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The potentially invasive opisthobranch *Polycera hedgpethi* Er. Marcus, 1964 (Gastropoda Nudibranchia), introduced in a Mediterranean coastal lagoon

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ABSTRACT The non-native opisthobranch *Polycera hedgpethi* Er. Marcus, 1964 is reported from the coastal lagoon of Capo Peloro (Central Mediterranean Sea) with notes on its habitat typology and feeding behavior. The recently published opinion that *P. hedgpethi* established in the Mediterranean Sea is disputed, since records of adult specimens and egg laying were not accompanied by the presence of juveniles and/or larvae. Mussels imported from Atlantic and North-Adriatic lagoons are hypothesized to be the source of incoming populations in the Peloro Lagoon.

KEY WORDS Opisthobranchs; Alien species; Sicily; Biopollution; Transitional waters.

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INTRODUCTION

Human activities are responsible of increasing introductions of non-indigenous species (NIS) worldwide. The rate of NIS introductions is notably high in the Mediterranean Sea due to the strong anthropogenic pressure, but also favoured by the marked longitudinal and latitudinal gradients in physical factors, and highly diversified habitat typologies. Since investigation efforts are mainly focused on those organisms having a potential impact on the human economy, taxa with indirect or weak interaction with anthropogenic activities are less known. The opisthobranchs, as highly diversified taxa including both generalist and specialized species, which may display invasive behaviors, constitute an ideal model to study colonization processes. Some examples are *Aplysia dactilomela* (Rang, 1828), *Bursatella leachii leachii* (Blainville, 1817), and *Melibe viridis* (Kelaart, 1858) , whose spread throughout the Mediterranean was carefully monitored (Cinar et al., 2006; Daskos & Zenetos, 2007; Borg et al., 2009).

Polycera hedgpethi is a small sized nudibranch, which has been considered an invasive species because of its worldwide distribution (Wilson, 2006). This species, that is known from the Mediterranean since 1988, has recently colonized transitional and coastal environments in the northern Adriatic (Keppel et al., 2012) and south Tyrrhenian Sea.

In this note, the occurrence of *P. hedgpethi* in the Lago Faro, coastal lagoon of Capo Peloro, Sicily, is reported. The aim of this paper is to contribute to the knowledge of the spread of *P. hedgpethi* in the Mediterranean, as an example of a species that could potentially become invasive.

METHODS

Study area

The Lago Faro (38°16'07"N, 15°38'13"E), north-eastern Sicily, is a temperate body of water (average temperature of shallow waters 20.4°C) characterized by a meromictic regime which determines anoxic conditions below 10 m depth. Faro is a mesotrophic lagoon (Saccà et al., 2008) with high levels of microbial productivity (Leonardi et al., 2009). A moderate anthropogenic contamination was attributed to the extensive shoreline urbanization (Giacalone et al., 2004; Minutoli et al., 2008), but the impact of molluscan farms has not been evaluated to date.

Molluscan assemblages have been scarcely investigated in the past (Spada, 1969; Parenzan, 1979), but recent data suggest the anthropogenic introduction of some extra-Mediterranean species, together with the progressive rarefaction of endemic taxa (Giacobbe, 2012). Alien molluscs, crustaceans and annelids from the Faro Lagoon were also reported by Cosentino et al. (2011), Cosentino & Giacobbe (2011), Crocetta (2012) and Giangrande et al. (2012).

Sampling

This research has been carried out in the framework of the PRA 2008/2009 program: "Settlement dynamics and colonization of allochthonous assemblages in the Capo Peloro lagoon". Qualitative surveys were carried out monthly since March 2009, along the oxygenated shallower lake-floors (0-4 m depth). Quantitative samples were collected in 16 stations in Spring 2012, and replicated in Autumn 2012 and Spring 2013. Each station, covering a 100 m^2 surface, was explored by means of a 5x5 m grid (four replicates). The most easily recognizable opisthobranchs were identified in situ, photographed and counted. Some specimens were also collected to confirm their identification, and preserved in ethanol 95%, or formaldehyde 4%, or frozen at -24°C, according to the different analytical requirements. Collected specimens are currently deposited at the Department of Biological and Environmental Sciences, Messina, Italy.

RESULTS AND DISCUSSION

A total of eight *P. hedgpethi* specimens were found between April 2012 and May 2013 inside the Faro Lagoon and adjacent channels. The specimens were recorded in the stations shown in figure 1, and the data are summarized in table 1. Four specimens were found along the channel that connects the Messina Strait with the lagoon (stations K14, K15, K16). A mussel farm is located close to the inner mouth. Mussel farming is currently practiced in the proximity of the K4 station, whereas stations K5 and K3 are not located near aquaculture farms.

All specimens were recorded on fouled hard substrata, less than 1 m depth, except for the first specimen, found at 1.5 m depth and the fourth specimen, which was sampled on floating green algae, *Ulva rigida* C. Agardh 1823 (Fig. 2). All the specimens were found in association with bryozoans, *Bugula neritina* (L., 1758), 3 specimens, and *Zoobotryon verticillatum* (Delle Chiaje, 1822), 5 specimens. All the specimens, whose size was comprised between 15 mm and 35 mm, showed the characteristic chromatic pattern consisting in a whitish background color, largely covered by dense grey dots, with yellow-orange bands on propodial, tentacles, rhinophores, branchial plumes and related lateral processes, as accurately described by Keppel et al. (2012) for Mediterranean specimens. A description of anatomical features was provided by Cervera et al. (1988), who comprehensively confirmed previous records, except for some details in the reproductive system.

Wilson (2006) indicated that *P. hedgpethi* is native to California, where it is widely distributed and common, and it was also recorded in several localities both in Pacific and Atlantic oceans. The species, that might be cryptogenic in the Caribbean, was introduced to South Africa (Gosliner, 1982), Australia (Wilson, 2006), New Zealand (Miller, 2001), Japan (Keiu, 2000), the Atlantic coasts of the Iberian Peninsula (Caballer & Ortea, 2002), and the Mediterranean Sea, where it was first reported from the Fusaro Lake, south Tyrrhenian Sea (Cervera et al., 1988). Subsequently, the species was found in the coastal lagoon of Thau, Southern France (http://www.seaslugforum.net/find.cfm?id=10791), and more recently, in the North-Western Adriatic Sea and the Venice Lagoon (Keppel et al., 2012), the northernmost limit of its range.

P. hedgpethi has a planktotrophic development which favours natural dispersal (Goddard, 2004). However, natural larval fluxes between the small and sparsely situated Italian lagoons are difficult, whilst human-mediated connections are frequent. Because of the disjunct distribution of this species, ship fouling was suggested as the most probable vector (Ryland et al. 2011) as its favourite prey, the bryozoan *Bugula neritina* and other congeneric species (McDonald & Nybakken, 1978; Gosliner,

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2

3

Figure 1. Distribution of *P. hedgpethi* in Italian waters. Faro Lake location and related sampling stations are reported. Figure 2. On-field photo of *P. hedgpethi* on floating green algae. Figure 3. On-field photo of *P. hedgpethi* preying upon *Bugula neritina*, with egg ribs.

1982) often grow on ship hulls. Nevertheless, *P. hedgpethi* has been never reported from commercial harbors in Mediterranean, while it occurs in moderately polluted water bodies whose common trait is the presence of mussel and oyster farms (Sacchi & Renzoni, 1962; Ceccherelli & Barboni, 1983; Malet et al., 2012; Giacobbe, 2012). (Fig. 1). The regular occurrence in the Faro Lagoon of *B. neritina* on mussels and oysters imported from both Atlantic and Adriatic Sea, together with the Adriatic record of *P. hedgpethi* "on a mussel bed" (Keppel et al., 2012), support the hypothesis of a mussel-mediated spreading in the Mediterranean lagoons.

Spawning is documented in Spring (May 2012) for the Faro Lagoon (Fig. 3), whilst in the Venice Lagoon, Keppel et al. (2012) found egg masses in Autumn, as reported by Gosliner, (1982) for South hemisphere. Keppel et al. (2012) also found a juvenile specimen "which did not survive" and documented egg laying in the laboratory, followed by larval hatch seven days later. Nevertheless, egg laying is a common stress-induced response in opisthobranchs, which does not necessarily involve reproductive success. The low number of specimens recorded in the Faro Lagoon confirms that *P. hedgpethi* introductions do not result in dense populations outside its native range (Cervera et al., 1988; Caballer & Ortea, 2002; Cervera et al., 2010), contrary to typical invasive behavior. Moreover, *P. hedgpethi* was recently considered as casual in the Mediterranean (Gofas & Zenetos, 2003; Zenetos et al., 2010; Cervera et al., 2010; Occhipinti-Ambrogi et al., 2011; Crocetta, 2012) until the recent records from the Venice Lagoon, that were considered consistent to an established population (Keppel et al., 2012). Keppel et al. (2012) opinion was accepted in the most recent revision by Crocetta et al. (2013), because of the increased frequency of specimens and egg depositions in different areas of the Mediterranean, despite the fact that it was not supported by the detection of a planktonic larvae supply for self-sustaining populations. For a species to be considered established, it is necessary to provide evidence of "self-maintaining and self-perpetuating populations" (European Commission, 2004). In the case of *P. hedgpethi* such evidence is lacking since no generation replacement has been observed. On the contrary, the hypothesis of recurrent pseudo-populations supported by external supplies appears to agree with both the spatial-temporal discontinuity of records and disappearance of the species from early-colonized areas (Villani, pers. comm.).

CONCLUSIONS

The present record of *P. hedgpethi* increases the number of NIS that have recorded in the Faro Lagoon, which might be considered a Mediterranean hotspot for species introductions, similarly to the larger and better known Venice Lagoon (Keppel et al., 2012). The Mediterranean range of *P. hedgpethi*

Specimen	**n° 1**	**n° 2**	**n° 3**	**n° 4**	**n° 5**	**n° 6**	**n° 7**	**n° 8**
Date	04/12/2012	05/16/2012	05/24/2012	05/24/2012	05/24/2012	05/24/2012	02/09/2013	05/15/2013
Station	K5	K13	K14	K14	K15	K16	K4	K16
Lat. N	38°16'12.2"	38°16'15"	38°15'59.78"	38°15'59.78"	38°15'57.40"	38°15'54.39"	30°16'9.4"	38°15'54.39"
Long. E	15°38'2.9"	15°38'10"	15°38'22.24"	15°38'22.24"	15°38'28.04"	15°38'35.01"	15°38'2.1"	15°38'35.01"
Depth	1.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m
Substratum	iron	builders	beton	green algae	builders	builders	builders	green algae
Association	*Zoo. vert.*	*Zoo. vert.*	*Bug. nerit.*	*Zoo. vert.*	*Zoo. vert.*	*Bug. nerit.*	*Bug. nerit.*	*Zoo. vert.*

Table 1. Sampling data for the eight collected specimens. The associated preys, *Zoobothryon verticillatum* (*Zoo. vert.*) and *Bugula neritina* (*Bug. ner.*), are indicated.

suggests that its introduction in the Faro Lagoon might be mediated by mussel and oyster fouling, confirming the role of aquaculture as an important pathway for introduction and/or secondary spread into Mediterranean semi-enclosed water bodies. Similarly to other non-indigenous and introduced species, *P. hedgpethi* needs to be carefully monitored for a better management and spread prevention. Nevertheless, this species does not appear to show invasive characteristics despite its rapid worldwide spread. *P. hedgpethi* might be recently established in the Venice Lagoon, but this needs to be confirmed with further evidence of the existence of self-maintaining and self-perpetuating populations. The Venice Lagoon might be the source of incoming populations in the Faro Lagoon by mussel trade, but a direct introduction from Atlantic farms cannot be discarded.

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REFERENCES

Borg J.A., Evans J. & Schembri P.J., 2009. Occurrence of the alien nudibranch *Melibe viridis* (Kelaart, 1858) (Opisthobranchia,Tethydidae), in the Maltese Islands. Mediterranean Marine Science, 10: 131-136.

Caballer M. & Ortea J.A., 2002. Primera cita de *Polycera hedgpethi* Marcus, 1964 (Mollusca: Opisthobranchia) para la Península Ibérica. Noticiario SEM, 37: 55-56.

Ceccherelli V.U. & Barboni A., 1983. Growth, survival and yield of *Mytilus galloprovincialis* Lamk. on fixed suspended culture in a bay of the Po River Delta. Aquaculture, 34: 101-114.

Cervera J.L., Garcia-Gomez J.C., Toscano F. & Garcia F.J., 1988. *Polycera hedgpethi* Marcus, 1964 (Gastropoda: Nudibranchia), an Indo-Pacific species discovered in the Mediterranean Sea. Iberus, 8: 225-231.

Cervera J.L., Tamsouri N., Moukrim A. & Villani G., 2010. New records of two alien opisthobranch molluscs from the north-eastern Atlantic: *Polycera hedgpeti* and *Godiva quadricolor*. Marine Biodiversity Records, 3; e51: 4 pp.

Cinar M.E., Bilecenoglu M., Öztürk B. & Can A., 2006. New records of alien species on the Levantine coast of Turkey. Aquatic Invasions, 1: 84-90.

Cosentino A., Giacobbe S. & Potoschi A., 2011. The CSI of the Faro Lake (Messina): a natural observatory for the incoming of marine alien species. Biologia Marina Mediterranea, 16: 132-133.

Cosentino A. & Giacobbe S., 2011. The new potential invader *Linopherus canariensis* (Polychaeta: Amphinomidae) in a Mediterranean coastal lake: Colonization dynamics and morphological remarks. Marine Pollution Bulletin, 62: 236-245.

Crocetta F., 2012. Marine alien Mollusca in Italy: a critical review and state of the knowledge. Journal of the Marine Biological Association, 92: 1357-1365.

Crocetta F., Macali A., Furfaro G., Cooke S., Villani G. & Valdes A., 2013. Alien molluscan established along the italian shores: an update, with discussions on some Mediterranean "alien species" categories. ZooKeys, 277: 91-108.

Daskos A. & Zenetos A., 2007. Additions to the knowledge of alien Opisthobranchia of Greece. Aquatic Invasions, 2: 258-260.

European Commission, 2004. Environment Directorate-General LIFE Focus I Alien species and nature conservation in the EU. The role of the LIFE program. Luxembourg: Office for Official Publications of the European Communities, 55 pp.

Giacalone A., Gianguzza A., Mannino M.R., Orecchio S. & Piazzese D., 2004. Polycyclic aromatic hydrocarbons in sediments of marine coastal lagoons in Messina, Italy: extraction and GC/MS analysis, distribution and sources. Polycyclic Aromatic Compounds, 24: 135-149.

Giacobbe S., 2012. Biodiversity loss in Sicilian transitional waters: the molluscs of Faro Lake. Biodiversity Journal, 3: 501-510.

Giangrande A., Cosentino A., Lo Presti C. & Licciano M., 2012. Sabellidae (Annelida) from the Faro coastal lake (Messina, Ionian Sea), with the first record of the invasive species *Branchiomma bairdi* along the Italian coasts. Mediterranean Marine Science, 13: 283-293.

Goddard J.H.R., 2004. Develpmental mode in benthic opisthobranch molluscs from the northeast Pacific Ocean: feeding in a sea of plenty. Canadian Journal of Zoology, 82: 1954-1968.

Gofas S. & Zenetos A., 2003. Exotic molluscs in the Mediterranean basin: current status and perspectives. Oceanography and Marine Biology: an Annual Review, 41: 237-277.

Gosliner T.M., 1982. A new record of the nudibranch gastropod *Polycera hedgpethi* Marcus, from the Indian Ocean of South Africa. Journal of Molluscan Studies, 48: 30-35.

Keppel E., Sigovini M. & Tagliapietra D., 2012. A new geographical record of *Polycera hedgpethi* Er. Marcus, 1964 (Nudibranchia: Polyceridae) and evidence

of its established presence in the Mediterranean Sea, with a review of its geographical distribution. Marine Biology Research, 8: 969-981.

Keiu S., 2000. Opisthobranchs of Izu Peninsula, TBS-Britannica Co., Ltd, Tokyo. 184 pp.

Leonardi M., Azzaro F., Azzaro M., Caruso G., Mancuso M., Monticelli L.S., Maimone G., La Ferla R., Raffa F. & Zaccone R., 2009. A multidisciplinary study of Cape Peloro brackish area (Messina, Italy): characterizzation of tropic conditions, microbial abundances and activities. Marine Ecology, 30: 32-42.

Malet N., Pastoureaud A., Vaquer A., Quéré C. & Dubroca L., 2012. Marine diatoms sustain growth of bivalves in a Mediterranean lagoon. Journal of Sea Research, 68: 20-32.

McDonald G.R., & Nybakken J.W., 1978. Additional notes on the food of some California nudibranchs with a summery of known food habits of California species. Veliger, 21:110-118.

Miller M.C., 2001. Descriptions of the dorid nudibranchs *Polycera hedgpethi* Marcus, 1964 and *P. fujitai* Baba, 1937 in New Zealand. Journal of Molluscan Studies, 67: 491-499.

Minutoli R., Fossi M.C., Zagami G., Granata A. & Guglielmo L., 2008. First application of biomarkers approach in the zooplanktonic copepod *Acartia latisetosa* for the early management and conservation of transitional waters ecosystem. Transitional Water Bulletin, 1: 45-52.

Occhipinti-Ambrogi A., Marchini A., Cantone G., Castelli A., Chimenz C., Cormaci M., Froglia C., Furnari G., Gambi M.C., Giaccone G., Giangrande A., Gravilli C., Mastrototaro F., Mazziotti C., Orsi-Relini L. & Piraino S., 2011. Alien species along the Italian coasts: An overview. Biological Invasions, 13: 215-237.

Parenzan P., 1979. Fauna malacologica dei laghi di Ganzirri e del Faro (Messina). Thalassia Salentina, 9: 67-78.

Ryland J.S., Bishop J.D.D., De Blauwe H., El Nagar A., Minchin D., Wood C.A. &Yunnie A.L.E., 2011. Alien species of *Bugula* (Bryozoa) along the Atlantic coasts of Europe. Aquatic Invasions, 6: 17-31.

Saccà A., Guglielmo L. & Bruni, V., 2008. Vertical and temporal microbial community patterns in a meromictic coastal lake influenced by the Straits of Messina upwelling system. Hydrobiologia, 600: 89-104.

Sacchi C.F. & Renzoni A., 1962. L´ecologie de *Mytilus galloprovincialis* (Lam.) dans l´étang littoral du Fusaro et les rythmes annuels et nyctemeraux des facteurs environnants. Pubblicazioni della Stazione Zoologica di Napoli, 32 (Suppl.): 255-293.

Spada A., 1969. Breve esplorazione malacologica del lago di Ganzirri e del Pantano di Torre del Faro presso Messina. Conchiglie, 5: 60-65.

Terrence M.G., 1982. A new record of the nudibranch gastropod *Polycera hedgpethi* Marcus, from the Indian Ocean of South Africa. Journal of Molluscan Studies, 48: 30-35.

Wilson N., 2006. New record of the nudibranch *Polycera hedgpethi* Er. Marcus, 1964, in South Australia, with a discussion on its occurrence in Australia. Records of the Western Australian Museum, Suppl. 69:137-140.

Zenetos A., Gofas S., Verlaque M., Çinar M.E., García-Raso J.E., Bianchi C.N., Morri C., Azzurro E., Bilecenoglu M., Froglia C., Siokou I., Violanti D., Sfriso A., San Martín G., Giangrande A., Katağan T., Ballesteros E., Ramos-Esplá A., Mastrototaro F., Ocaña O., Zingone A., Gambi M.C. & Streftaris N., 2010. Alien species in the Mediterranean by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11: 381-493.