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SHORT COMMUNICATION

First record of the alien sponge *Paraleucilla magna* (Family Amphoriscidae) on the Moroccan Mediterranean coast

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Abstract: The alien calcareous sponge *Paraleucilla magna* Klautau, Monteiro & Borojevic, 2004 was detected for the first time in Morocco, which represents an important contribution to the understanding of alien species in the region. The species was recorded at aquaculture facilities in Amsa and M'diq during February and March 2024. Specimens were found at depths ranging from 1 to 4 meters, cohabiting with the *Mytilus galloprovincialis* on artificial hard substrates. Numerous individuals ranging in size from 1 cm to 4 cm were observed. The introduction of *P. magna* into Moroccan waters is likely due to biofouling on aquaculture facilities and vessels, which is consistent with its spread in other Mediterranean areas. This finding enhances our knowledge of its biogeographical distribution and ecological impact in the Mediterranean and underscores the importance of monitoring its proliferation and potential effects on local ecosystems.
***Keywords*:** non-native; Morocco; *Paraleucilla magna*; alien sponge; biodiversity; invasive species

Sažetak: PRVI NALAZ STRANE VRSTE SPUŽVE *PARALEUCILLA MAGNA* (PORODICA AMPHORISCIDAE) NA PODRUČJU MAROKANSKE OBALE SREDOZEMNOG MORA. Strana spužva vapnenjača *Paraleucilla magna* Klautau, Monteiro & Borojevic, 2004 prvi je put otkrivena u Maroku, što predstavlja važan doprinos razumijevanju stranih vrsta u ovoj regiji. Vrsta je zabilježena u objektima za akvakulturu u Amsi i M'diqu tijekom veljače i ožujka 2024. Jedinke su pronađene na dubinama od jednog do četiri metra, zajedno s vrstom *Mytilus galloprovincialis,* na umjetnim tvrdim podlogama. Uočene su brojne jedinke veličine od jednog do četiri centimetra. U marokanske vode *P. magna* vjerojatno je unesena putem obraštaja na akvakulturnim objektima i brodovima, što je u skladu s njezinim širenjem u drugim sredozemnim područjima. Ovaj nalaz proširuje znanje o biogeografskoj distribuciji i ekološkom utjecaju ove vrste u Sredozemnom moru te naglašava važnost praćenja njezinog širenja i potencijalnih učinaka na lokalne ekosustave.
Ključne riječi: nezavičajna vrsta; Maroko; *Paraleucilla magna*; strana vrsta spužve; biološka raznolikost; invazivna vrsta

INTRODUCTION

Biological invasions have been identified as one of the principal factors contributing most directly to the decline of biodiversity. The impacts extend to the loss of genetic diversity, reduction of native populations, displacement of species, modification of habitats, and even the transformation of entire ecosystems (Vlachogianni *et al.,* 2013). The Mediterranean Sea is one of the world's most important biodiversity hotspots (Goffredo and Dubinsky, 2014). It is home to a wide variety of marine species, many of which are endemic. However, it is also at risk from other significant threats, such as biological invasions (Goffredo and Dubinsky, 2014).

Morocco recorded 39 non-indigenous species in its Mediterranean waters between 1990 and 2024. These species are classified into the following groups: Rhodophyta (11 species), Chlorophyta (3 species), Ochrophyta (4 species), Mollusca (2 species), Crustacea (6 species), Tunicata (4 species), Annelida (1 species), Nematoda (1 species), Bryozoa (1 species), Vertebrata (Fish, 3 species), and Cnidaria (3 species) (Galanidi *et al.,* 2023; Mghili *et al.,* 2024).

The calcareous sponge *Paraleucilla magna*, originally described from the Brazilian coast (Klautau *et al*., 2004), is not considered native to Brazil. However, it has successfully spread in the Mediterranean Sea for nearly 24 to 30 years (Longo *et al*., 2007). This species was first documented in Italy in 2001 (Longo *et al*., 2007) and has since been recorded in several other Mediterranean countries, including Malta in 2009 (Zammit *et al*., 2009), Croatia in 2013 (Cvitković *et al*., 2013), Turkey in 2016 (Topaloğlu *et al*., 2016), Greece in 2017 (Gerovasileiou *et al*., 2017), Algeria in 2019 (Bachetarzi *et al*., 2019), and Libya in 2020 (Katsanevakis *et al*., 2020). *P. magna* is notable for its high fecundity rates, with reproductive elements produced continuously throughout the year, particularly during warmer water

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periods (Lanna *et al*., 2007; Longo *et al*., 2012; Lanna *et al*., 2014). The discontinuous dispersal of *P. magna*, its concentration near port areas, and its rapid proliferation have raised concerns regarding its potential for bioinvasion (Lanna *et al*., 2014). This sponge typically inhabits environments enriched with suspended organic material, often found near sea farms, small marinas, harbors, and river mouths (Longo *et al*., 2007; Zammit *et al*., 2009). Consequently, within the Mediterranean, *P. magna* is classified as an invasive species due to its negative impacts on mollusc farming activities (Longo *et al*., 2007).

Research has demonstrated that the ethanolic extract of *P. magna* exhibits antifouling effects on juvenile *Mytilus galloprovincialis*, as well as toxic activity on nauplii of the brine shrimp *Artemia salina* and growth inhibition in microalgae such as *Nannochloropsis sp.* and *Tetraselmis suecica* (Longo *et al*., 2021). Furthermore, the introduction of *P. magna* has been associated with an adaptive antioxidant response in the algae *Peyssonnelia squamaria*, as indicated by biomarker studies (Guzzetti *et al*., 2019).

Genetic studies have elucidated the structure of *P. magna* populations in the western Mediterranean, highlighting its dispersion and adaptation within this recipient environment (Guardiola *et al*., 2012). More recently, Cavalcanti *et al*. (2020) analyzed the genetic structure of this sponge across a wide geographic range from Rio de Janeiro to the Adriatic Sea, emphasizing its rapid expansion and ability to colonize diverse marine habitats. Additionally, Padua *et al*. (2013) reported on the macrofauna associated with *P. magna* along the coast of Rio de Janeiro, Brazil. The life cycle of *P. magna* in the Mediterranean basin was described by Longo *et al*. (2012), providing insights into its reproductive strategies and ecological impacts. Understanding these dynamics is crucial for developing effective management strategies for this invasive species.

This study reports the first occurrence of the alien sponge *P. magna* in Morocco, marking an important milestone as the first recorded case of an alien sponge in the country. Thus, one of the main objectives of this research is to extend the existing biogeographic data on *P. magna* in the Mediterranean basin, with a particular focus on Moroccan waters. In this context, this study aims to provide a fundamental basis for monitoring the future spread of this alien sponge species.

MATERIAL AND METHODS

Samples were collected from two mussel farms located in the northwestern region of the Mediterranean coast of Morocco: Amsa mussel farm (35°32'30.52"N, 5°12'21.57"W) and M'diq mussel farm (35°41'27"N, 5°17'54"W). Both sites were surveyed during February and March 2024 at depths ranging from 1 to 4 meters (Fig. 1). The M'diq shellfish farm is located approximately 700 meters offshore, while the Amsa shellfish farm is situated about 250 meters from the shoreline. Specimens were collected by scuba diving and fixed in 96% ethanol for subsequent analysis. Identification was based on spicule morphology and skeletal architecture (Fig. 2), following the methods described by Klautau *et al*. (2004) and Longo *et al*. (2007). Optika B-150D-BR-PL microscope was used for the identification. To pre-

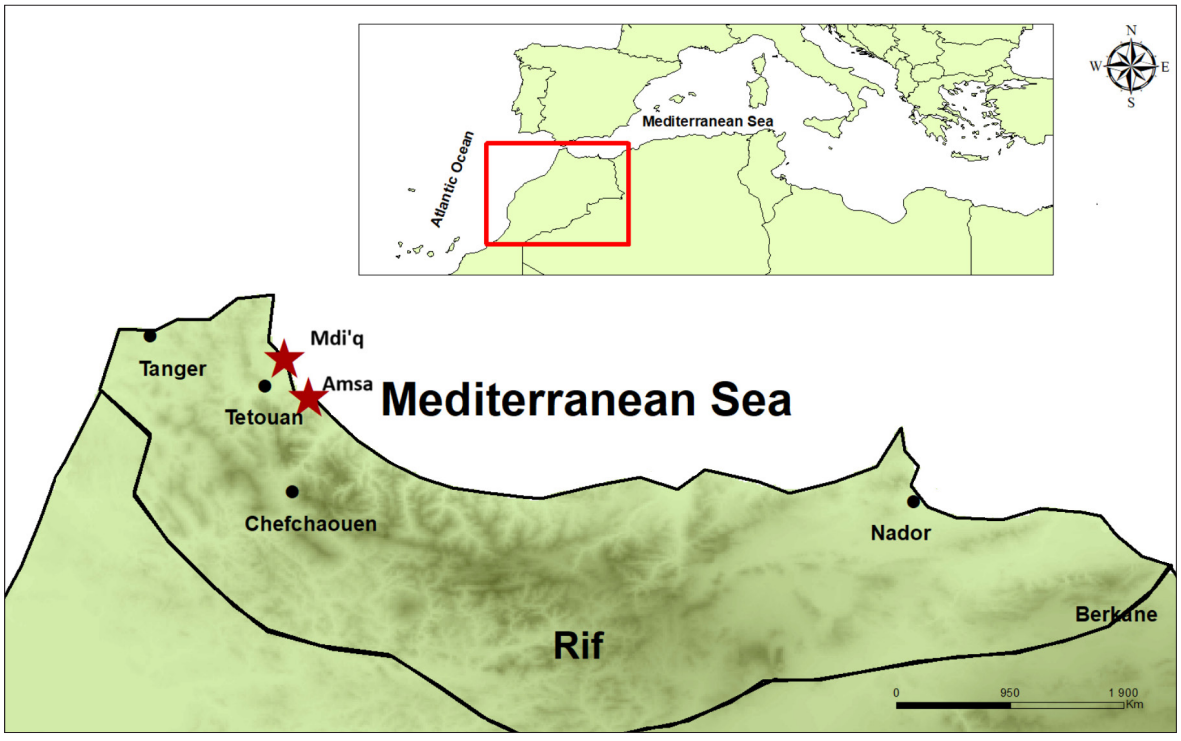

Fig. 1. Map of the sampling sites M'diq and Amsa.

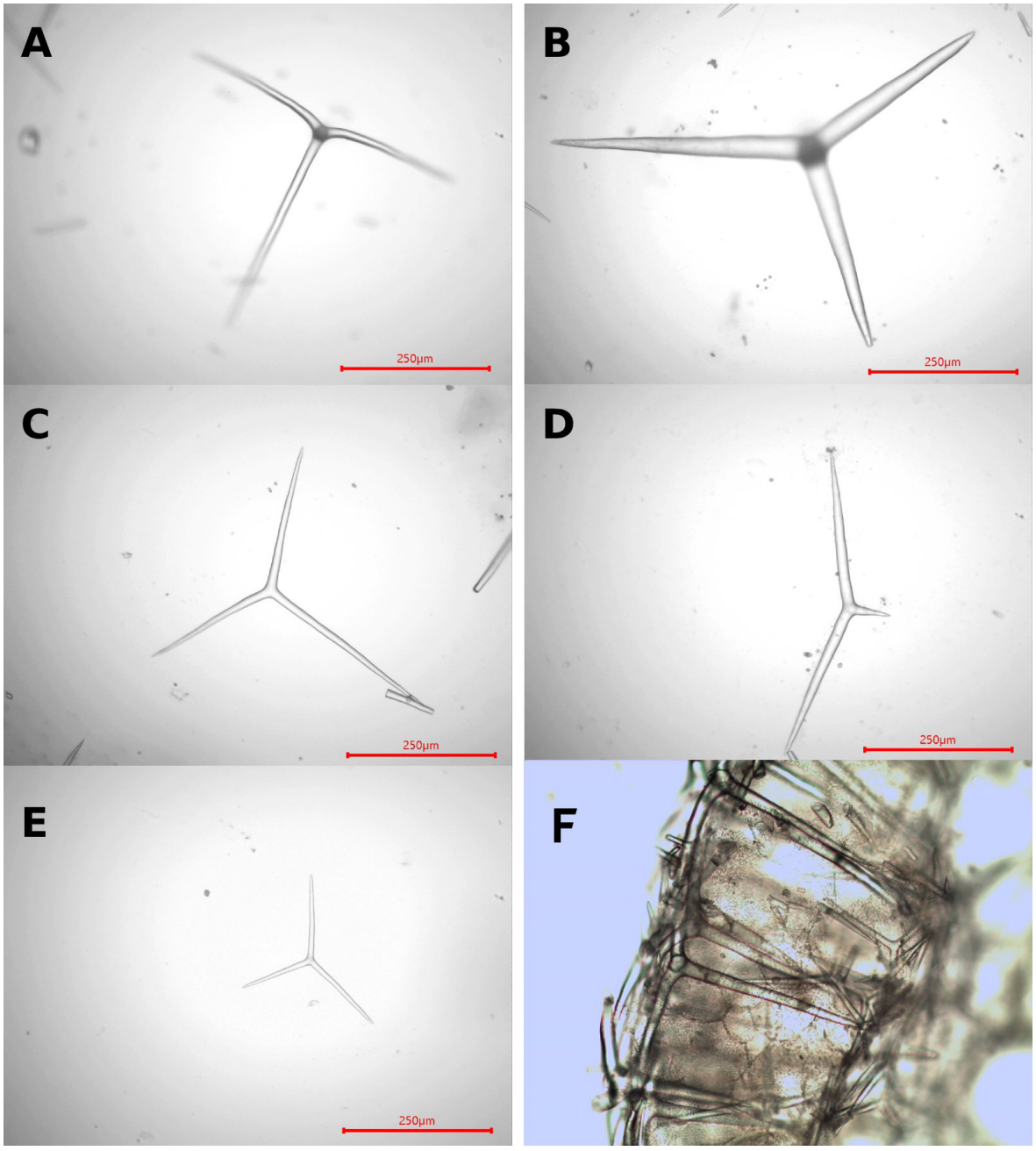

Fig. 2. Spicules of *Paraleucilla magna*: cortical tetractine (**A**); subatrial tetractine (**B**); subatrial triactine (**C**); atrial triactine (**D**); cortical triactine (**E**); skeletal cross section (**F**) (Gx100).

pare the spicules for measurement, five specimens were selected to assess various parameters. The length and thickness of actines were measured from 25 spicules of each species using the Optika B-150D-BRPL microscope with an integrated camera, following the protocols of Klautau *et al*. (2004) and Longo *et al*. (2007).

RESULTS AND DISCUSSION

The presence of *P. magna*, an alien marine sponge species, was first recorded in shellfish farms near Amsa and M'diq coasts along the western Mediterranean coast of Morocco Through systematic surveys of these aquaculture facilities, we identified numerous individuals of *P. magna* cohabiting with *Mytilus galloprovincialis* (Fig. 3).

Morphological examinations revealed that *P. magna* exhibits various morphologies, ranging from leaf-shaped bodies with prominent oscula to irregular massive shapes. The sponge appears white to light cream *in vivo* and varies in length from 1 to 4 cm. Both the spicule analysis and the skeletal architecture were considered in the identification of specimens collected from Moroccan shellfish farms (Table 1). This sponge has been observed

Fig. 3. Photo of live specimens of *Paraleucilla magna* found as biofouling on *Mytilus galloprovincialis*.

for the first time in these aquaculture settings in the bays of Amsa and M'diq. Our monitoring at both sites confirms the presence of *P. magna* individuals colonizing the infrastructure and surrounding substrates of local aquaculture facilities.

The combined results of the morphological examination and the spicule analysis (Table 1) revealed characteristics consistent with descriptions reported by Klautau *et al*. (2004) and Longo *et al*. (2007). The presence of *P. magna* on aquaculture installations such as ropes, chains, and buoys indicates a successful adaptation of the sponge to conditions prevalent in local shellfish farms. This observation aligns with previous reports on the sponge's capacity to develop and survive in aquaculture environments (Longo *et al*., 2007; Zammit *et al*., 2009; Longo et al., 2012; Gerovasileiou *et al*., 2017). The introduction of *P. magna* into Moroccan waters likely occurred *via* biofouling on aquaculture equipment or vessels, as documented for other localities in the Mediterranean Sea (Longo *et al*., 2007).

The successful establishment of *P. magna* in the aquaculture environments of Amsa and M'diq bays gives rise to significant ecological concerns. The sponge's capacity to flourish in these environments indicates a high degree of adaptability, which may potentially impact local biodiversity. As observed in Algeria, where *P. magna* was found to proliferate in artificial substrates and compete with native species (Bachetartzi *et al*., 2019), our findings suggest that this sponge could disrupt local ecosystems by outcompeting indigenous marine organisms for space and resources.

Furthermore, the documented rapid colonization patterns of *P. magna* across various Mediterranean locations underscore its invasive potential. Studies have demonstrated that this species can reproduce almost year-round, with peak reproductive activity during warmer months, allowing it to maintain high population densities (Lanna *et al*., 2007; Longo *et al*., 2012; Lanna *et al*., 2014). The presence of *P. magna* in aquaculture settings not only reflects its resilience but also points to potential pathways for further spread along the coast.

In consideration of the increasing investment in aquaculture projects in Morocco, such as the recently established marine fish hatchery with the objective of enhancing local fisheries, it is crucial to monitor the impact of *P. magna* on these developing ecosystems. To assess its effects on native biodiversity and to implement effective management strategies that mitigate its invasive impacts, continuous surveillance will be essential.

CONCLUSION

Our study reports the first occurrence of the calcareous sponge *P. magna* in Morocco, marking the first recorded instance of an alien sponge species in the country. This finding is significant as it highlights the ongoing spread of non-indigenous species in the Mediterranean, particularly in aquaculture settings. The species has successfully colonized aquaculture infrastructures, likely through biofouling on equipment and vessels, a pathway that is consistent with its introduction in other Mediterranean regions.

Table 1. Measurements taken from *P. magna* spicules from Amsa and M'diq, Morocco. The values correspond to the range, with the mean value and the standard deviation indicated in parenthesis.

Spicules	Actine	Length (µm)	Thickness (µm)
Cortical triactine	Paired	80-329 (193 ± 76)	8-26 (17 ± 6)
	Unpaired	59-303 (161 ± 68)	
Cortical tetractine	Apical	177-573 (407 ± 97)	16-52 (30 ± 10)
	Basal	150-440 (311 ± 81)	
Subatrial triactine	Paired	60-261 (184 ± 57)	8-28 (18 ± 6)
	Unpaired	69-336 (220 ± 73)	
Subatrial tetractine	Paired	120-400 (250 ± 77)	12-45 (25 ± 10)
	Unpaired	93-379 (205 ± 68)	
Atrial triactine	Paired	120-310 (218 ± 58)	10-29 (19 ± 5)
	Unpaired	40-168 (101 ± 36)	

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