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## First occurrence of *Actaeodes tomentosus* (H. Milne Edwards, 1834) (Brachyura: Xanthidae: Actaeinae) in the Mediterranean Sea

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### Abstract

The presence of the crab *Actaeodes tomentosus*, native to the Indo-Pacific Ocean and the Red Sea, is documented for the first time in the Mediterranean Sea, on the basis of two specimens collected from Rhodes Island (Aegean Sea), a marine area particularly vulnerable to warm-water alien invasions. Along with the recent report of *Xanthias lamarckii* in similar conditions and region, the finding of another non-indigenous xanthid poses many questions regarding their occurrence in the area. Apart from Lessepsian migration, other possible vectors of introduction are therefore examined.

**Keywords:** *Actaeodes tomentosus*, Xanthidae, bioinvasions, vectors of introduction, Mediterranean Sea, Rhodes Island, Greece.

### Introduction

Among the alien species dispersed in the Mediterranean Sea, decapod crustaceans are one of the most successful invasive groups, the tropical species of Red Sea and Indo-Pacific origin in particular, which mainly occur in the eastern part of the basin. Although most of these alien decapods entered through the man-made Suez Canal, ship-mediated introductions have been implicated (Galil, 2011; Brockerhoff & McLay, 2011).

This study presents the first record of the genus *Actaeodes* Dana, 1851 in the Mediterranean. The new alien crab was collected from the island of Rhodes, located in the south-eastern part of the Aegean Sea, a region particularly prone to biological invasions (Zenetos *et al.*, 2011; Pancucci-Papadopoulou *et al.*, 2012).

### Materials and Methods

During biological surveys on the shallow rocky habitat of Rhodes Island, two male *Actaeodes tomentosus* (H. Milne Edwards, 1834) were collected by hand at a depth of 2 m. The first crab (specimen A) was collected during daytime on 13 September 2013, at Kolimbia, 36.25444°N, 28.17028°E, seawater temperature 25.3°C, salinity 39.4. The second sample (specimen B) was collected during night time on 20 October 2014 in Lindos Bay, 36.09444°N, 28.09250°E, seawater temperature 22.8 °C, approximate salinity 39.3 (Fig. 1). The former was noted after a slight movement of small stones covered with algae, under which it remained strongly attached, hidden in a crevice, whereas

the latter was found anchored to the surface of a rock.

The specimens were identified following Serène (1984). The carapace width (CW) and carapace length (CL) of samples were measured to the nearest 0.05 mm using a Vernier calliper.

### Results

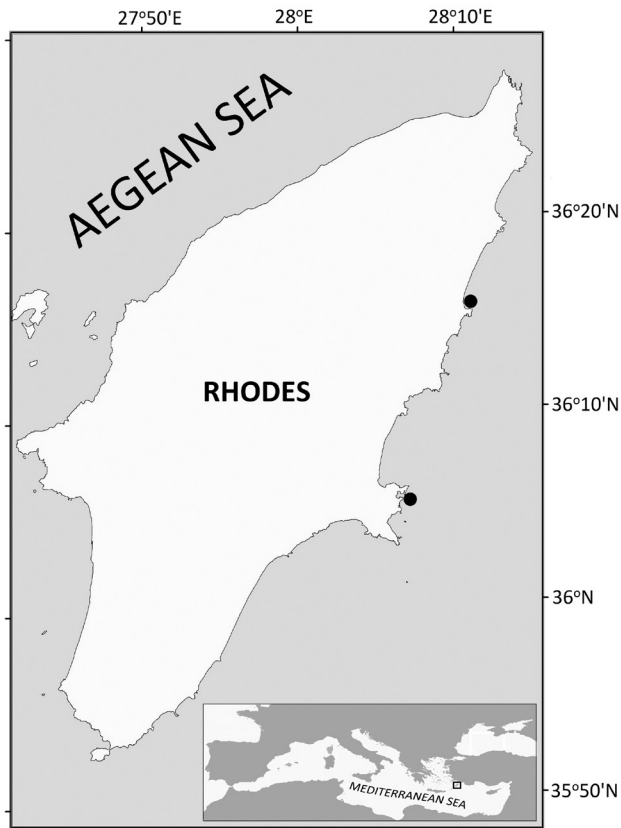
#### Measurements

Specimen A: CL 13.1 mm, CW 20.2 mm, specimen B: CL 16.0 mm, CW 25.2 mm. The ratios between CW and CL obtained for the two specimens (1.54 and 1.58 for specimen A and B respectively) are close to the value (1.55) reported for the species by Serène (1984).

Specimen A was maintained for a long period in a 5 L reservoir at 23-24°C, salinity 37, where it was observed with difficulty, because it assumed a coloration similar to the substrate and hid under rocks or algae or in the sand. Although artificial fish food in flakes was administered regularly, the crab was observed to manipulate the existing hair algae present in the container, probably to feed on them. Specimen A was preserved in ethanol 70% at the Hydrobiological Station of Rhodes collection (Catalogue number HSR110). At present, Specimen B, is maintained in the aquarium in similar conditions as above, and displays the characteristic behaviour previously described.

#### Diagnosis

The greater part of the description given here follows Serène (1984). Front bilobed, not extending beyond the



**Fig. 1:** Location of the records of *Actaeodes tomentosus* in Rhodes Island (eastern Mediterranean).

supra-orbital angles (Fig. 2A). Carapace longitudinally oval, divided into numerous areolas separated by narrow furrows (Fig. 2B). Area 2M divided longitudinally into 2 parts; the external branch is entire. Each areola covered with tubercles. Carapace entirely covered by a fine, close-cropped, velvet felt only leaving exposed the apices of the granules. Less dense velvet also covers a great part of the sternum and, in general, the ventral face of the crab (Fig. 2C). Antero-lateral margins of the carapace convex, granular and divided into four rounded not prominent teeth included in the general convexity. Postero-lateral margins strongly concave, forming a deep cavity to accommodate the last three pairs of ambulatory legs. Setae along the antero-lateral and postero-lateral margins of the carapace and along the upper and lower margins of ambulatory legs. Chelipeds and ambulatory legs granular. Chelipeds massive, subequal and similar, with relatively thick, short and dentate fingers, rounded at the extremities and slightly spooned with setae on their internal upper margin. Merus and propodus of walking legs are posteriorly doubly crested, in order to accommodate in closed position (Fig. 2C).

#### Coloration in life

Coloration variable. Dorsal surface of the carapace dark grey or brown, but tubercles of the central areolas prevalently whitish, forming two bands anteriorly, eyes

red (Fig. 2A, B). Chelipeds and ambulatory legs similarly dark grey or brown patterned on their outer face. Series of dark granules on the outer face of both movable and fixed dactyls, approaching their distal extremity (Fig. 2C). Dactyls brown or black, teeth whitish. The black or dark brown pigmentation on the fixed finger reaches approximately the middle of the lower margin of the palm (Fig. 2D).

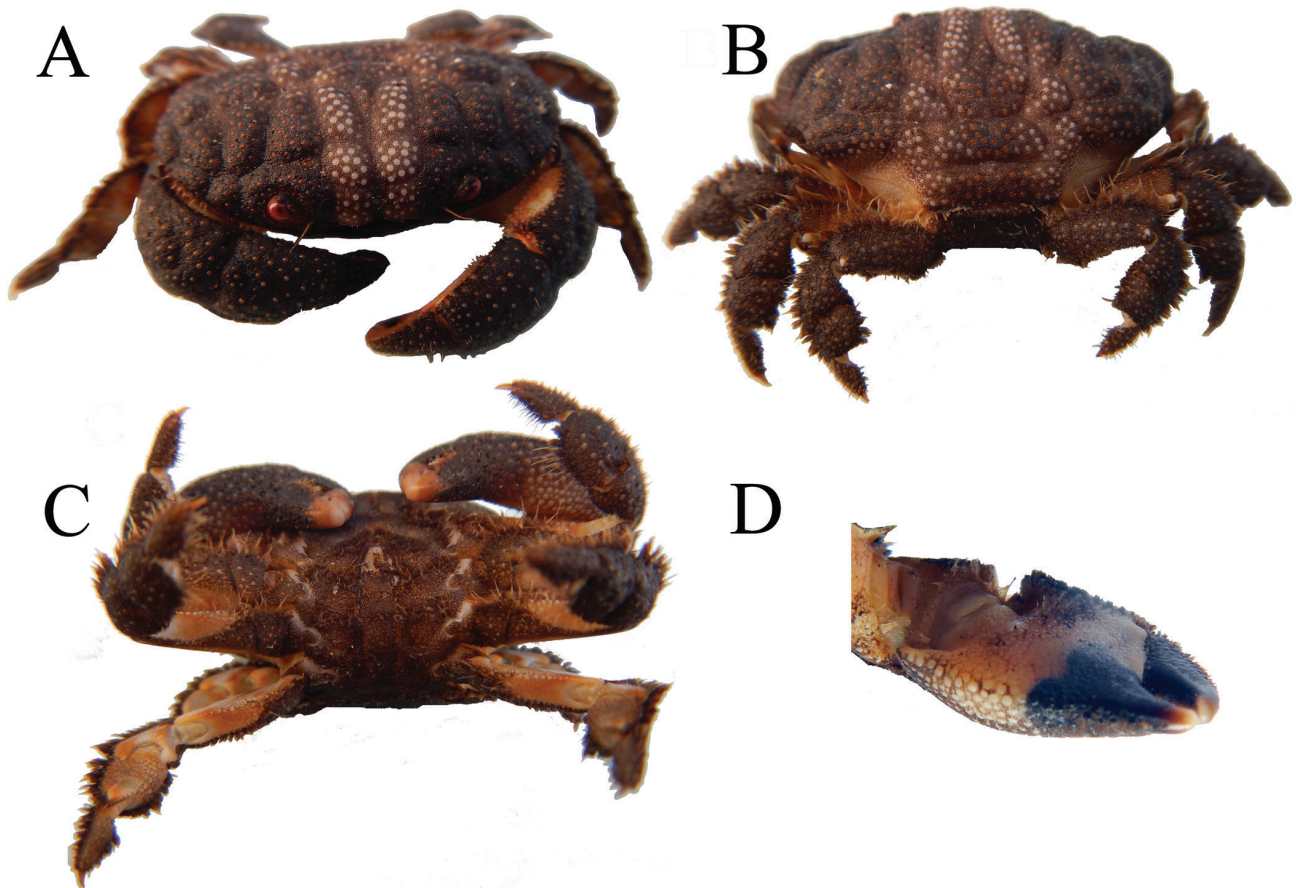
#### Discussion

Until recently, alien xanthids in the Mediterranean were only represented by *Atergatis roseus* (Rüppell, 1830), a species of Indo-Pacific/Red Sea origin. This species has steadily colonized the Levantine and south-eastern Aegean waters, since its first appearance off the the Mediterranean coasts of Israel, in the 60s (Karhan *et al.*, 2013). A second alien xanthid, *Actaea savignii* (H. Milne Edwards, 1834), discovered for the first time in the shallow waters of the Mediterranean coasts of Israel, Haifa Bay (2010), and Turkey, Mersin (2011), is considered already established (Karhan *et al.*, 2013). This species is distributed throughout the Indo-West Pacific and known from the Suez Canal and its lakes. Alien xanthid species increased to three, with the collection of *Xanthias lamarckii* (H. Milne Edwards, 1834) in 2013 from Rhodes Island, south-eastern Aegean Sea, Greece (Corsini-Foka *et al.*, 2013). Although *X. lamarckii* is widely distributed in the shallow waters of the Indo-West Pacific, it has not been recorded from the Red Sea and the Suez Canal.

As for the above species, the present record adds a new genus, *Actaeodes* Dana, 1851 to the xanthids occurring in Mediterranean waters.

According to Serène (1984), *A. tomentosus* is the most common species on intertidal coral reefs. It is widely distributed throughout the Indo-Pacific region, from the Red Sea, Aden, Somalia, Kenya, Tanzania, Mozambique and S. Africa to the Western Indian Ocean islands up to Australia, Japan and Hawaii Islands (Serène, 1984; Galil & Vannini, 1990; Davie, 2013). Its presence in the Suez Canal has not been documented up to date. The first zoeas of the species have been described by Clark & Al-Aidaros (1996) from females collected off the Red Sea coast of Saudi Arabia. Similarly to other co-familial species, this crab feeds prevalently on algae in tropical aquarium tanks (Reeflex, 2013; Reef Central online Community, 2013).

This first Mediterranean record of *A. tomentosus* is reported here from two well-developed tourist resorts on the east coast of Rhodes comprising a high concentration of hotels and tourism facilities, while *X. lamarckii* was reported from an unpopulated islet to the west of the island (Corsini-Foka *et al.*, 2013). However, in contrast to the single finding of *X. lamarckii*, the two subsequent captures of *A. tomentosus* could be an indication of the existence of a small population, locally. Alternatively, both species were found around Rhodes, a marine area of the eastern Mediterranean characterized by an environ-



**Fig. 2:** The male *Actaeodes tomentosus* (H. Milne Edwards, 1834) in life (specimen B in the text), carapace width 25.2 mm, carapace length 16.0 mm (A: frontal view, B: dorsal view, C: ventral view, D: detail, frontal view of the left chela).

ment that is particularly suitable for the establishment of warm-water alien species (Pancucci-Papadopoulou *et al.*, 2012), a large number of which, collected from the wild, acquired or are acquiring the character of “ornamentals” in the exhibits of the marine Mediterranean public Aquarium of the Hydrobiological Station of Rhodes (Corsini-Foka *et al.*, 2014). Moreover, the above two small-sized xanthid species were collected in shallow water rocky habitats. Both are frequently unexpected inhabitants of live rocks shipped for tropical aquaria (Reef Central online Community, 2013); hence the common name “hitch hikers”, often unknown to hobbyists and sometimes considered as “not reef safe” (Reef Aquarium Forum, 2013).

In its native range, *A. tomentosus* is listed among the toxic coral reef crabs, like many other xanthids worldwide (Deshpande, 2002; Sylvester Fredrick *et al.*, 2011). Tetrodotoxin (TTX), the same neurotoxin present in Tetraodontiformes fish (pufferfish, porcupinefish, ocean sunfish, triggerfish) has been identified in *A. tomentosus* specimens from Taiwan (Ho *et al.*, 2006), while Saxitoxin and related compounds (STXs) in specimens from Japan (Deeds *et al.*, 2008 and references therein). The toxin production processes in crabs are not completely understood.

Up to 2012, all alien brachyurans previously reported from the area under study have entered via the Suez Canal

and are considered Lessepsian migrants (Corsini-Foka & Pancucci-Papadopoulou, 2012). At present, the pathway of the introduction of *A. tomentosus* and *X. lamarckii* in the marine area of Rhodes is also a matter of speculation (Corsini-Foka *et al.*, 2013). Both these alien crab species may have entered via the Suez Canal through Lessepsian migration and occur at other sites along the Levantine coasts, as already shown for *A. savignii* (Karhan *et al.*, 2013). They still remain undetected due to their small size, prevalently nocturnal activity, their tendency to penetrate crevices, and also their coloration that adapts to the surrounding environment (Bedini, 2002). All these factors could contribute to elude their observation.

Another explanation with regards to a possible vector is shipping. Coastal maritime traffic has increased in the last decades. The arrivals of Greek or foreign dry cargo ships, tankers and passenger ships at the port of Rhodes, regardless of their origin have steadily quadrupled from approximately 1800 thousand Net Registered Tons (NRT) at the end of the 70s to 8000 NRT in 2006, although constituting only 1.0-2.2 % of total NRT registered in Greek ports (National Statistic Service of Greece).

Rhodes is one of the main Mediterranean tourism destinations and is located along the itineraries of many cruises performed in the basin. The gross tonnage of

cruise ships can exceed 100.000 tons, while their length can be more than 300 m. The number of cruise ship arrivals at the main port ranged between 539 and 458 in 2010 and 2012 respectively, while the number of yacht arrivals at Mandraki marina, Rhodes, was 1115 and 1309 respectively in the same years (Central Port Authority of Rhodes). The Straits of Rhodes and Karpathos, at the North and South of the island are on the route of intense maritime traffic, mainly cargo ships and tankers, many in transit from/to the southern and eastern Levant.

Taking into account this maritime activity and the absence of knowledge on distribution records in the Levant and eventual establishment of the crab described here, shipping (hull fouling and/or ballast waters) could be considered as a possible vector of introduction of *A. tomentosus* in the marine area of Rhodes. This type of vector has been recently hypothesized for other Indo-Pacific/Red Sea brachyurans introduced into the basin, such as *Eurycarcinus integrifrons* De Man, 1879 in Iskenderun Bay, Turkey (Özcan *et al.*, 2010) and *Elamena mathoei* (Desmarest, 1823) in Tunisian waters (Zaouali *et al.*, 2013).

The trade in ornamental tropical marine species relies heavily on the export and import of introduced species worldwide (Katsanevakis *et al.*, 2013). In Greece, a recent overview of aquarium fish in large stores revealed that this trade is mainly targeted to freshwater tropical fish (Papavlasopoulou *et al.*, 2014). On the other hand, little is known about the trade in marine ornamental algae, invertebrates and live rocks. The conclusions of Papavlasopoulou *et al.* (2014) concerning the aquarium fish sector in Greece are alarming; it is “practically uncontrolled given the presence of threatened species, species potentially harmful to humans and species capable of establishing non-indigenous populations, if released into the wild”. At the local level of Rhodes Island, only two pet shops were found to be involved in aquaria with their trade being connected to large stores on mainland Greece. Both shops keep freshwater fish mainly and a few marine tropical fish species. One shop, however, has live tropical rocks and corals available. Tropical marine species and live rocks for home aquaria can be purchased from other suppliers all over the world, and through the web, and are shipped by plane or boat. A survey conducted at local level showed that private (home, hotels, shops, restaurants, cafeterias) marine tropical aquaria are scarce. As expressed by Papavlasopoulou *et al.* (2014), they require a particular level of care, more expensive basic and auxiliary equipment compared to freshwater aquaria. Although it appears a far eventuality, the probability of collecting a sample of a tropical species such as the crabs under study, after escape from aquarium trade or accidental release or discard from marine tropical aquaria, does exist, even if, in our opinion, it presupposes that a small population of the species is already established in the wider area.

Among the 18 Indo-Pacific/Red Sea alien decapods

recorded to date in the area under study, brachyurans show an apparent higher propensity to enter the coastal waters of the island (14 species), compared to the remaining alien decapods (4 species of Dendrobranchiata). Although this result is probably dependent on the method used for the biological surveys and sampling, alien brachyurans of Indo-Pacific/Red Sea origin constitute 22 % of the total locally listed crab species, a percentage very close to that of the alien brachyurans listed from the Mediterranean coasts of Israel and Turkey (Galil & Shlagman, 2010; Corsini-Foka & Pancucci-Papadopoulou, 2012 and references therein; Corsini-Foka *et al.*, 2013).

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