

Rapid Communication**An expansion of the invasive species *Amphibalanus subalbidus* (Henry, 1973) in the south of Iraq**

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OPEN ACCESS**Abstract**

Aquatic ecosystems are under threat from nonindigenous species invasion. Fouling organisms on ship hulls are constantly in transit, posing a threat to recipient communities by reducing biodiversity and causing severe economic and public health impact. In the south of Iraq, a range expansion for the nonindigenous barnacle *Amphibalanus subalbidus* was recorded. On a West Asian scale, Shatt Al-Arab could be a hotspot for biological invasions in Iraq, since this river connects the Persian Gulf to inland waterbodies. *Amphibalanus subalbidus* could establish settlements in a variety of habitats due to its highly oligohaline distribution, which can withstand prolonged exposure to fresh water. Thus, a morphological consideration and their related distribution in the south of Iraq are discussed for this invasive species.

Key words: nonindigenous species, fouling organisms, Shatt Al-Arab, Euphrates, southern Iraqi marshes

Introduction

Biological invasions have far-reaching consequences for native biotic communities. Competition, predation, parasitism, trophic web modifications, and habitat modification are all examples of how invasive non-indigenous species can disrupt local communities (Vitousek 1990; Williamson 1996; Simberloff et al. 2013).

Because of the increase in international trade during the 20th century, rates of introduction have risen dramatically. The vast trade in living organisms and the unintended transit of many organisms in or on cargo ships and other modes of transportation, as well as the development of canals connecting formerly separate biogeographic regions, have all contributed to the breakdown of biogeographic boundaries (Williams et al. 2013; Seebens et al. 2018).

The Tigris, Euphrates, and Karun rivers flowed directly into the Persian Gulf in the recent geologic past. There is currently a channel of the Shatt

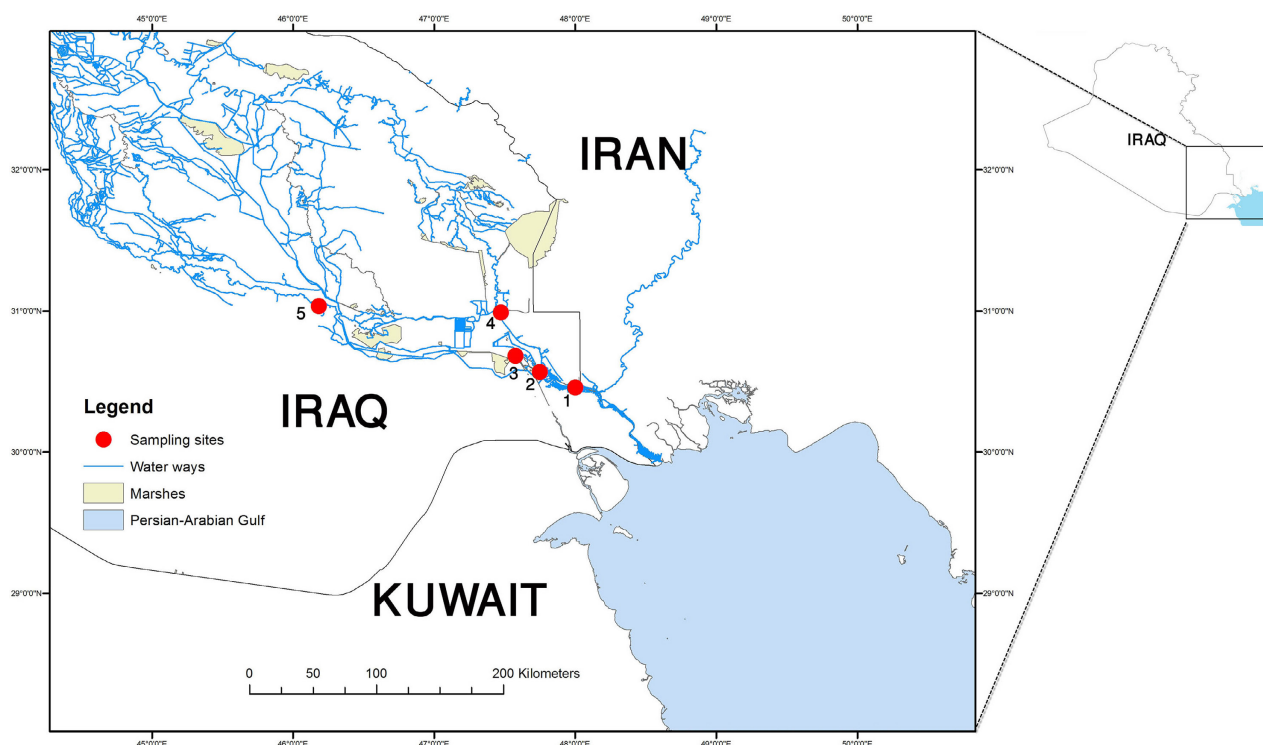


Figure 1. Distribution of *Amphibalanus subalbidus* in the south of Iraq, the sites are: 1) Abu Al-Khasib, 2) Garmmat Ali, 3) Al-Hammar marsh, 4) Upper part of Shatt Al-Arab River and 5) Euphrates River.

Al-Arab between the Tigris and Euphrates and the Persian Gulf, surrounded by enormous lakes and marshes (Isaev and Mikhailova 2009; Naser et al. 2011). The Shatt Al-Arab River is a possible hotspot for biological invasions on a West Asian scale because it serves as a connecting channel between the Persian Gulf and the Iraqi inland waters (Naser et al. 2011). This channel has an important role in the distribution and spread of invasive species to different regions in Iraq, due to the presence of vessels for the unloading and shipping of crude oil and the commercial exchange operations that take place in the northwest of the Persian Gulf. Many introduced species have been recorded and listed as potential invasive species that have arrived via the Shatt al-Arab River (Naser and Son 2009; Naser et al. 2011, 2012, 2015).

Amphibalanus subalbidus (Henry, 1973) is found in the Western Atlantic and Gulf of Mexico, where it lives in oligo-mesohaline estuaries and on a variety of intertidal substrata (Henry and McLaughlin 1975; Dineen and Hines 1994). This species has also been previously recorded from Shatt Al-Arab (Arvandroud) (Shahdadi et al. 2014).

Materials and methods

Samples of *Amphibalanus subalbidus* were collected from the banks of five different parts of Shatt Al-Arab (Figure 1; Table 1) from February to May 2021. The specimens were cleaned and preserved in 70% ethanol. The specimens of *Amphibalanus* collected in the present study were identified using Shahdadi et al. 2014.

Table 1. Markers, names, and salinities of sampling locations.

Marker	Location	Latitude	Longitude	Salinity (ppt)	Sampling date
1	Abu Al-Khasib	30.57	47.75	2.2	21-02-2021
2	Garmat Ali	30.458	48.001	2	23-02-2021
3	Al-Hammar Marsh	30.683	47.577	1.4	03-05-2021
4	Upper part of Shatt Al-Arab River	30.99	47.474	1.4	12-05-2021
5	Euphrates River	31.036	46.183	0.8	18-05-2021


Figure 2. *Amphibalanus subalbidus* 12 mm height, collected from Abu Al-Khasib site 1. Photograph by Dr. Murtada D. Naser.

Results

Phylum: Arthropoda
 Subphylum: Crustacea
 Class: Maxillopoda
 Subclass: Cirripedia
 Order: Thoracica
 Family: Balanidae

Amphibalanus subalbidus (Henry, 1973) (Figure 2)

Description: *A. subalbidus* is a small barnacles with a conical to nearly cylindrical shell that grows to approximately 12 mm height (Figure 2). Color is whitish with hyaline longitudinal lines. The epicuticle is thick, typically permanent, but it can also be simply superficial. Scutal growth lines are usually crenulate and have delicate longitudinal striae. The orifice is toothed or has a small tooth.

Habitat: Common in intertidal fouling communities and adhered to hard surfaces, including rocks (Figure 3), pier pilings, ship hulls, molluscs shells, and aquatic plants.



Figure 3. Habitat of *Amphibalanus subalbidus* attached to the stones from Garmmat Ali site 2 of the Shatt Al-Arab River. Photograph by Dr. Murtada D. Naser.

Distribution: The species' native range is the Western Atlantic Ocean and the Gulf of Mexico (Henry and McLaughlin 1975). It is introduced to Iran (Shahdadi et al. 2014), and the present study has found it in Iraq as an introduced species.

Discussion

Marine traffic in the Persian Gulf is quite high because of the oil industry, with an estimated 25,000 tankers delivering crude oil across the Strait of Hormuz annually (Haapkylai et al. 2007; Shahdadi et al. 2014). The northern region of the Gulf has the most oil facilities and ports. Barnacles have been found to bypass biological barriers as hull fouling or in ballast water (Yamaguchi et al. 2009; Tottrup et al. 2010). As a result of the high volume of ship activity, the area is prone to the introduction of foreign invasive marine species (Naser et al. 2012).

For the first time, Shahdadi et al. (2014) recorded the nonindigenous species *A. subalbidus* along the banks of the Arvandroud River (also known as Shatt Al-Arab) (salinity 17.8 ppt), the Karoon River (1.6 ppt), the Bahmanshir River, and the Zohre River in the northern Persian Gulf, on a variety of living and inanimate substrates. Shahdadi et al. (2014) speculated that *A. subalbidus* species is most likely established in the lower catchments of the Euphrates and Tigris basin.

Unlike the euryhaline nonindigenous species *Amphibalanus improvisus* (Darwin, 1854) that can be found from the littoral to the shallow subtidal in mesohaline sections of estuaries all over the world, and which can endure brackish to totally marine conditions (Naser et al. 2015), *A. subalbidus* has an oligohaline distribution and can withstand prolonged exposure to fresh water. The species thrives at salinities ranging from 0.5 to 10 ppt, with

sporadic occurrences up to 18 ppt, but has never been observed at greater salinities (Poirrier and Partridge 1979; Kennedy and DiCosimo 1983; Dineen and Hines 1994). *Amphibalanus subalbidus* was collected from salinities ranging from 2.2 ppt at Abu Al-Khasib on the Shatt Al-Arab River to Al-Hammar marsh at 1.4 ppt and 0.8 ppt from Euphrates River in the south of Iraq, and could become established at any of these salinities. This is supported by the studies that indicated that the species could establish populations even in freshwater, since it can tolerate low salinity and can withstand prolonged exposure to fresh water (Dineen and Hines 1994).

Many euryhaline or oligohaline species of marine origin such as *A. subalbidus* began to increasingly be found in big rivers as a result of reduced water flow and climatic changes. Specific to Iraq, freshwater flow from the headwaters in Turkey has been reduced due to the construction of multiple dams and barrages on the Tigris-Euphrates basins in recent decades, causing the water levels in the Tigris and Euphrates to drop to dangerously low levels (Adamo et al. 2018; Kibaroglu 2019). The reduced freshwater flow has caused the water of the Shatt Al-Arab River to become brackish, which allows for the survival of nonindigenous species in the Shatt Al-Arab River and for their ranges to expand to inland water bodies such as *Amphibalanus amphitrite* (Naser et al. 2011) and *Eriocheir hepueensis* (Naser et al. 2012), etc. Furthermore, climate change has exacerbated environmental issues in recent decades in Iraq, wreaking havoc on the Tigris and Euphrates Rivers and creating vulnerable ecosystems (USAID 2017). There has been a reduction of water volume owing to decreased annual rainfall (Issa et al. 2014), which has resulted in rising water temperatures (by 1–2 °C) and rising salinity levels (Rahi and Halihan 2010; Issa et al. 2014; Abdullah et al. 2016; Rahi 2018). If these trends continue, we expect that *A. subalbidus* will continue to spread through the Shatt Al-Arab and Euphrates Rivers.

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Authors contribution

MDN, RM, MY, MSH and RA: sample collection. AGh: managed the survey planning and design, contributed to the methodology. AGhY and MDN: analysis and preliminary identification of the specimen and wrote the original draft manuscript.

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