BioInvasions Records (2023) Volume 12, Issue 1: 265–271

Rapid Communication

First record of the invasive non-native Asian date mussel *Arcuatula senhousia* (Benson 1842) (Mollusca: Bivalvia: Mytilidae) from Shatt Al-Basrah Canal, Basrah, Iraq

Amaal Gh. Yasser[1,2], Murtada D. Naser[1,2,*], Ibtisam M. Abdul-sahib[1], Mikhail O. Son[3] and P. Graham Oliver[4]

[1]*Marine Science Centre, University of Basrah, Basrah, Iraq*
[2]*School of Environment and Science, Griffith University, 170 Kessels Road, Nathan, Queensland, 4111, Australia*
[3]*Institute of Marine Biology, National Academy of Sciences of Ukraine, Pushkinskaya st., 37, Odessa, 65048, Ukraine*
[4]*National Museum of Wales, Cardiff, United Kingdom*

**Corresponding author*
E-mail: *murtada.naser@uobasrah.edu.iq*

Citation: Yasser AG, Naser MD, Abdul-sahib IM, Son MO, Oliver PG (2023) First record of the invasive non-native Asian date mussel *Arcuatula senhousia* (Benson 1842) (Mollusca: Bivalvia: Mytilidae) from Shatt Al-Basrah Canal, Basrah, Iraq. *BioInvasions Records* 12(1): 265–271, https://doi.org/10.3391/bir.2023.12.1.22

Received: 4 May 2022
Accepted: 23 September 2022
Published: 21 November 2022

Handling editor: Tammy Robinson
Thematic editor: Amy Fowler

Abstract

The invasive Asian date mussel *Arcuatula senhousia* has now been recorded from the Shatt Al-Basrah Canal in the south of Iraq. High densities of up to 102 ind.m^{-2} were found on rocky substrates in the intertidal zone during March 2020. The species was confirmed based on morphological characters of the shell. We hypothesize that the initial introduction was associated with shipping, with secondary dispersion into the Shatt Al-Basrah canal. It is possible that the species could extend its distribution into the Shatt Al-Arab and northern Arabian Gulf naturally or by additional anthropogenic means.

Key words: bivalve, mytilid, Middle East, Persian-Arabian Gulf, aquatic invasions, pathways

Introduction

The Asian date mussel *Arcuatula senhousia* (Benson, 1842) is a small mytilid bivalve with a maximum shell length of 34 mm and a fast growth rate, which allows it to reach 20–25 mm after the first year of life (Crooks 1996; Bachelet et al. 2009). The native range of *A. senhousia* extends from southern Siberia (Kuril Islands) to Singapore (Chuang 1961). It has been introduced into numerous locations around the world over many decades, including New Zealand and Australia (Willan 1985, 1987), the United States (Crooks 1996; Wasson et al. 2001), India (Kutty et al. 2016), West Africa (Lourenço et al. 2018) and Europe including the Mediterranean Sea (Mistri et al. 2004; Bachelet et al. 2009; Barfield et al. 2018; Zhulidov et al. 2021; Massé et al. 2022). *Arcuatula senhousia* is an opportunistic suspension feeder capable of establishing enormous population densities, which can alter sediment structures, habitat, communities, and transform other aspects of ecosystem functioning (Crooks 1996). In cases where the densities of *A. senhousia* are very large this bivalve creates dense mats or clusters over

Figure 1. Sites along the Shatt Al-Basrah Canal from which the Asian date mussel *Arcuatula senhousia* (Benson, 1842) was recorded: s1 – site 1 (30.440493°; 47.761301° and s2 – site 2 (30.484962°; 47.740514°).

the substrate effectively cutting off the food supply and oxygen to any infaunal bivalves (Crooks 1996; Mistri et al. 2004; Hayward et al. 2008).

The present study records, for the first time, *A. senhousia* in the Shatt Al-Basrah Canal of Iraq, ~ 90 kilometres upstream from the coast of the Persian-Arabian Gulf. Dredging of the Shatt Al-Basrah Canal began in March 1970, and it was officially inaugurated in March 1983 (Naser et al. 2010). The Shatt Al-Basrah Canal originates from the Euphrates River and flows into Khor Al-Zubair, an estuarine lagoon connected to the Persian-Arabian Gulf (Figure 1). The canal itself measures 37 kilometers in length and 59 meters in width, with a depth range of 5 to 7 meters. The Shatt Al-Basrah Canal's salt water intrusion is mostly determined by the tidal range, the level of water in the Euphrates River, and the amount of water released by a water regulator located 22 kilometers from the canal's entrance. Extended

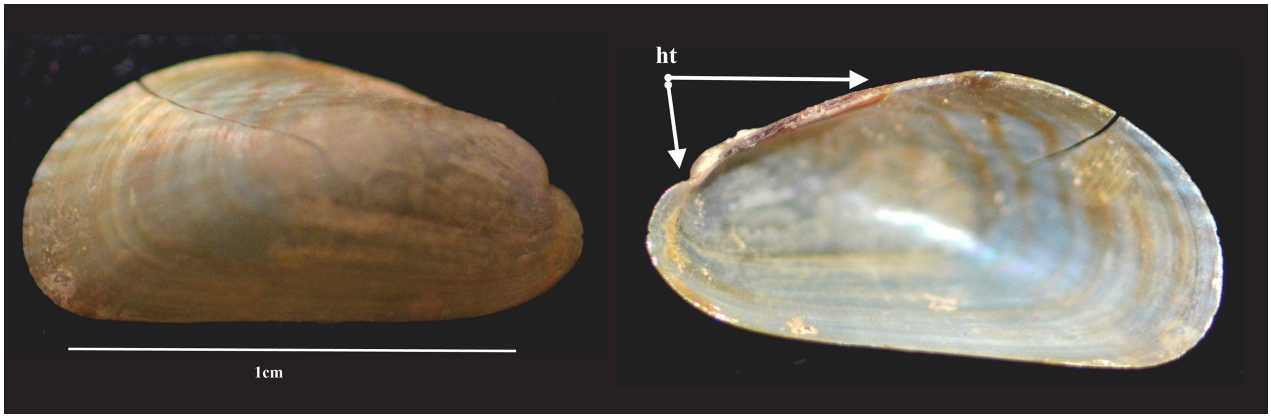

Figure 2. External and internal views of *Arcuatula senhousia* (18 mm shell length) collected from the Shatt Al-Basrah Canal in March 2020. Photographs by Dr. Murtada D. Naser.

floods in the Euphrates River frequently dilute the canal's brackish water (Naser et al. 2010). The salinities in this canal ranged from 16 ppt to 25 ppt, while the temperature ranged from 14 °C to 26 °C over a year.

Materials and methods

Samples of *Arcuatula senhousia* were collected during March 2020 from the banks of Shatt Al-Basrah Canal at two sites (Site 1, 30.440493°; 47.761301° and Site 2, 30.484962°; 47.740514°), both of which are included in long-term monitoring studies (Figure 1).

The specimens, which were attached to hard substratum at a depth of 0 to 2.5 meters, were scraped by a benthic frame sampler with a 25 × 25 cm area. Additionally, specimens inside the frame area were scraped off by hand. To determine population density, three replicate samples were collected at each site. The specimens were deposited in the Biological Invasion Lab, Marine Science Centre, University of Basrah, Basrah, Iraq.

Specimens of *A. senhousia* (Figure 2) were identified from descriptions of the characteristic features of the shell, including the following: brown to greenish periostracum with radiating reddish lines on the posterior half, small internal teeth on the dorsal edge posterior to the ligament, and a frail shell with a series of short ribs anterior to the umbones (Slack-Smith and Brearley 1987; Hoenselaar and Hoenselaar 1989; Faasse 2018).

Results

A total of 860 specimens of *A. senhousia* were collected from the two sites in March 2020. The specimens were attached by byssal threads to both stones and the druses of the introduced barnacle *Amphibalanus amphitrite* (Darwin, 1854). Population densities across three replicate samples were higher at Site 1 (mean 102.0 ± 20.5 SD) than at Site 2 (78.6 ± 6.1). The composition of substrates differed slightly between the two sites. Site 1 was composed of stony and sandy sediment with reed beds of *Phragmites australis* (Cav.) Trin. ex Steud. Site 2 was characterized by a mix of stone

and mud sediment. *Arcuatula senhousia* were absent from nearby samples that contained either only soft substrates or reed beds. The salinities (24.8 ppt and 23.9 ppt, respectively) and water temperatures (17 °C and 17.4 °C, respectively) were similar at the two sites.

Discussion

The Shatt Al-Arab River sub-basin is an important component in the invasion network of the region because it connects the major waterways of the Euphrates, Tigris, and Karun Rivers to the marine ecosystem of the Persian-Arabian Gulf (Naser et al. 2011). The Shatt Al-Basrah Canal is an artificial corridor connecting the Euphrates River (and the adjacent Al-Hammar marshes) to the estuarine lagoon Khor Al-Zubair, an arm of the Persian-Arabian Gulf. The region as a whole includes transitional waters of various types and conditions (tidal estuaries, lagoon complexes, marshes, etc). In addition to natural estuarine conditions, the salinity in the river channels can be increased through anthropogenic transformation, namely the "water wars" – large-scale hydraulic engineering to keep water resources within the boundaries of their states affecting the volume of freshwater runoff (Naser et al. 2010). Basra, the largest seaport in the Persian-Arabian Gulf, sits on the Shatt al-Arab and is an important vector for introduced brackish-water alien species in the Middle East (Panov et al. 2010; Naser et al. 2011). Previous assessments of the Shatt Al-Arab Canal have found high levels of biological pollution, biocontamination, and the presence of high-risk invasive species including *Amphibalanus amphitirite* and *Eriocheir hepuensis* (Dai, 1991) (Naser et al. 2011, 2012).

This study is the first to report *Arcuatula senhousia* from the Shatt Al-Arab sub-basin. While this species has been noted from the south-eastern Arabian/Persian Gulf (Dance et al. 1995) and from Kuwait (Behbehani and Gareeb 2002; Al-Yamani et al. 2012), it has never been reported in the densities found in this study or typically seen elsewhere. As *A. senhousia* is not used in aquaculture, live food or for bait these are unlikely sources of the introduction. It is far more likely that shipping is the vector for this species (Bailey et al. 2020). According to the Convention on Biological Diversity (CBD) classification, possible ways *A. senhousia* could have been introduced via shipping include "Hitchhikers on ship/boat (excluding ballast water and hull fouling)", "Ship/boat hull fouling" and "Ship/boat ballast water" (Harrower et al. 2017).

Theoretically, *A. senhousia* could use all three "shipping" pathways to arrive in a new destination, but in practice it is likely that the species has arrived via ballast water. Shipping is a dominant route for the Persian-Arabian Gulf and surrounding open seawaters, due, in particular, to intensive oil exports, requiring the intake of large volumes of ballast water by tankers returning to the exporting port (Clarke et al. 2020). The Gulf ports link with all major regions of the world where *A. senhousia* is ether native or

introduced, making this pathway most probable. However, the discharge of waters contaminated with petroleum products and machine oil directly into the sea in the Persian-Arabian Gulf is restricted under the MARPOL (International Convention for the Prevention of Pollution from Ships) protocol, strengthened by the Riyadh MoU of 2005. In addition, ships undergo special scrutiny in the Strait of Hormuz area (Mantoju 2021). Thus, ballast water is either discharged ashore or in the open parts of the Arabian Sea, outside the Persian-Arabian Gulf, which, given their small volumes, fundamentally reduces the risk of invasion.

Arcuatula senhousia can attach to all manner of substrates via fine byssus threads, although it has most frequently been recorded from soft, mixed sediments (Crooks 1996; Mistri et al. 2004; Magni et al. 2006; Despalatović et al. 2013; Watson et al. 2021; Zhulidov et al. 2021). Because *A. senhousia* usually colonizes soft substrates, it is unlikely that ship or boat hull fouling would be the vector in this case (Crooks 1996; Hosozawa et al. 2020). However, in this study and elsewhere (Faasse 2018), individuals have been observed attached to hard substrates. Thus, the ability to attach to ships hulls cannot be excluded. Populations of *A. senhousia* have shown an unusually wide level of salinity tolerance from oligohaline (e.g. 5–10 ppt) to fully marine (Bachelet et al. 2009; Yamamuro et al. 2010; Kovalev et al. 2017; Massé et al. 2022). This broad salinity tolerance range could indicate that the species would be able to cross all ranges of seawater salinity on possible shipping routes. Thus, the two pathways associated with shipping (ballast water and hull fouling) probably explain the primary invasion of *Arcuatula senhousia* into the region. Secondary dispersion in the region could use two pathways. Firstly, the artificial Shatt Al-Basrah Canal could function as a corridor between different natural habitats (pathway "Interconnected waterways/basins/seas" in the "Spread corridor" category). Secondly, there could be dispersal of the species by natural means ("Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5" in the CBD classification). Secondly, *Arcuatula senhousia* females can release more than 100,000 eggs, preceding an extended larval planktonic stage that lasts two to eight weeks (Watson et al. 2001). As a result, this could potentially lead to the expansion of this species both in the ecosystems of the river channel (which as a result of anthropogenic hydrological transformation has increased in salinity) and in the adjacent areas of the Persian-Arabian Gulf through larval dispersal.

Acknowledgements

We would like to thank the two anonymous reviewers and the Editor for their comments and suggestions, which helped to improve the paper.

Author contribution

IMA: sample collection. AGY, MDN and MOS: methodology. AGY, MDN, IMA, MOS, PGO: writing – original draft preparation; PGO: confirming identification and checking English grammar. All authors have read and agreed to the published version of the manuscript.

References

Al-Yamani FY, Skryabin V, Boltachova N, Revkov N, Makarov M, Grintsov V, Kolesnikova E (2012) Illustrated atlas on the zoobenthos of Kuwait. Kuwait Institute for Scientific Research, Kuwait, 401 pp

Bachelet G, Blanchet H, Cottet M, Dang C, de Montaudouin X, de Moura Queiros A, Gouillieux B, Lavesque N (2009) A round-the-world tour almost completed: first records of the invasive mussel *Musculista senhousia* in the North-east Atlantic (southern Bay of Biscay). *Marine Biodiversity Records* 2: e119, https://doi.org/10.1017/S1755267209001080

Barfield P, Holmes A, Watson G, Rowe G (2018) First evidence of *Arcuatula senhousia* (Benson, 1842), the Asian Date Mussel, in UK waters. *Journal of Conchology* 43(2): 217–222

Behbehani M, Ghareeb I (2002) (unpublished) Survey of the mollusca of the state of Kuwait. Report for Kuwait University, pp 1–66 + 4 appendices

Dance SP, Bosch D, Moolenbeek R, Oliver PG (1995) Seashells of Eastern Arabia. Motivate, Dubai, 296 pp

Despalatović M, Cukrov M, Cvitković I, Cukrov N, Žuljević A (2013) Occurrence of nonindigenous invasive bivalve *Arcuatula senhousia* in aggregations of non-indigenous invasive polychaete *Ficopomatus enigmaticus* in Neretva River Delta on the Eastern Adriatic coast. *Acta Adriatica* 54(2): 213–220

Chuang SH (1961) On Malayan shores. Muwu Shosa, Singapore, 255 pp

Clarke SA, Vilizzi L, Lee L, Wood LE, Cowie WJ, Burt JA, Mamiit RJ, Hassina A, Davison PI, Fenwick GV, Harmer R, Skóra ME, Kozic S, Aislabie LR, Kennerley A, Le Quesne WJF, Copp GH, Stebbing PD (2020) Identifying potentially invasive non-native marine and brackish water species for the Arabian Gulf and Sea of Oman. *Global Change Biology* 26: 2081–2092, https://doi.org/10.1111/gcb.14964

Crooks JA (1996) The population ecology of an exotic mussel *Musculista senhousia*, in a Southern California bay. *Estuaries* 19: 42–50, https://doi.org/10.2307/1352650

Faasse M (2018) A record of the Asian mussel *Arcuatula senhousia* (Benson in Cantor, 1842) from NW Europe (the Netherlands). *Spirula* 416: 14–15

Harrower CA, Scalera R, Pagad S, Schönrogge K, Roy HE (2017) Guidance for interpretation of CBD categories on introduction pathways. Technical note prepared by IUCN for the European Commission. https://www.cbd.int/doc/c/9d85/3bc5/d640f059d03acd717602cd76/sbstta-22-inf-09-en.pdf

Hayward BW, Grenfell HR, Sabaa AT, Morley MS (2008) Ecological impact of the introduction to New Zealand of Asian date mussels and cordgrass - the foraminiferal, ostracod and molluscan record. *Estuaries Coasts* 31: 941–959, https://doi.org/10.1007/s12237-008-9070-7

Hoenselaar HJ, Hoenselaar J (1989) *Musculista senhousia* (Benson in Cantor, 1842) in the western Mediterranean (Bivalvia, Mytilidae). *Basteria* 53: 73–76, https://natuurtijdschriften.nl/pub/596915

Hosozawa T, Kunii H, Nakamura M, Ojima T, Sugiyama Y, Yamaguchi K (2020) Spatial, temporal and vertical variation of distribution and major habitats in Asian mussel (*Arcuatula senhousia*) in a brackish river along Sea of Japan. *Plankton Benthos Research* 15: 121–131, https://doi.org/10.3800/pbr.15.121

Kovalev EA, Zhivoglyadova LA, Revkov NK, Frolenko LN, Afanasyev DF (2017) First record of the bivalve *Arcuatula senhousia* (Benson, 1842) in the Russian part of the Azov-Black Sea basin. *Russian Journal of Biological Invasion* 8: 24–29, https://doi.org/10.1134/S2075111717040051

Kutty R, Chakkayil, Pura SHPV (2016) Community structure of macrobenthos in Ponnani estuary, South India with reference to occurrence of invasive alien species. *International Journal of Aquatic Biology* 4: 269–276, https://doi.org/10.22034/ijab.v4i4.168

Lourenço PM, Henriques M, Catry I, Granadeiro JP, Catry T (2018) First record of the invasive Asian date mussel *Arcuatula senhousia* (Benson, 1842) (Mollusca: Bivalvia: Mytilidae) in West Africa. *Journal of Natural History* 52: 2567–2571, https://doi.org/10.1080/00222933.2018.1545058

Magni P, Como S, Montani S, Tsutsumi H (2006) Interlinked temporal changes in environmental conditions, chemical characteristics of sediments and macrofaunal assemblages in an estuarine intertidal sandflat (Seto Inland Sea, Japan). *Marine Biology* 149: 1185–1197, https://doi.org/10.1007/s00227-006-0298-0

Mantoju CD (2021) Analysis of MARPOL implementation based on port state control statistics. *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 5: 132–145, https://doi.org/10.1080/25725084.2021.1965281

Massé C, Jourde J, Fichet D, Sauriau P-G, Dartois M, Ghillebaert F, Dancie C (2022) Northern range expansion of the Asian mussel *Arcuatula senhousia* (Benson, 1842) along the French Atlantic coasts. *BioInvasions Records* 11: 700–709, https://doi.org/10.3391/bir.2022.11.3.12

Mistri M, Rossi R, Fano EA (2004) The spread of an alien bivalve (*Musculista senhousia*) in the Sacca di Goro lagoon (Adriatic Sea, Italy). *Journal of Molluscan Studies* 70: 257–261, https://doi.org/10.1093/mollus/70.3.257

Naser MD, White KN, Ali MH (2010) *Grandidierella macronyx* Barnard, 1935 (Amphipoda, Aoridae): a new record from Shatt Al-Basrah, Basrah, Iraq. *Crustaceana* 83: 1401–1407, https://doi.org/10.1163/001121610X533511

Naser MD, Son MO, Yasser, AG (2011) Assessing the risks of invasions of aquatic invertebrates in the Shatt Al-Arab River. *Russian Journal of Biological Invasions* 2: 120–125, https://doi.org/10.1134/S2075111711020081

Naser MD, Page TJ, Ng NK, Apel M, Yasser AG, Bishop JM, Ng PKL, Clark PF (2012) Invasive records of *Eriocheir hepuensis* Dai, 1991 (Crustacea: Brachyura: Grapsoidea: Varunidae): Implications and taxonomic considerations. *BioInvasions Records* 1: 71–86, https://doi.org/10.3391/bir.2012.1.1.15

Slack-Smith SM, Brearley A (1987) *Musculista senhousia* (Benson, 1842); a mussel recently introduced into the Swan River Estuary, Western Australia (Mollusca, Mytilidae). *Records of the Western Australian Museum* 13: 225–230

Wasson K, Zabin CJ, Bedinger L, Diaz MC, Pearse JS (2001) Biological invasions of estuaries without international shipping: the importance of intraregional transport. *Biological Conservation* 102: 143–153, https://doi.org/10.1016/S0006-3207(01)00098-2

Watson GJ, Dyos J, Barfield P, Stebbing P, Dey KG (2021) Evidence for self-sustaining populations of *Arcuatula senhousia* in the UK and a review of this species' potential impacts within Europe. *Scientific Reports* 11: 9678, https://doi.org/10.1038/s41598-021-86876-x

Willan RC (1985) Successful establishment of the Asian mussel *Musculista senhousia* (Benson in Cantor, 1842) in New-Zealand. *Records of the Auckland Institute and Museum* 22: 85– 96, https://www.jstor.org/stable/42906352

Willan RC (1987) The mussel *Arcuatula senhousia* in Australasia; another aggressive alien highlights the need for quarantine at ports. *Bulletin of Marine Science* 41: 475–489.

Yamamuro M, Hiratsuka J, Ishitobi Yu (2010) What prevents *Musculista senhousia* from constructing byssal thread mats in estuarine environments? A case study focusing on Lake Shinji and nearby estuarine waters. *Landscape Ecology and Engineering* 6: 23–28, https://doi.org/10.1007/s11355-009-0074-7

Zhulidov AV, Kozhara AV, Son MO, Morhun H, van der Velde G, Leuven RSEW, Gurtovaya TY, Zhulidov DA, Kalko EA, Kuklina YA, Kosmenko LS, Santiago-Fandino VJR, Nalepa TF (2021) Additional records of the bivalves *Mytilopsis leucophaeata* (Conrad, 1831) (Dreissenidae) and *Arcuatula senhousia* (Benson, 1842) (Mytilidae) in the Ponto-Caspian region. *BioInvasions Records* 10: 119–135, https://doi.org/10.3391/bir.2021.10.1.14