAN *et al.*, 2017). This in turn further stresses the importance of comparative studies with baselines drawn for coastal biotic communities. Since molluscs are in many cases considered to be important bioindicators, both by virtue of their ubiquity in the marine environment but also due to the ease with which they are collected and due to their sensitivity to environmental change, they can provide important environmental health information, reflected in temporal variations in species composition and abundance data (SOUSA *et al.*, 2018; REGUERA *et al.*, 2018).

The Maltese islands are located in the centre of the Mediterranean, just 96 km south of Sicily, 290 km from North Africa, 1836 km from Gibraltar, and 1519 km from Alexandria Egypt, making them one of Europe's southernmost outposts (SCHEMBRI, 1993). The Maltese archipelago is made up of three major inhabited islands: Malta, the largest; Gozo (Għawdex) and Comino, the smallest (Kemmuna). The total surface area of the Maltese islands is 316 km^2. The Maltese Islands represent an interesting test case since they combine both a well-studied and highly diverse marine gastropod community (e.g. EVANS *et al.*, 2018) as well as the ubiquitous impact of human activities (JONES, 2017). Thus, regular monitoring of components of the Maltese marine environment, including mollusc assemblages (rather than populations of individual species) might represent a useful paradigm which assists in the monitoring of impacts operating at larger scales.

Collectors group very small shelled Mollusca, "micro-mollusca", without any further taxonomic detail. So-called shell grit samples consisting of specimens (or fragments of) from micro-mollusca, however, reflect the entire spectrum of species, and not just of the very small species, since the larger species are also represented within shell grit as juvenile shells. This type of community has, to date, received very little scientific attention so far, although one can find very high numbers of individuals within these samples (POPPE & GOTO, 1991), with the elucidated species composition giving a good overall representation of the habitats from where the species originated. Furthermore, shell grit sampling can be used as standardized shell sampling method and so serves as a good possibility to integrate samples from different investigations over a longer period of time. Summarized we want to get an actual species list of beached marine shelled molluscs at Malta and check for differences in two locations of the Maltese coast viz. Marsaxlokk and St. Pauls Island. The locations were chosen because Marsaxlokk is a heavily anthropogenic influenced location whereas St. Pauls Island is a near natural one. This situation offers a wide amount of later analysis. E.g. the repetition of the samples provides not only a comparison of species number and composition. One could also calculate if and how an anthropogenically influenced location changes more or less than a natural one.

MATERIAL AND METHODS

A checklist of Mollusca was drawn up for two coastal locations (Fig. 1) on the island of Malta – St. Pauls Island (= Selmunett Island; 35°57'57.64"N,

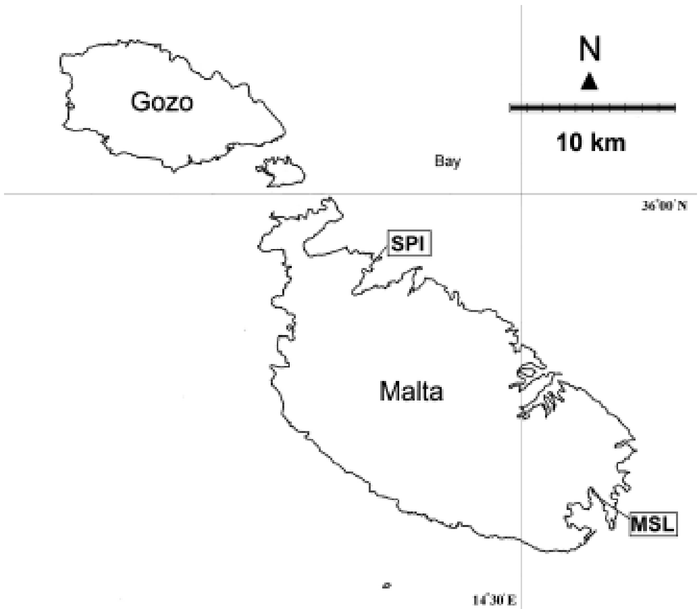

Fig. 1 — Geographic location of the two sampled sites cited in this study.

14°24’8.91”E) and Marsaxlokk (35°50’19.00”N, 14°32’56.57”E), hereafter referred to as ‘SPI’ and ‘MSL’ – recorded through the collection of beached shell grit samples. The two locations are sited at a distance of about 20 km from each other. The SPI site is characterised by a gravel seabed and has largely been spared by tourism, as it is an uninhabited island. The MSL site is characterised by a sandy and muddy seabed, which is heavily influenced by human activities but which still supports seagrass beds. Beached surface shell grit was collected at the SPI and MSL sites, in the form of 3500 g (SPI) and 1300 g (MSL) of sediment collected on the 10.V.2012 at the mean sea level of both sites, respectively. The samples were cleaned and the taxonomic identity of all marine shelled Mollusca was determined where possible. Single valves of Bivalvia and incomplete/damaged shells of Gastropoda were counted as individuals. The individuals were classified taxonomically down to species level, wherever possible. Doubtful species determinations were denoted with “cf.”. If individual species could not be exhaustively determined due to their shell condition, they were listed as a species complex, denoted by “spp.”. If taxonomic identification to species level was not possible, on the exercise was truncated at genus level, whilst congeneric species which were difficult to distinguish were listed collectively – for e.g. *Calliostoma laugieri/zizyphinum* (Payraudeau 1826/L. 1758). Small-sized individuals of *Cerithium vulgatum* (Bruguière 1792), which are easy to confuse with related species, were cross-checked by Alberto Cecalupo (a specialist for Cerithiidae). The latest classification conventions were extracted from WORMS (World Register of Marine Species) (www.marinespecies.org, last visited: 6.II.2019) and from the Check List of European Marine Mollusca (CLEMAM) from Museum Nátional d’Histoire Naturelle (Department of Systematics and Evolution) (https://biotaxis.fr/clemam/index.clemam.html, last visited: 6.II.2019).

The individual-based rarefaction statistical technique (Gotelli & Colwell, 2011), based on extrapolation theory, using a standard baseline of 6000 mollusc individuals, was deployed to estimate the total number of mollusc species at each of the two sampled sites. The analysis was conducted through the application of the iNEXT software (Chao *et al.*, 2016).

Results

In total, we analysed 7662 fragments of marine shelled Mollusca from both locations, 2916 fragments from the SPI site and 4746 fragments from the MSL site, representing a total of 141 species and 60 families. For the SPI site, 51 families and 115 species were listed, while at the MSL site, there were 24 families and 45 species (Tab. I, II).

At SPI, only one species belonging to the class Scaphopoda and one species belonging to the class Polyplacophora were found. 95 species within

Tab. I.
Species list of SPI in taxonomic order.

Class	Family	Species	Number
Polyplacophora	Chitonidae	*Chiton olivaceus* (Spengler 1797)	35
Gastropoda	Patellidae	*Patella caerulea* (L. 1758)	12
Gastropoda	Patellidae	*Patella rustica* (L. 1758)	4
Gastropoda	Fissurellidae	*Diodora gibberula* (Lamarck 1822)	115
Gastropoda	Fissurellidae	*Emarginula huzardii* (Payraudeau 1826)	1
Gastropoda	Fissurellidae	*Emarginula octaviana* (Coen 1939)	12
Gastropoda	Haliotidae	*Haliotis* cf. *tuberculata* (L. 1758)	5
Gastropoda	Trochidae	*Clanculus cruciatus* (L. 1758)	20
Gastropoda	Trochidae	*Jujubinus exasperatus* (Pennant 1777)	43
Gastropoda	Trochidae	*Jujubinus gravinae* (Dautzenberg 1881)	18
Gastropoda	Trochidae	*Jujubinus striatus* (L. 1758)	30
Gastropoda	Trochidae	*Gibbula ardens* (Salis Marschlins 1793)	37
Gastropoda	Trochidae	*Steromphala umbilicaris* (L. 1758)	17
Gastropoda	Trochidae	*Steromphala varia* (L. 1758)	13
Gastropoda	Calliostomatidae	*Calliostoma laugieri / zizyphinum* (Payraudeau 1826 / L. 1758)	14
Gastropoda	Calliostomatidae	*Calliostoma* sp.	2
Gastropoda	Chilodontaidae	*Danilia tinei* (Calcara 1839)	1
Gastropoda	Colloniidae	*Homalopoma sanguineum* (L. 1758)	1
Gastropoda	Skeneidae	*Skenea catenoides* (Monterosato 1877)	1
Gastropoda	Phasianellidae	*Tricolia pullus* (L. 1758)	34
Gastropoda	Phasianellidae	*Tricolia punctura* (Gofas 1993)	1
Gastropoda	Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld 1824)	21
Gastropoda	Phasianellidae	*Tricolia tenuis* (Michaud 1829)	1
Gastropoda	Phasianellidae	*Tricolia tingitana* (Gofas 1982)	16
Gastropoda	Phasianellidae	*Tricolia* sp.	1
Gastropoda	Neritidae	*Smaragdia viridis* (L. 1758)	16
Gastropoda	Neritidae	*Neritidae* sp.	1
Gastropoda	Cerithiidae	*Bittium lacteum* (Philippi 1836)	18

Class	Family	Species	Number
Gastropoda	Planaxidae	*Fossarus ambiguus* (L. 1758)	2
Gastropoda	Triphoridae	*Metaxia metaxa* (Delle Chiaje 1828)	9
Gastropoda	Triphoridae	*Triphoridae* spp.	82
Gastropoda	Eulimidae	*Melanella lubrica* (Monterosato 1890)	2
Gastropoda	Eulimidae	*Parvioris ibizenca* (Nordsieck 1968)	11
Gastropoda	Littorinidae	*Melarhaphe neritoides* (L. 1758)	16
Gastropoda	Rissoidae	*Rissoa auriscalpium* (L. 1758)	10
Gastropoda	Rissoidae	*Rissoa similis* (Scacchi 1836)	10
Gastropoda	Rissoidae	*Rissoa variabilis* (Megerle von Mühlfeld 1824)	50
Gastropoda	Rissoidae	*Rissoa violacea* (Desmarest 1814)	5
Gastropoda	Rissoidae	*Rissoa* sp.	2
Gastropoda	Rissoidae	*Pusillina cf. philippi* (Aradas & Maggiore 1844)	71
Gastropoda	Rissoidae	*Setia* sp.	1
Gastropoda	Rissoidae	*Alvania cimex/mamillata* (L. 1758 / Risso 1826)	122
Gastropoda	Rissoidae	*Alvania discors* (T. Allan 1818)	30
Gastropoda	Rissoidae	*Alvania lineata* (Risso 1826)	19
Gastropoda	Rissoidae	*Alvania subcrenulata* (Bucquoy, Dautzenberg & Dollfus 1884)	926
Gastropoda	Rissoidae	*Alvania weinkauffi jacobusi* (Oliverio, Amati & Nofroni 1986)	2
Gastropoda	Rissoidae	*Alvania* sp.	37
Gastropoda	Rissoidae	*Manzonia crassa* (Kanmacher 1798)	1
Gastropoda	Rissoidae	*Rissoina bruguieri* (Payraudeau 1826)	31
Gastropoda	Caecidae	*Caecum auriculatum* (de Folin 1868)	9
Gastropoda	Caecidae	*Caecum trachea* (Montagu 1803)	10
Gastropoda	Tornidae	*Tornus subcarinatus* (Montagu 1803)	10
Gastropoda	Vermetidae	*Vermetus triquetrus* (Bivona-Bernardi 1832)	1
Gastropoda	Vermetidae	*Vermetidae* sp.	10
Gastropoda	Calyptraeidae	*Crepidula unguiformis* (Lamarck 1822)	2
Gastropoda	Triviidae	*Trivia mediterranea* (Risso 1826)	5
Gastropoda	Muricidae	*Muricopsis cristata* (Brocchi 1814)	5
Gastropoda	Cystiscidae	*Gibberula oryza* (Lamarck 1822)	15
Gastropoda	Cystiscidae	*Gibberula* spp.	163
Gastropoda	Marginellidae	*Granulina melitensis* (Smriglio, Mariottini & Rufini 1998)	16
Gastropoda	Mitridae	*Episcomitra cornicula* (L. 1758)	12

Class	Family	Species	Number
Gastropoda	Costellariidae	*Pusia ebenus* (Lamarck 1811)	10
Gastropoda	Costellariidae	*Pusia savignyi* (Payraudeau 1826)	3
Gastropoda	Costellariidae	*Pusia tricolor* (Gmelin 1791)	13
Gastropoda	Buccinidae	*Euthria cornea* (L. 1758)	1
Gastropoda	Buccinidae	*Chauvetia* sp.	27
Gastropoda	Pisaniidae	*Pisania striata* (Gmelin 1791)	1
Gastropoda	Pisaniidae	*Aplus scaber* (Locard 1891)	76
Gastropoda	Nassariidae	*Tritia cuvierii* (Payraudeau 1826)	1
Gastropoda	Columbellidae	*Columbella rustica* (L. 1758)	48
Gastropoda	Columbellidae	*Mitrella scripta* (L. 1758)	4
Gastropoda	Columbellidae	*Mitrella svelta* (Kobelt 1889)	1
Gastropoda	Mitromorphidae	*Mitromorpha columbellaria* (Scacchi 1836)	5
Gastropoda	Mitromorphidae	*Mitromorpha olivoidea* (Cantraine 1835)	83
Gastropoda	Mangeliidae	*Mangelia taeniata* (Deshayes 1835)	12
Gastropoda	Mangeliidae	*Mangelia vauquelini* (Payraudeau 1826)	4
Gastropoda	Raphitomidae	*Clathromangelia granum* (Philippi 1844)	6
Gastropoda	Raphitomidae	*Raphitoma* sp.	4
Gastropoda	Conidae	*Conus ventricosus* (Gmelin 1791)	34
Gastropoda	Cornirostridae	*Tomura depressa* (Granata-Grillo 1877)	2
Gastropoda	Pyramidellidae	*Parthenina emaciata* (Brusina 1866)	5
Gastropoda	Pyramidellidae	*Folinella excavata* (Philippi 1836)	5
Gastropoda	Pyramidellidae	*Chrysallida interstincta* (J. Adams 1797)	1
Gastropoda	Pyramidellidae	*Chrysallida* sp.	6
Gastropoda	Pyramidellidae	*Odostomella doliolum* (Philippi 1844)	22
Gastropoda	Pyramidellidae	*Eulimella cerullii* (Cossmann 1916)	1
Gastropoda	Pyramidellidae	*Megastomia conoidea* (Brocchi 1814)	7
Gastropoda	Pyramidellidae	*Auristomia fusulus* (Monterosato 1878)	2
Gastropoda	Pyramidellidae	*Ondina vitrea* (Brusina 1866)	1
Gastropoda	Pyramidellidae	*Pyrgostylus striatulus* (L. 1758)	1
Gastropoda	Pyramidellidae	*Turbonilla pumila* (G. Seguenza 1876)	1
Gastropoda	Pyramidellidae	*Turbonilla sinuosa* (Jeffreys 1884)	5
Gastropoda	Pyramidellidae	*Turbonilla* sp.	1
Gastropoda	Bullidae	*Bulla striata* (Bruguière 1792)	1
Gastropoda	Siphonariidae	*Williamia gussoni* (O.G. Costa 1829)	4
Gastropoda	Trimusculidae	*Trimusculus mammillaris* (L. 1758)	4

Class	Family	Species	Number
Bivalvia	Nuculidae	*Nucula* sp.	2
Bivalvia	Nuculanidae	*Lembulus pella* (L. 1758)	1
Bivalvia	Arcidae	*Arca noae* (L. 1758)	31
Bivalvia	Arcidae	*Barbatia barbata* (L. 1758)	33
Bivalvia	Noetiidae	*Striarca lactea* (L. 1758)	43
Bivalvia	Mytilidae	*Mytilidae* sp. 1	2
Bivalvia	Mytilidae	*Mytilidae* sp. 2	5
Bivalvia	Pectinidae	*Pectinidae spec.*	3
Bivalvia	Spondylidae	*Spondylus gaederopus* (L. 1758)	5
Bivalvia	Limidae	*Lima lima* (L. 1758)	14
Bivalvia	Limidae	*Limaria hians* (Gmelin 1791)	1
Bivalvia	Lucinidae	*Ctena decussata* (O.G. Costa 1829)	18
Bivalvia	Chamidae	*Chama gryphoides* (L. 1758)	31
Bivalvia	Cardiidae	*Cardita calyculata* (L. 1758)	71
Bivalvia	Cardiidae	*Glans trapezia* (L. 1767)	45
Bivalvia	Cardiidae	*Parvicardium scriptum* (Bucquoy, Dautzenberg & Dollfus 1892)	9
Bivalvia	Veneridae	*Venus verrucosa* (L. 1758)	2
Bivalvia	Veneridae	*Irus irus* (L. 1758)	10
Scaphopoda	Dentaliidae	*Antalis vulgaris* (da Costa 1778)	1

Tab. II. *Species list of MSL in taxonomic order.*

Class	Family	Species	Number
Gastropoda	Trochidae	*Clanculus jussieui* (Payraudeau 1826)	4
Gastropoda	Trochidae	*Jujubinus exasperatus* (Pennant 1777)	5
Gastropoda	Trochidae	*Jujubinus striatus* (L. 1758)	2
Gastropoda	Trochidae	*Gibbula ardens* (Salis Marschlins 1793)	23
Gastropoda	Trochidae	*Steromphala adansonii* (Payraudeau 1826)	257
Gastropoda	Trochidae	*Steromphala rarilineata* (Michaud 1829)	2
Gastropoda	Trochidae	*Steromphala umbilicaris* (L. 1758)	2
Gastropoda	Phasianellidae	*Tricolia pullus* (L. 1758)	3
Gastropoda	Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld 1824)	21
Gastropoda	Cerithiidae	*Bittium cf. latreillii* (Payraudeau 1826)	4
Gastropoda	Cerithiidae	*Bittium reticulatum* (da Costa 1778)	33
Gastropoda	Cerithiidae	*Cerithium vulgatum* (Bruguière 1792)	3699
Gastropoda	Potamididae	*Pirenella conica* (Blainville 1829)	53

Class	Family	Species	Number
Gastropoda	Rissoidae	*Rissoa* sp.*1*	1
Gastropoda	Rissoidae	*Rissoa* sp.*2*	1
Gastropoda	Rissoidae	*Setia maculata* (Monterosato 1869)	3
Gastropoda	Rissoidae	*Alvania discors* (T. Allan 1818)	1
Gastropoda	Rissoidae	*Alvania mamillata* (Risso 1826)	6
Gastropoda	Rissoidae	*Alvania* sp.	1
Gastropoda	Truncatellidae	*Truncatella subcylindrica* (L. 1767)	2
Gastropoda	Vermetidae	*Vermetidae* sp.	2
Gastropoda	Naticidae	*Naticarius hebraeus* (Martyn 1786)	1
Gastropoda	Naticidae	*Natica* sp.	8
Gastropoda	Muricidae	*Hexaplex trunculus* (L. 1758)	12
Gastropoda	Costellariidae	*Pusia ebenus* (Lamarck 1811)	1
Gastropoda	Nassariidae	*Tritia cuvierii* (Payraudeau 1826)	48
Gastropoda	Nassariidae	*Tritia neritea* (L. 1758)	1
Gastropoda	Columbellidae	*Columbella rustica* (L. 1758)	33
Gastropoda	Columbellidae	*Mitrella scripta* (L. 1758)	3
Gastropoda	Mangeliidae	*Mangelia striolata* (Risso 1826)	1
Gastropoda	Conidae	*Conus ventricosus* (Gmelin 1791)	119
Gastropoda	Bullidae	*Bulla striata* (Bruguière 1792)	2
Bivalvia	Nuculidae	*Nucula* sp.	1
Bivalvia	Arcidae	*Arca noae* (L. 1758)	2
Bivalvia	Arcidae	*Barbatia barbata* (L. 1758)	2
Bivalvia	Glycymerididae	*Glycymeris glycymeris* (L. 1758)	1
Bivalvia	Anomiidae	*Anomia ephippium* (L. 1758)	1
Bivalvia	Lucinidae	*Loripes orbiculatus* (Poli 1795)	323
Bivalvia	Carditidae	*Cardites antiquatus* (L. 1758)	33
Bivalvia	Carditidae	*Glans trapezia* (L. 1767)	8
Bivalvia	Cardiidae	*Cardiidae* sp.	2
Bivalvia	Cardiidae	*Cerastoderma glaucum* (Bruguière 1789)	5
Bivalvia	Cardiidae	*Parvicardium exiguum* (Gmelin 1791)	5
Bivalvia	Tellinidae	*Gastrana fragilis* (L. 1758)	4
Bivalvia	Veneridae	*Polititapes aureus* (Gmelin 1791)	5

37 families were present for the class Gastropoda and 18 species within 12 families were present within the class Bivalvia (Tab. 3). The most abundant family at the SPI site was the Rissoidae one, with 1317 sampled individuals

Tab. III. *Number of families, species and individuals found at SPI*

Class	Family	Species	Individuals
Scaphopoda	1	1	1
Polyplacophora	1	1	35
Gastropoda	37	95	2554
Bivalvia	12	18	326
Total	51	115	2916

(belonging to 15 species). The most abundant species was *Alvania subcrenulata* (Bucquoy, Dautzenberg & Dollfus 1884), with 926 individuals. Besides Rissoidae, Pyramidellidae was anoher abundant family, with 58 individuals (13 species) being recorded. A hypothetical maximum of 134 (± 14) species was estimated by presuming a sampling total of 6000 individuals for the SPI site (Fig. 2).

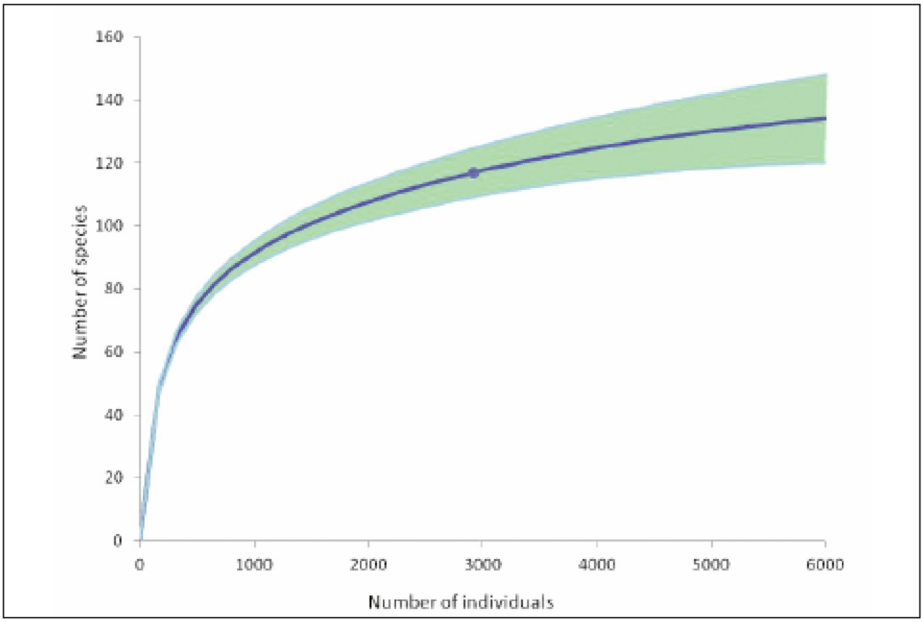

Fig. 2 — Species extrapolation curve for the St. Pauls Island site, with upper and lower bounds (shaded areas), generated through the individual-based rarefaction technique. The blue point marks the observed number of individuals and species and so the full set of collected data.

At the MSL site, no Scaphopoda nor Polyplacophora individuals were recorded. Gastropoda were represented by 32 species belong to 15 families. For Bivalvia, 13 species within 9 families were recorded (Tab. 4). Cerithiidae

Tab. IV. *Number of families, species and individuals found at MSL*

Class	Family	Species	Individuals
Gastropoda	15	32	4354
Bivalvia	9	13	392
Total	24	45	4746

were by far the most frequently-recorded family (3736 sampled individuals belonging to 3 species). The most frequently recorded species was *Cerithium vulgatum,* with 3699 individuals. The individual-based extrapolation exercise for a hypothetical total of 6000 sampled individuals gave an estimated species number of 49 (± 5) species at the MSL site (Fig. 3).

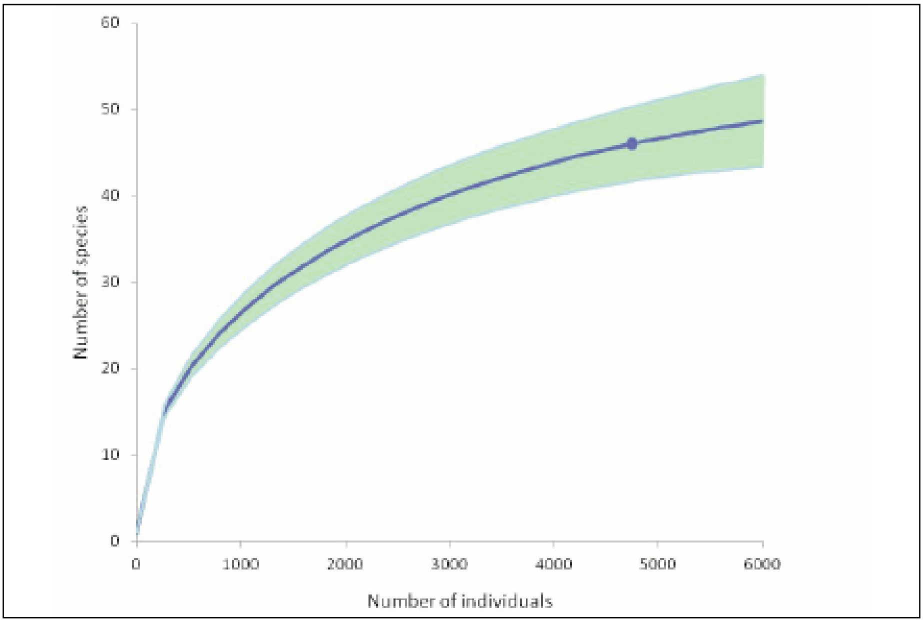

Fig. 3 — Species extrapolation curve for the Marsaxlokk site, with upper and lower bounds (shaded areas), generated through the individual-based rarefaction technique. The blue point marks the observed number of individuals and species and so the full set of the collected data.

Furthermore, the following terrestrial mollusc species were recorded within our samples: 10 individuals of *Tudorella* cf. *melitense* (Sowerby 1847) (SPI site) and 1 individual of *Cepaea* sp. (MSL) that could not be fully identified due to the poor state of preservation.

DISCUSSION

The present study provides insight into the number of mollusc species and families at the Maltese locations SPI and MSL. We can say now that both locations are fundamentally different with regard to the composition of marine shelled Mollusca as well as in their sampled and estimated number of species. One could hypothesize that differences in the degree and intensity of anthropogenic disturbance at the two sites could be the major reason behind the observed differences in mollusc assemblage species number for the two sampled sites, although site-specific differences (e.g. degree of benthic habitat heterogeneity, wave exposure values, granulometric properties of the sediment) could be shaping the same assemblages. Consequently, further research concerning the composition of the marine shelled Mollusca assemblage in Maltese nearshore waters is highly recommended, especially in identifying the sensitivity and response of different mollusc species to different human impacts. Such trait-based investigations would also be useful in identifying habitat and food preferences.

Shell grit sampling has - besides its suitability as a standardized mollusc sampling method - some disadvantages. Unidentifiable remnants of shell grit are one of these. In our case, especially at the SPI site, there were numerous indeterminate mollusc individuals or shell fragments in the rest of the grit, with a definite taxonomic identification not being possible due to the condition of these remains. Another problem is the probable under-representation of species having very thin shells that break easy, such that they cannot be identified any longer.

The occurrence of a particular mollusc species is being inferred from the occurrence of empty, beached shells. The latter does not conclusively indicate that the listed species are still present in the contiguous marine area since long-distance transport of the recorded shell might have occurred (especially by virtue of intense storm action). Differences in the abundance of shells beached for different species may also reflect real differences in such abundance values.

Additional physical factors (e.g. seasonal hydrodynamic fluctuations, as for sea current direction and intensity) will affect the composition of the beached micro molluscs. The prevailing direction of the sea currents might determine the point of accumulation of the shell grit. The size and weight of the shells are another source of variability, since large and heavy ones are not as easily washed ashore as small ones. The slope and profile, as well as the sediment grain properties of a coastal zone also play an instrumental role in shaping the composition of the beached micro mollusc assemblage.

The present study provides a baseline or benchmark for future micro-mollusc assemblage monitoring by proposing a simple and streamlined protocol to hypothesize total species richness at a given location, which can overcome differences in sampling effort between locations. Additional correlation analyses, linking the intensity of a number of anthropogenic activities operating at a site with the total hypothesized number of species occurring at the same site, might enable the adoption of changes in micro mollusc assemblage as a proxy for the degree of environmental change within a coastal area. Such an analysis needs to be applied over a broader spectrum of coastal sites representing different degrees of anthropogenic disturbance besides different geomorphological (e.g. wave dynamics, sediment parameters) variables.

Acknowledgements. We are indebted to Jeffrey Sciberras, Esther Sciberras, Romario Sciberras and Patrick Vella for their constant assistance in the field. Mario Sciberras kindly supported the fieldwork by using his boat to reach the sampling locations. Special thanks go to Patrick Schembri for providing useful contacts and literature. We are also thankful to Tiziano Cossignani and Alberto Cecalupo for taxonomic advice. Finally we thank the anonymous reviewers for their helpful comments on the earlier manuscript draft.

REFERENCES

Andrady A.L., 2011. Microplastics in the marine environment. *Marine poll. Bull.*, 62(8): 1596-1605.

Cachia C., Mifsud C. & Sammut P.M., 1991. The Marine Shelled Mollusca of the Maltese Islands: Part One: Archaeogastropoda. Grima Print. & Pub. Industries.

Chao A., Ma K.H. & Hsieh T.C., 2016. iNEXT (iNterpolation and EXTrapolation) Online: Software for Interpolation and Extrapolation of Species Diversity. Program and User's Guide published at http://chao.stat.nthu.edu.tw/wordpress/software_download/

Evans J., Borg J.A. & Schembri P.J., 2011. Biology and conservation status of the endemic Maltese top-shell *Gibbula nivosa* (A. Adams, 1851) (Trochidae). *Tentacle*, 19: 44-45.

Evans J., Attrill M.J., Borg J.A., Cotton P.A. & Schembri P.J., 2018. Hidden in plain sight: species richness and habitat characterisation of sublittoral pebble beds. *Marine Biology*, 165(2): 35.

Gorman D., Turra A., Connolly R.M., Olds A.D. & Schlacher T.A., 2017. Monitoring nitrogen pollution in seasonally-pulsed coastal waters requires judicious choice of indicator species. *Marine poll. Bull.*, 122(1-2): 149-155.

Gotelli N.J. & Chao A., 2013. Measuring and Estimating Species Richness, Species Diversity, and Biotic Similarity from Sampling Data. Pp. 195-211 in: Levin S.A. (ed.), Encyclopedia of Biodiversity, 2nd ed., Vol. 5,. *Academic Press*, Waltham, MA.

Hoegh-Guldberg O. & Bruno J.F., 2010. The impact of climate change on the world's marine ecosystems. *Science*, 328(5985): 1523-1528.

Jones A., 2017. Case Study Malta: Climate change and tourism: risks, hazards and resilience-an island perspective. Pp. 138-146 in: Global Climate Change and Coastal Tourism: Recognizing Problems, Managing Solutions and Future Expectations.

Poppe T.G. & Goto Y., 1991. European Seashells. *Verlag Christa Hemmen*, Wiesbaden, Vol. 1: 21 p.

Reguera P., Couceiro L. & Fernández N., 2018. A review of the empirical literature on the use of limpets *Patella* spp. (Mollusca: Gastropoda) as bioindicators of environmental quality. *Ecotoxicol. & environ. Safety*, 148: 593-600.

ROMANO B. & ZULLO F., 2014. The urban transformation of Italy's Adriatic coastal strip: Fifty years of unsustainability. *Land Use Policy*, 38: 26-36.

SCHEMBRI P.J. 1993. Physical geography and ecology of the Maltese Islands: A brief overview. *Options Méditerranéennes*, Série B, 7 : 27-39.

SOUSA R., DELGADO J., GONZÁLEZ J.A., FREITAS M. & HENRIQUES P., 2018. Marine Snails of the Genus *Phorcus*: Biology and Ecology of Sentinel Species for Human Impacts on the Rocky Shores. *Biol. Res. Water*. IntechOpen.

Addresses of the authors. M. WÖLFLING, Schweinfurter Str., 34 - 97464 Niederwerrn (Germany); e-mail: saturnia@web.de (corresponding author); B. UHL, Dietpaldstr., 19 - 89426 Wittislingen (Germany); A. SCIBERRAS, Animal Kingdom LTD. 136 Ditch St. Paola, PLA 1234, Malta; A. DEIDUN, Department of Geosciences, University of Malta, Tal-Qroqq, Msida MSD 2080, Malta.