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ORIGINAL ARTICLE

The first record of the Lessepsian sacoglossan *Elysia* sp. 2 from the Aegean Sea, with discussion of its taxonomy and habitat preferences

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Abstract: Native to the Indo-Pacific region, the sacoglossan species complex *Elysia* cf. *marginata-grandifolia* is considered a Lessepsian migrant and an alien species in the Mediterranean Sea, following its first record along the coast of Turkey in 2001, and consecutive observations in the area. Subsequent studies have reported its presence in the Levantine basin along the coasts of Turkey, Israel, Lebanon, and Cyprus, with uncertainties around its taxonomic assignment. This paper highlights the presence of two alien *Elysia* species included in these reports, separated now for the first time. We also present new findings of *Elysia* sp. 2's range, marking its first occurrence in the Aegean Sea in July 2024 along the coast of Lipsi Island, Greece. This record represents the species' westernmost distribution in the Mediterranean basin, highlighting a potential ongoing range expansion. Although further examinations in the region would be needed to fully ascertain whether an established population is present in the Aegean Sea, this report demonstrates the importance of continuous monitoring in the early detection of the presence of alien and invasive species, to inform conservation and management strategies.
Keywords: Mollusca; Mediterranean Sea; alien species; marine invasions; coastal waters

Sažetak: PRVI ZAPIS O LESEPSIJSKOJ VRSTI MORSKOG PUŽA IZ NADREDA SACCOGLOSSA *ELYSIA* SP. 2 U EGEJSKOM MORU, UZ RASPRAVU O NJEGOVOJ TAKSONOMIJI I PREFERIRANIM STANIŠTIMA. Kompleks vrsta morskih puževa iz nadreda Sacoglossa *Elysia* cf. *marginata-grandifolia* porijeklom iz indo-pacifičke regije smatra se lesepsijskim migrantom i stranom vrstom u Sredozemnom moru, temeljem prvog nalaza uz tursku obalu 2001. godine i naknadnih uzastopnih opažanja u tom području. Kasnije studije su izvijestile o prisutnosti ovog kompleksa u levantinskom bazenu duž obala Turske, Izraela, Libanona i Cipra, s nesigurnom taksonomskom pripadnošću. Ovaj rad rasvijetljava prisutnost dviju stranih vrsta iz roda Elysia uključenih u navedene studije, a koje su sada po prvi put razdvojene. Također dokumentiramo nove nalaze vrste *Elysia* sp. 2, navodeći njeno prvo pojavljivanje u Egejskom moru u srpnju 2024. godine duž obale grčkog otoka Lipsi. Ovaj zapis predstavlja najzapadniju točku rasprostranjenosti ove vrste u Sredozemnom bazenu, ukazujući na njezino potencijalno daljnje širenje. Iako su potrebna daljnja istraživanja u regiji kako bi se u potpunosti utvrdilo je li populacija uspostavljena u Egejskom moru, ovaj rad pokazuje važnost kontinuiranog praćenja za rano otkrivanje prisutnosti stranih i invazivnih vrsta u svrhu izrade strategija očuvanja i upravljanja.
Ključne riječi: Mollusca; Sredozemno more; strane vrste; morske invazije; obalne vode

INTRODUCTION

While the Mediterranean Sea is considered a biodiversity hotspot (Coll *et al.*, 2010), it is also recognised as the most invaded sea globally (Costello *et al.*, 2021). In fact, more than 1000 alien species have been documented in the region to date (Zenetos *et al.*, 2022a, b), with invasions primarily driven by the opening of the Suez Canal, and dense marine traffic (Zenetos *et al.*, 2012). Alien species represent a major threat to marine ecosystems in the Mediterranean Sea, impacting ecosystem functioning, disrupting native communities, and increasing biotic homogenisation (Tsirintanis *et al.*, 2022). The eastern Mediterranean in particular, due to its proximity to the Suez Canal and warmer waters that favour thermophilic species, hosts a significant proportion of these alien and invasive species (Galanidi *et al.*, 2023). However, rising sea surface temperatures and continued shipping activity are increasingly facilitating the westward expansion of their occurrence (Katsanevakis *et al.*, 2020).

The genus *Elysia* Risso, 1818 (Mollusca: Gastropoda: Sacoglossa: Plakobranchidae) is one of the most speciose taxa within the superorder Sacoglossa, including

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individuals characterised by a leaf-like shape and colouration, with two parapodia that extend dorsally (Kelaart, 1858; Pease, 1871). *Elysia* species are herbivorous and are generally found closely associated with algae as both a substrate and food source (Jensen, 1994). Species within the genus *Elysia* are distributed throughout the world's oceans (Jensen, 2006; Martín-Hervás *et al*., 2023), with many of them described from the Central Pacific (Jensen, 2006). Twelve accepted species within the genus *Elysia* reside in European waters, including the non-native *Elysia grandifolia* Kelaart, 1858, originally described from Sri Lanka (Martín-Hervás *et al*., 2023). Although *E. grandifolia* was originally synonymised with *Elysia ornata* (Swainson, 1840) (Jensen, 1992), an integrative systematic study performed by Krug *et al.* (2013), and later by Martín-Hervás *et al*. (2023), addressed some of the confusion in the systematics among *Elysia* species, referring to a potential species complex. Krug *et al.* (2013) reported that the putative "circumtropical" *E. ornata* consisted of a Caribbean species and four Indo-Pacific candidate species. These previously synonymised Indo-Pacific species include *Elysia marginata* (Pease, 1871), originally described from the South Pacific Ocean, and *E. grandifolia*. Both the *E. marginata* and the *E. grandifolia* species have been described as having a pale green colouration with small black spots and two dorsally extending parapodia that fuse at the tail (Kelaart, 1858; Pease, 1871). These parapodia are marginated by parallel black and gold lines (Kelaart, 1858). The observable distinction between the two lies in the presence of a thin, white, marginal line on the parapodia of *E. marginata*, which is not found in individuals of *E. grandifolia* (Pease, 1871). However, Krug *et al*. (2013) observed that this might just be intraspecific variation, and refer to the Mediterranean alien species as *Elysia* cf. *grandifolia* complex.

Previous records of this species complex in the Mediterranean have been reported as either *E. ornata* (Ammar *et al*., 2022), *E. grandifolia* (Crocetta *et al*., 2013), or *Elysia marginata-grandifolia* (Christidis *et al*., 2024). However, in the Red Sea, these species were described as *Elysia* sp. 1 and *Elysia* sp. 2, and thought to be endemic to the basin (Yonow, 2008, 2024). In the Mediterranean Sea, the alien sacoglossan *E*. cf. *grandifolia* complex was first reported in September 2001 off the coast of Antalya, Turkey (Yokes, 2001 as *E. ornata?*) and amended by Rudman (2001) as *E. grandifolia*. This first record was followed by a series of observations from the same geographical region in 2003 and 2004 (Yokes and Rudman, 2004; Yokes, 2005: Çevik *et al.,* 2016). Subsequently, the species, identified as both *E. grandifolia* and *E. ornata* was frequently observed across the Israeli and Lebanese coastline (Firer, 2005; Halevy, 2005; Kanzen, 2009; Pasternak and Galil, 2012; Bitar, 2013; Crocetta *et al*., 2013). This increased occurrence led to the classification of this alien species as 'established' within the Levantine basin of the Mediterranean Sea (Zenetos *et al*., 2022a). Despite this increase in observations, no further significant changes in the species distribution were noted until January 2024, when the first observation of the *E*. cf. *grandifolia* complex was reported in Cyprus as *E. marginata-grandifolia* (Christidis *et al*., 2024). Furthermore, the taxonomic uncertainties surrounding these Mediterranean records have not been addressed until now. Drawing on the works of Yonow (2008, 2024) in the Red Sea, we propose that the Mediterranean has been invaded by two distinct *Elysia* species and recommend reclassifying the Mediterranean records as either *Elysia* sp. 1 or *Elysia* sp. 2.

Although these two alien species have expanded in the Mediterranean basin, where molluscs are among the most prominent invaders (Galanidi *et al*., 2023), the genus *Elysia* has long attracted scientific interest due to its unique biological characteristics and valuable applications. The genus has been studied for its potential in drug discovery and its distinctive life strategies, including its role in the biocontrol of invasive algae and other ecologically significant behaviours. For instance, the species complex *Elysia tomentosa* K.R. Jensen, 1997 holds ecological significance due to their observed role in regulating the chemically defended invasive algae *Caulerpa cylindracea* Sonder, 1845 and *Caulerpa taxifolia* (M. Vahl) C. Agardh, 1817 (Coquillard *et al*., 2000; Thibaut *et al*., 2001). The genus *Elysia* includes some of the few known multicellular organisms capable of kleptoplasty (Pelletreau *et al*., 2011; Melo Clavijo *et al*., 2018), a life strategy that incorporates algal chloroplasts to retain their photosynthetic function (Pelletreau *et al*., 2011). Some rare species of this genus exhibit poecilogony (i.e., polymorphism in larval development) which makes them valuable as models for studying larval development (Vendetti *et al*., 2012; Krug *et al*., 2015). Furthermore, *E. ornata* and related species are sources of a potential anticancer drug candidate kahalalide (Horgen *et al*., 2000; Fontana *et al.*, 2001; Ashour *et al*., 2006).

Given the ecological importance of this genus, tracking its distribution is essential for understanding its impact on Mediterranean ecosystems. Monitoring the spread of this Mediterranean invader is particularly valuable as it not only enhances our understanding of this species but also provides broader insights into spatio-temporal patterns of mollusc invasions, which represent the largest group of alien species in the Mediterranean Sea (Zenetos *et al*., 2022a). In this context, we present an update on the biogeographic distribution of the Mediterranean alien *Elysia* cf. *grandifolia* complex, reporting its first documented observation in the Aegean Sea, marking its northern- and western-most record to date. This underscores the importance of continued monitoring in the Aegean to track the north- and westward spread of Lessepsian migrants from the Levantine Basin, allowing for early observations of alien species as they expand beyond their initial establishment. Such monitoring is crucial for identifying the vectors driving these changes and planning conservation measures.

MATERIALS AND METHODS

Sampling

During a biodiversity survey conducted on Lipsi Island, Greece on 28 July 2024, one live specimen of the sacoglossan genus *Elysia* was observed. The sighting occurred in Vroulia bay (37° 19' 1.3'' N, 26° 43' 29.2'' E), in the northwest region of the island. Following its observation, the specimen was photographed *in situ* with an Olympus Tough TG-6 waterproof camera, ensuring detailed documentation of its morphology and habitat. Following the observation, the specimen was collected using tweezers for subsequent morphological analyses.

Morphological analyses

The length of the relaxed specimen was measured with a calliper to the nearest millimetre. Measurements were taken from the anterior tip of the head (excluding rhinophores) to the posterior end of the foot. The specimen was subsequently observed and photographed under a Zuzi E series B-HB11 digital microscope at 2-4× magnification. Following morphological examination, the specimen was fixed in 70 % ethanol for long-term storage. Taxonomic and morphological characters outlined in the original descriptions by Kelaart (1858), Pease (1871), and Eliot (1906) were used as references to identify the specimen.

RESULTS

Identification

The single specimen was collected and measured, recording a length of 4.5 cm and approximately 3 cm in diameter with the parapodia expanded. The leaf-like specimen exhibited a pale green colouration in its head and body and its large, thin parapodia were highly folded, forming numerous siphonal openings (Fig. 1A-C). The parapodia extended dorsally, fusing at the distal tail. Dorsal images (Fig. 1D) show the parapodia bordered by a black marginal line and an orange submarginal line; there are broken white dots marking the innermost margin on the inner side of the parapodia.

The body is densely covered in visible black spots and patches of varying sizes (Fig. 2A). Microscopic examination confirmed these features providing further detail on the parapodia morphology (Fig. 2B-D). The rhinophores of the specimen measure less than 1 cm

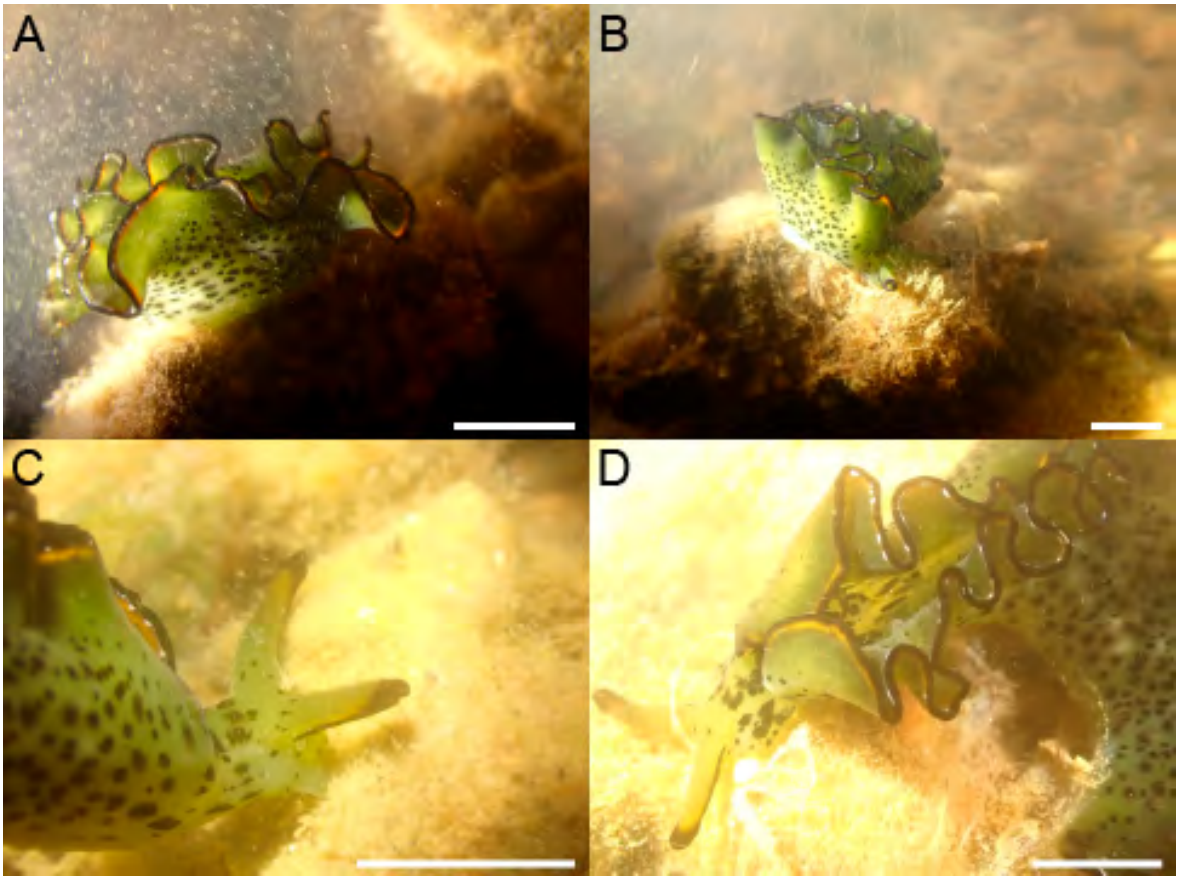

Fig. 1. *In situ* pictures of *Elysia* sp. 2 recorded in Vroulia bay (Lipsi Island) on 28 July 2024; living specimen on macroalgae substrate **(A, B)**; detail of the rhinophores **(C)**; dorsal view of head and body showing the diagnostic black patches on both **(D)**. Scale bars: 1 cm. Photo credits: Nermin Sena Ozger.

in length and culminate in a solid black coloration that extends down the margins. These morphological characteristics support the identification of this specimen as *Elysia* sp. 2 according to Yonow (2008).

Mediterranean distribution

Re-evaluation of the Mediterranean records published to date, based on the published images, revealed that the previous records belong to both *Elysia* sp. 1 and *Elysia* sp. 2. Both *Elysia* spp. occur in Israel, Syria, and Turkey, while *Elysia* sp. 2 only in Lebanon, Cyprus, and Greece (Table 1). Fig. 3 illustrates the distribution of the two species in the eastern Mediterranean.

Habitat and ecological insights

The specimen was observed in murky inshore waters, inhabiting a mainly rocky habitat and associated with a macroalgal substrate (Fig. 1). Species level identification of the algae would require further microscopic and molecular investigation. Notably, the specimen occupied a shallow depth of approximately 0.2 m below sea level, representing the shallowest documentation for *Elysia* sp. 2. This record marks the first reported occurrence of this species in the Aegean Sea and represents its northern- and western-most observation to date.

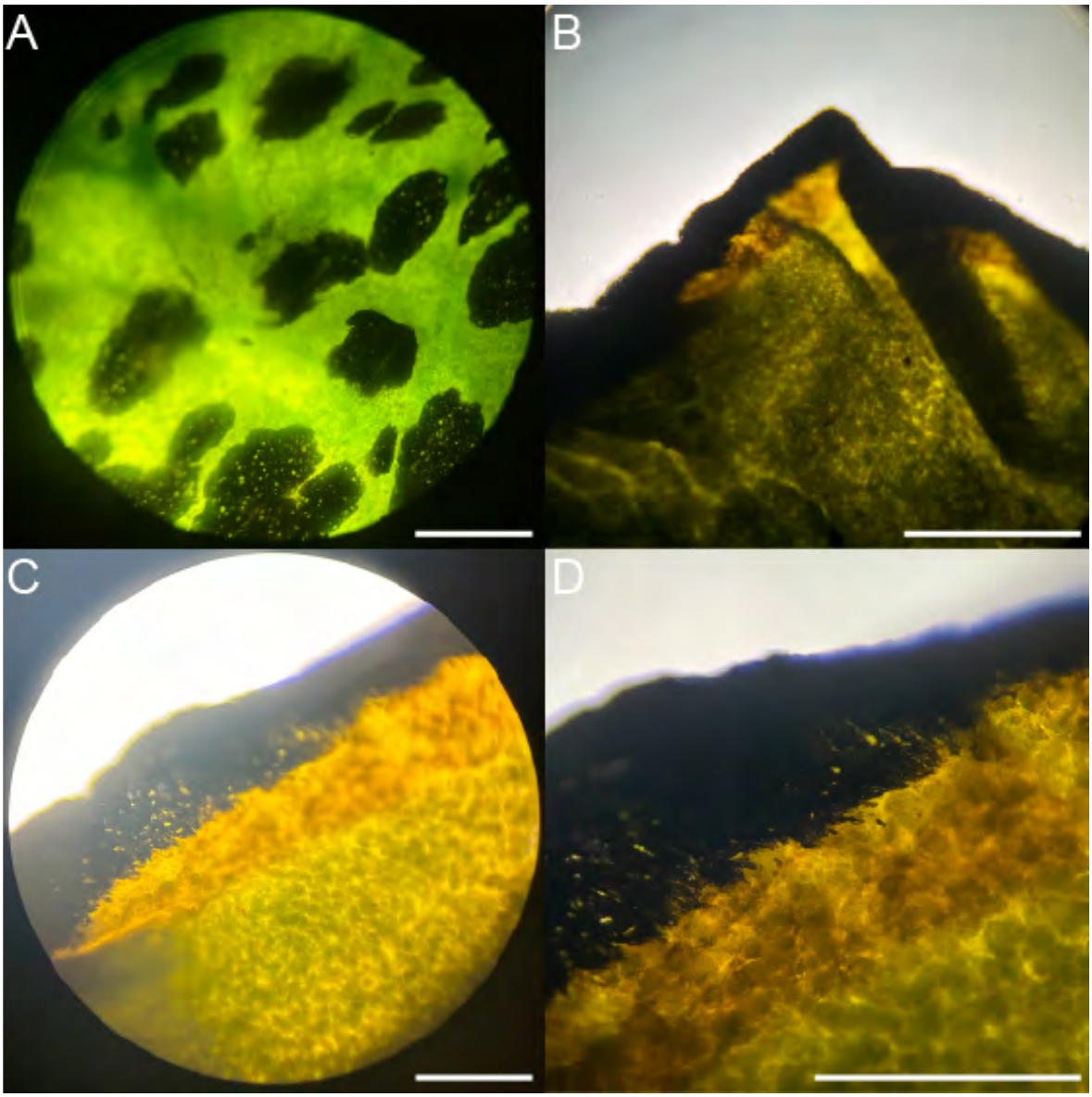

Fig. 2. Detailed morphological characteristics of *Elysia* sp. 2 observed by digital microscopic images; pale green body colouration marked by numerous black dots **(A)**; parapodial margin featuring black marginal and orange submarginal lines imaged at 2-4× magnification **(B, C, D).** Scale bars: 1 mm.

Table 1. Re-evaluation of reported *Elysia* spp. in the Mediterranean

Year of detection	Country	Reported as	Source	Current identification
2001	Turkey	*Elysia ornata*	Yokes, 2001	*Elysia* sp. 1
		Elysia grandifolia	Rudman, 2001	*Elysia* sp. 1
2002	Lebanon	*Elysia grandifolia*	Crocetta *et al.,* 2013	*Elysia* sp. 2
2005	Israel	*Elysia grandifolia*	Firer, 2005; Halevy, 2005	*Elysia* sp. 2
2006	Turkey	*Elysia grandifolia*	Çevik *et al.,* 2016	*Elysia* sp. 2
2012	Israel	*Elysia grandifolia*	Pasternak and Galil, 2012	*Elysia* sp. 1
2019	Syria	*Elysia ornata*	Ammar *et al.,* 2022	*Elysia* sp. 1
2021	Syria	*Elysia grandifolia*	Ammar *et al.,* 2022	*Elysia* sp. 2
2024	Cyprus	*Elysia marginata-grandifolia*	Christidis *et al.,* 2024	*Elysia* sp. 2
2024	Greece	*Elysia* sp. 2	This study	*Elysia* sp. 2

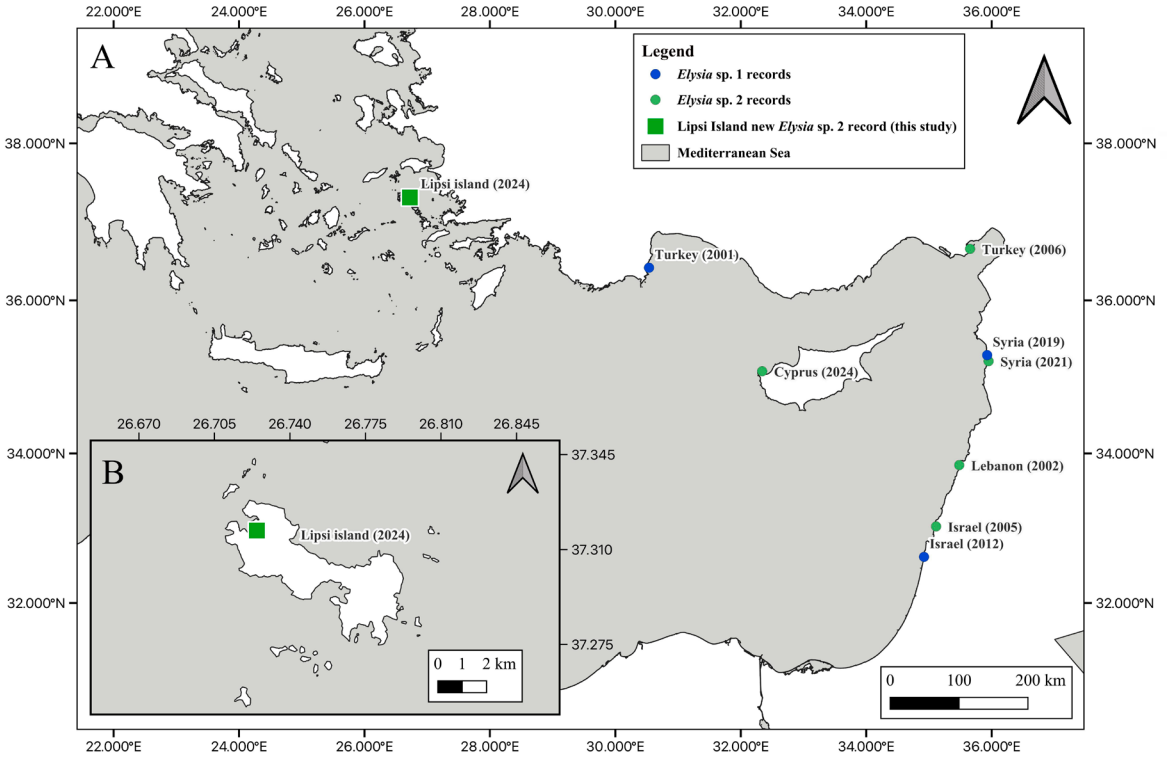

Fig. 3. Map showing the locations of the previous first records for Mediterranean countries for the *Elysia* cf. *marginata-grandifolia* species complex and the new *Elysia* sp. 2 record reported in this study, with the year of the first record at each location indicated **(A)**; inset of Lipsi Island, Greece, the location of the new *Elysia* sp. 2 record in the Aegean Sea, Vroulia Bay (**B**)**.**

DISCUSSION

The increasing trend of alien species in the Aegean

This expansion of *Elysia* sp. 2 into the Aegean follows the trend of an increased number of Lessepsian migrants observed in the area for other taxa (Katsanevakis *et al*., 2020; Zenetos *et al.,* 2024). Mollusca represents the most successful group of invaders in the Mediterranean, with 230 taxa identified out of more than 1000 alien species recorded until December 2021 (Zenetos *et al*., 2022a, b). Warming ocean temperatures have been strongly associated with the geographic expansion of alien marine species, particularly in the

Mediterranean (Raitsos *et al*., 2010). The Aegean Sea, increasingly affected by the tropicalisation of the Levantine Basin - the Mediterranean's warmest region (Pisano *et al*., 2020) - is experiencing more thermal stress events with sea surface temperatures (SST) rising by 0.048 ± 0.006 °C per year between 1981 and 2018 (Sisma-Ventura *et al*., 2014; Pisano *et al*., 2020). This increase in SST is making the typically cooler Aegean, compared to the Levantine, more suitable for tropical Lessepsian migrants already established in the Levantine basin (Zenetos *et al.,* 2024).

This report documents a westward expansion of the occurrence of *Elysia* sp. 2 illustrating the potential role that these environmental conditions may play in facilitating a rising number of alien species in the Aegean (Katsanevakis *et al*., 2020). Notably, the new record of *Elysia* sp. 2 at Lipsi Island, southeastern Aegean, reported in this study aligns with predictions by Pancucci-Papadopoulou *et al.* (2012) and Corsini-Foka *et al.* (2015) who identified the south-eastern Aegean and Dodecanese region as a hotspot for current and future invasions. The prevalence of alien species in the Aegean is not only due to the region's role as a natural corridor from the Levantine and Suez Canal, but also because its shallow and warm temperatures favour the presence of thermophilic alien species (Tsirintanis *et al*., 2023). Shallow-water invasive species are more prevalent as a result of the invasion vectors, the Suez Canal, shipping, and aquaculture which operate in shallow water facilitating their spread (Katsanevakis *et al*., 2014, 2016). Furthermore, the higher frequency of alien species observations in shallow areas may in part be a result of increased sampling efforts, both from targeted scientific surveys and citizen scientists, in shallower and more accessible coastal environments (Tsirintanis *et al*., 2023).

Invasion pathways

The Suez Canal has remained the primary introduction pathway for tropical species into the Mediterranean since its opening and acting as a direct route for Lessepsian migrants (Galil, 2006). The expansion of non-native *Elysia* spp. into Mediterranean waters reflects this pattern of invasion. However, the Suez Canal is not only a historical route but a persistent and continuous vector, consistently facilitating the introduction of new organisms that contribute to and sustain existing non-native populations in the Mediterranean. Although the recent doubling in size of the Suez Canal initially sparked fears of an even greater invasion of tropical species into the Mediterranean (Galil *et al*., 2015), this was not the case (Zenetos, 2017).

Given the significant geographic distance between the latest reported distributions of *Elysia* sp. 2 from Cyprus (Christidis *et al*., 2024) to this new report, its range expansion may result from either natural or human-mediated processes. The planktonic larval stage of *Elysia* species facilitates natural range expansion by enabling dispersal *via* currents (unaided introduction in the Aegean Sea). Larvae can be transported over significant distances, with the extent of dispersal influenced by larval duration and current patterns (Krug, 2009). Vendetti *et al.* (2012) highlighted that larval dispersal is a critical factor in the range dynamics of marine organisms, including *Elysia* spp. However, the potential for human mediated transfer, particularly *via* shipping cannot be overlooked. Worldwide, shipping is a significant pathway for alien introductions (Hewitt *et al*., 2004). In fact, analysis of pathways demonstrated that the Suez Canal is responsible for 46 % of all introductions into the Aegean Sea, either directly (4 %) or indirectly through the spread of Lessepsian species from the Levantine Sea (42 %), while transfer with vessels accounts for 45 % of introductions (Zenetos *et al.*, 2024). Furthermore, analysis of ballast water (Briski *et al*., 2012) and the frequent observations of higher numbers of alien species in or near harbours indicate shipping as a common and significant invasion pathway (Crocetta *et al*., 2017; Kalyvioti *et al*., 2024). Invasive species monitoring in ports offers an opportunity for the early identification of invasions. This is exemplified by Zenetos *et al*. (2020) who identified the Saronikos Gulf, near Piraeus port, as a major gateway of invasions. Notably, 20 % of Greece's initial invasive species observations were recorded in this region (Zenetos *et al*., 2020), highlighting its importance as a monitoring point. However, Lipsi Island is not located within major shipping routes and has a relatively small harbour, receiving primarily recreational craft so the invasion pathway into the Aegean remains uncertain. This gap in observations, exacerbated by the lack of targeted surveys, limits our abilities to identify vectors of alien species invasions in the area. A lack of reporting has been identified as an issue in previous studies on *Elysia* spp. records (Çevik *et al*., 2016; Christidis *et al*., 2024).

The first Mediterranean record of this species, in Lebanon (Crocetta *et al.,* 2013), occurred relatively far from the Suez Canal, the main introduction pathway for the Lessepsian species, given the range of *Elysia* sp. 2 in the Red Sea. The absence of data surrounding the species initial entry reduces our ability to monitor its range expansion and establishment and limits broader comparisons to other mollusc invasions. This gap reinforces the need for consistent and accurate reporting moving forward, where citizen scientists could play a critical role. In fact, numerous publications including Roy *et al.* (2018) and Kousteni *et al.* (2022), have highlighted citizen science as a valuable resource for tracking invasive species by expanding ecological monitoring efforts without requiring substantial financial and logistical support from research institutions. Notably, some of the initial records of the *E.* cf. *marginata-grandifolia* complex in the Levantine were documented by marine enthusiasts (e.g., Firer, 2005; Halevy, 2005). Thus, addressing this gap in reporting is crucial for developing more accurate predictions of future introduction pathways allowing for

more proactive methods of management and mitigation of alien invasions.

Ecological insights

Our findings of the specimen residing on a shallow rocky substrate largely correlate with previous observations of *Elysia* sp. 2 in the Mediterranean, confirming its substrate and depth preferences (Ammar *et al*., 2022; Yokes and Rudman, 2004; Çevik *et al*., 2016; Christidis *et al*., 2024). Previous observations consistently indicate that the *E*. cf. *marginata-grandifolia* complex is found on rocky or hard surfaces with macroalgal substrate as documented by reports from the Levantine region (Yokes and Rudman, 2004; Pasternak and Galil, 2012; Çevik *et al*., 2016; Ammar *et al*., 2022; Christidis *et al*., 2024). This pattern is further confirmed by records from citizen scientists submitted through the Sea Slug Forum (e.g., Kanzen, 2009; Halevy, 2005). This is concurrent with the known dependency of *Elysia* spp. on macroalgae as both a substrate and food source (Jensen, 2006). Records of *Elysia* spp., including our study, have been limited to summer months, except for the most recent observation in Cyprus (Christidis *et al*., 2024) where two individuals were observed in the winter period. The increased sightings in summer months may be a result of *Elysia* population alignment with seasonal abundances of algae or due to the increased activity of the thermophilic Lessepsian species. In fact, Laetz and Wägele (2018) highlighted how increased temperatures boost metabolic activity making *Elysia* species more active, and therefore easier to observe.

This report documents the shallowest recorded depth of *Elysia* sp. 2 at 0.2 m, extending the known depth range for the species. This finding is consistent with previous observations indicating a preference for shallow habitats, while *Elysia* sp. 1 appears to favour slightly deeper waters. The reasoning could be due to a multitude of factors. For instance, Pasternak and Galil (2012) observed copulatory aggregations of *Elysia* sp. 1 at shallow depths (2.5 m) during a similar time period, implying that reproductive activities could contribute to their presence in shallow waters. Additionally, the preference for shallower waters could reflect differences in algal species feeding preferences, although this remains difficult to ascertain from depth records alone. Observations of *E*. cf. *grandifolia* in new geographical ranges, at previously undocumented depths, and sightings on artificial structures (Christidis *et al*., 2024), could suggest that, although an obligate herbivore, they are more adaptable and generalist in habitat preference than previously described, such as by Jensen (2006).

Overall, there are significant gaps in our understanding of the genus *Elysia*, with limited knowledge regarding species-specific ecology and the environmental factors that limit their distribution (Jiménez *et al*., 2021). Publications seem to focus on basic descriptions of its habitat, diet, and exploration of its unique life traits such as kleptoplasty, poecilogony, and chemical derivatives which are explored for their significance in other scientific contexts (Vendetti *et al*., 2012). Although Jiménez *et al*. (2021) modelled ecological niches of *Elysia* species in the Atlantic, no comparable studies have been conducted in the Mediterranean to date. Similarly, Sanvicente *et al.* (2012) described the influence of habitat type and food availability for five *Elysia* species resident in Arrecife Alacranes National Park in Mexico. They found that the species *Elysia crispata* Mörch, 1863 and *Elysia velutinus* Pruvot-Fol, 1947 showed a more euryphagous diet consisting of numerous green algae species than previously thought (Jensen, 2006). These aspects remain unstudied for the Mediterranean alien *Elysia spp.* complex.

Research on the invasive gastropod *Conomurex persicus* (Swainson, 1821) may provide insights into potential ecological impacts, since, similarly to the *Elysia* cf. *marginata-grandifolia* species complex, it relies on macroalgae as a food source and habitat (Mutlu, 2004; Mutlu and Betil Ergev, 2006). Long-term observations by Mutlu and Betil Ergev (2006) indicated that *C. persicus* invasions negatively affect the abundance of the algae *Jania rubens* (Linnaeus) J.V.Lamouroux, 1816, a native species that supports a high biodiversity (Ravaglioli *et al*., 2021), although these results were observational and not based on quantitative studies. While the feeding strategy and radula morphology of individuals belonging to the *E.* cf. *marginata-grandifolia* complex differ from those of *C. persicus* (Jensen, 1994), the pressure and impact of a non-native species feeding on native algae should be studied. Targeted laboratory experiments assessing the alien species preference of Mediterranean algae could help reveal this.

CONCLUSIONS

This report outlines a potential range expansion of the alien sacoglossan *Elysia* sp. 2, contributing to the growing trend of evidence on the increasing number of Lessepsian migrants observed in the Aegean Sea. Currently, the paucity of observations and targeted research on this species and alien molluscs as a whole limits our ability to identify key invasion pathways and assess population establishment, preventing mitigation efforts. Furthermore, the absence of species-specific ecological data and a lack of understanding of the environmental conditions that limit the distribution of alien *Elysia* species in the Mediterranean Sea hinders the opportunity to forecast further range shifts and define the ecological niches of these species. This uncertainty hampers the prediction of their impacts on native ecosystems and communities. Continuous and targeted monitoring leading to a better understanding of their presence and abundance could enable the conservation of ecologically important native macroalgae, which support high biodiversity in the region. The report presented here highlights the importance of implementing monitoring

strategies for the early detection of the presence of alien species in the Aegean Sea, warranting further assessments to ascertain whether established populations of *Elysia* sp. 1 and *Elysia* sp. 2 are present in the area. Finally, this report serves as baseline data on the distribution of these invasive species to inform conservation and management priorities.

AUTHOR CONTRIBUTIONS

MCS and LM conceptualised the study, performed investigation, data curation, and visualisation, and wrote the manuscript. AZ and NY provided comments and insights that greatly improved an earlier version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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