Rapid Communication

# First record of the invasive alien mussel *Mytella strigata* (Hanley, 1843) in Hong Kong

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**Citation:** Joyce PWS, Lee SY, Falkenberg LJ (2023) First record of the alien invasive mussel *Mytella strigata* (Hanley, 1843) in Hong Kong. *BioInvasions Records* 12(2): 385–391, https://doi.org/10.3391/bir.2023.12.2.03

**Received:** 20 September 2022
**Accepted:** 1 March 2023
**Published:** 3 April 2023

**Handling editor:** Kevin Ma
**Thematic editor:** Amy Fowler



## Abstract

The brackish water mytilid mussel *Mytella strigata* (Hanley, 1843) is recorded for the first time in July 2022 in Hong Kong. Native to Central and South America, the first reports of *M. strigata* in Asia were recorded in the Philippines, with subsequent reports from India, Singapore, Thailand, and Taiwan. Here, the mussels were found attached to hard, artificial substrates throughout the Tolo and Victoria Harbours in Hong Kong, with 13 accessible specimens collected and more inaccessible specimens observed. *Mytella strigata* tended to co-occur with a previously recognised introduced mussel, *Xenostrobus securis* (Lamarck, 1819). The largest individual observed had a shell length of ~ 54 mm and the smallest ~ 22 mm, and all specimens were found in brackish water areas. Externally, the shells were generally black with a green tinge and internal surfaces were iridescent purple. Two small teeth on the internal anteroventeral margin, typical of *Mytella*, were observed. With the recent introduction of *M. strigata* throughout Asia, future research is required to document the full extent of the population within Hong Kong, as well as developing a greater understanding of the ecological and economic impacts of this highly invasive species.

**Key words:** alien invasive species, Asia, bivalve, ecological impact, marine, non-native species

## Introduction

Biological invasions are a major driver of declines in native biodiversity and ecosystem functioning worldwide (Blackburn et al. 2019; Pyšek et al. 2020). Increased connectivity among regions through human movement is a likely source of many biological invasions, which are predicted to continue to increase (Seebens et al. 2013; Sardain et al. 2019). Thus, marine and brackish water systems with heavy traffic loads are at greater risk of successful biological invasions compared to areas with light traffic.

Hong Kong is one of the largest shipping ports globally and receives large volumes of traffic. The world shipping council listed Hong Kong as the 8th most heavily trafficked port in the world in 2020, with upwards of 17 million twenty-foot equivalent units received per year (TEU; https://www.worldshipping.org/top-50-ports). As well as being facilitated by the large volume of marine traffic, the disturbed and artificial shorelines of Hong

Kong are particularly susceptible to biological invasions (Glasby et al. 2007; Tyrrelland Byers 2007) as they provide competitor free space for biofouling species. While particularly at risk of biological invasions, documentation of aquatic invasive species and their ecological and economic impacts in the region are few (but see Morton and Leung 2015; Astudillo et al. 2017, 2018). A number of invasive bivalves have been found in Hong Kong including *Xenostrobus securis* (Lamarck, 1819), *Mytilopsis sallei* (Récluz, 1849), and *Mytilus galloprovincialis* Lamarck, 1819; however the latter was not detected during the most recent targeted surveys in 2012 (Astudillo et al. 2014) after initial recognition in the 1980s (Lee and Morton 1985).

The mytilid mussel, *Mytella strigata* (= *Mytella charruana* (d'Orbigny, 1846)), is native to Central and South America and has invasive populations in North America (Spinuzzi et al. 2013). More recently, introductions of *M. strigata* have been reported throughout Asia in India, the Philippines, Singapore, Taiwan, and Thailand (Lim et al. 2018; Jayachandranet al. 2019; Sanpanichand Wells 2019; Fuertes et al. 2021; Huang et al. 2021). Here, we provide the first report of the occurrence of *M. strigata* at multiple locations across Hong Kong. Documentation of this species in Hong Kong for the first time highlights the largely unknown nature of invasive species in these coastal waters. Better identification and quantification of invasive species in the region is required to inform management that limits their ecological and economic impacts.

## Methods

Mussels were collected in July 2022 as part of a survey of bivalves fouling artificial structures and shorelines throughout the coastal waters of Hong Kong, focussing on Tolo Harbour and Victoria Harbour (Figure 1). In Tolo Harbour and at Central in Victoria Harbour, surface water salinities are generally ~ 30, with regular decreases to ~ 25–27 during rainy summer months. Salinity in the Kwun Tong typhoon shelter is more brackish, varying between 20 and 30 (https://cd.epic.epd.gov.hk/EPICRIVER/marine/). The survey was designed to update population information regarding a previously documented introduced bivalve, *Xenostrobus securis*. During the survey, specimens of bivalves previously not recognised in the literature from Hong Kong were haphazardly collected during the targeted survey and returned to the laboratory for further inspection of anatomy and shell morphology. Mussels were identified based on morphological features and shell length was measured with digital callipers.

## Results

### *Identification and shell morphology*

Initially, collected mussels were thought to be *Xenostrobus securis*, however, discovery of larger individuals and the presence of two small teeth on the inner

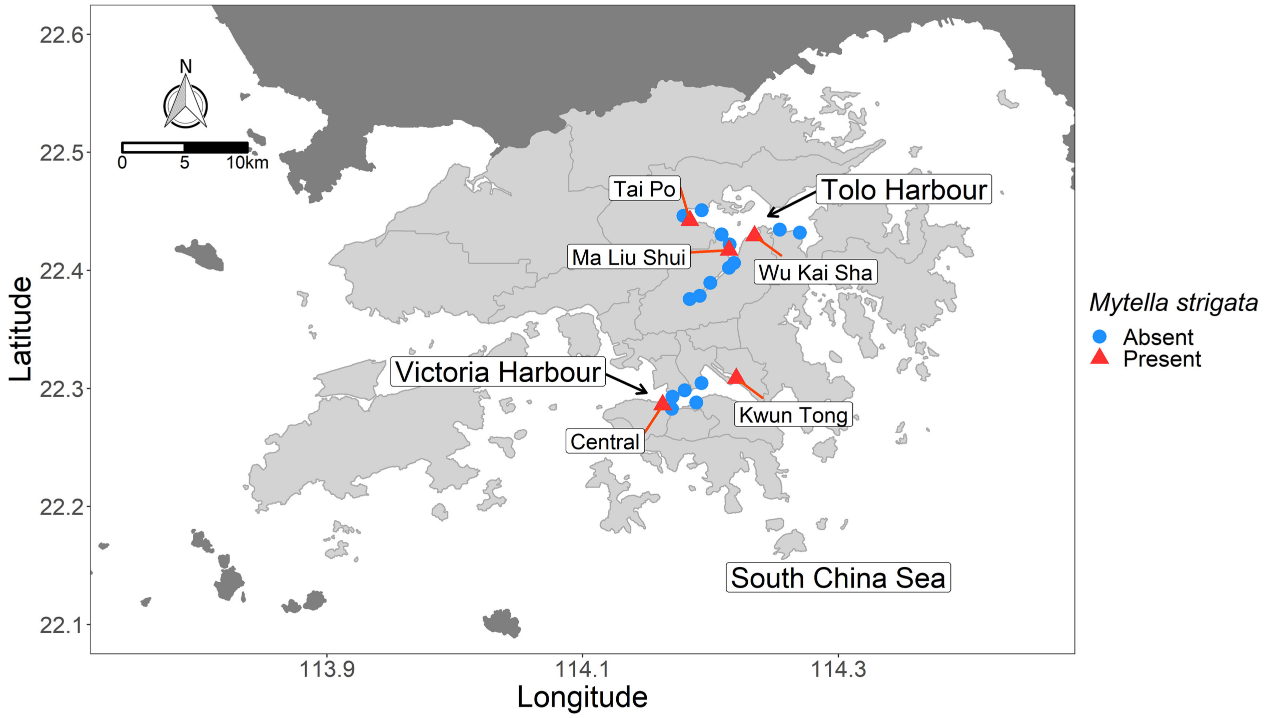


**Figure 1.** Map showing sites sampled around Tolo Harbour and Victoria Harbour, in Hong Kong SAR (light grey), on the southern coast of China (dark grey). Blue circles denote sites where *M. strigata* was absent, red triangles denote sites where *M. strigata* was present. Labelled sites are those where *M. strigata* was present.

anteroventeral margin suggested specimens belonged to the genus *Mytella*. The conchological features of the newly observed mussels agreed with those of the American charru mussel, described as *Mytella charruana* (d'Orbigny, 1846) by Narchiand Galvão-Bueno (1983), and more recently described as *Mytella strigata* (Hanley, 1843) in recent first records in Singapore (Lim et al. 2018), India (Jayachandranet al. 2019), and Taiwan (Huang et al. 2021). All *M. strigata* observed had typically modioliform shape shells with subterminal umbones, distinguishing them from the terminal umbo observed in *Perna*. Shells had dark blue-black exteriors, some with a green-brown tinge (Figure 2A, B). No green colour morphs were observed (as found in Lim et al. 2018; Jayachandranet al. 2019). Internal nacreous surfaces were observed to be smooth and iridescent purple in colour. The resilial ridge under the ligament exhibited pitting (Figure 2C, D), and two small teeth were observed on the anteroventeral margin (Figure 2E, F), typical of *Mytella*.

### *Distribution*

All *Mytella strigata* specimens were collected in the intertidal, coexisting with *Xenostrobus securis*. In Tolo Harbour, three specimens were collected at Ma Liu Shui, one specimen was collected at Wu Kai Sha, and four specimens were collected at the Tai Pao promenade (Figure 1). In Victoria Harbour, four specimens were collected within the Kwun Tong typhoon shelter (Figure 1), and one specimen was collected at Central (Figure 1). Mussels

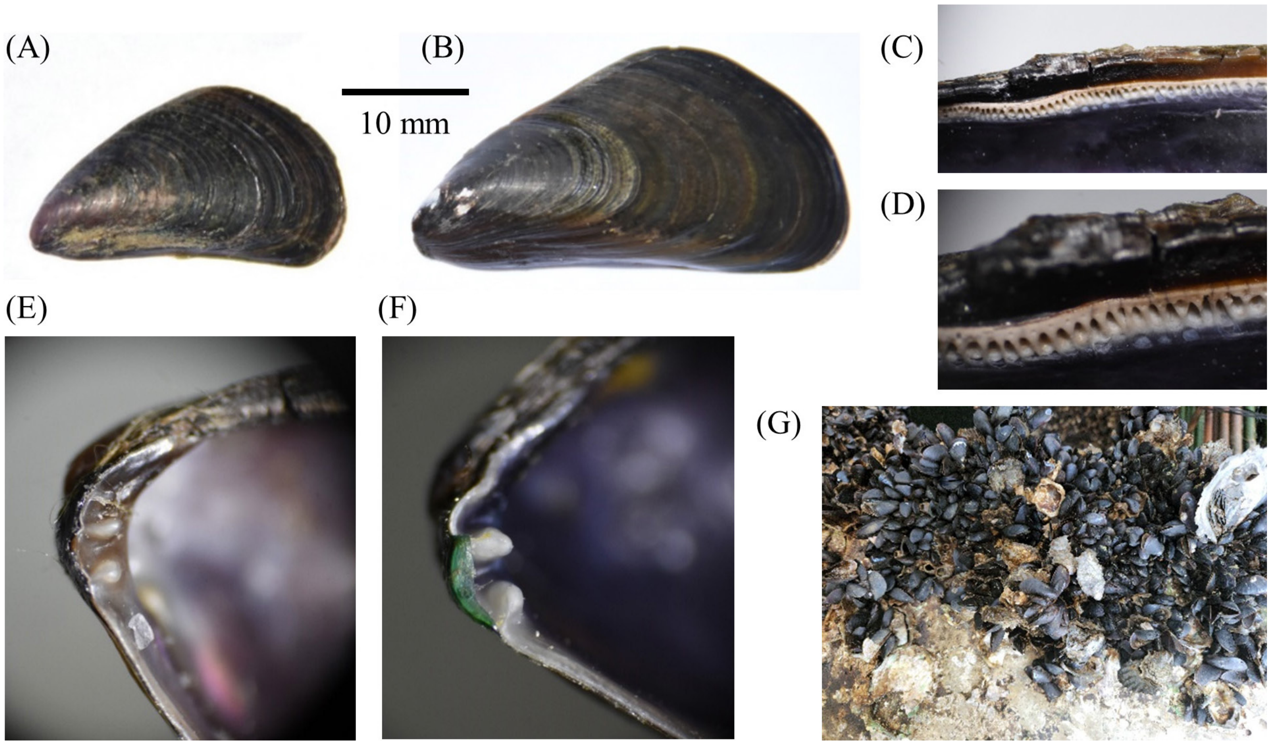


**Figure 2.** Shells of *Mytella strigata* from Hong Kong. External view of left valve from two specimens (A) and (B); pitted resilial ridge under ligament (C) and (D); internal teeth on the anteroventeral margin (E) and (F); *In-situ* population of *Xenostrobus securis* at Kwun Tong typhoon shelter, among which *Mytella strigata* were collected (G). Photographs by Patrick Joyce.

ranged from 21.9 to 54.6 mm shell length, with the smallest specimen found at Ma Liu Shui and the largest at Kwun Tong Typhoon Shelter. The greatest number of specimens was observed in Kwun Tong typhoon shelter compared to sites in Tolo Harbour (*pers. obs.*), however access did not allow collection of more specimens.

## Discussion

The American mussel, *Mytella strigata*, native to Central and South America, has here been recorded for the first time in Hong Kong. Previous observations throughout East Asia found the mussel to occur in the Philippines in 2014 (Rice et al. 2016), Singapore in 2016 (Lim et al. 2018), Thailand in 2018 (Sanpanichand Wells 2019), India in 2019 (Jayachandran et al. 2019), and Taiwan in 2019 (Huang et al. 2021). Although there is potential that *M. strigata* was introduced to Hong Kong through natural dispersal from nearby populations (i.e., from those recently introduced to Singapore and Taiwan, which are south and north of Hong Kong respectively), it is much more likely that this species was transported to Hong Kong's coastlines by shipping transport. The introduction of *M. strigata* to Hong Kong is unsurprising given the volume of shipping traffic in Hong Kong, which is ranked as the port with greatest invasion risk in China (Wan et al. 2021) and third globally (Seebens et al. 2013).

Previous surveys documenting the occurrence of another invasive bivalve (*Xenostrobus securis*) in Tolo Harbour in 2011 and 2014 did not report the occurrence of *M. strigata* (Morton and Leung 2015), suggesting that the introduction of *M. strigata* occurred within the 10 years between this earlier survey and the one described here, likely at a similar time that introductions to Singapore (2016) and Taiwan (2019) occurred. In Hong Kong, it appears that invasion by *M. strigata* is still early, and establishment may be confined to a few locations. However, studies of the previous introduction of *X. securis* to Hong Kong revealed that it spread rapidly throughout Tolo Harbour (Morton and Leung 2015), likely due to successful reproduction. The collected specimens of *M. strigata* had shell lengths up to 56 mm and showed ripening of the gonad (*pers. obs.*), thus successful reproduction is probable and may also lead to the rapid spread of *M. strigata* throughout Hong Kong.

While *M. strigata* has a wide salinity tolerance (Yuan et al. 2010; Rice et al. 2016), it appears most abundantly in brackish water environments. In the surveys conducted here, locations where *M. strigata* occurred corroborates the brackish water preference observed elsewhere, with greatest abundance observed in the Kwun Tong typhoon shelter (salinity ~ 20–30). Sites with a higher salinity (Tolo Harbour and Central in Victoria Harbour) led to fewer observations of specimens compared to those with lower salinities.

The occurrence of *M. strigata* in Hong Kong has the potential to induce ecological and economic consequences, however, such impacts of introductions are largely unknown, especially in Asia. Where *M. strigata* is able to form dense beds on anthropogenic structures and natural intertidal substrates (Lim et al. 2018), there is potential that damaging effects may occur within the recipient ecosystems. In the United States of America, *M. strigata* competes with native species such as *Crassostrea virginica* (Gmelin, 1791), a commercially important oyster (Galimany et al. 2017). Such competition holds the potential to reduce production of aquaculture species, as well as induce changes in water column characteristics, as has been observed after freshwater invasions by *Dreissena* spp. (Effler et al. 1996; Reynolds and Aldridge 2021). The global economic costs associated with aquatic invasive species have increased, and are estimated to have reached > US$23 billion in 2020 (Cuthbert et al. 2021), despite being largely under reported. These costs include those accrued through management (e.g., fouling removal) and damage (e.g., yield reduction through fouling of aquaculture). Further effects may be observed through feeding patterns within recipient communities. Invasive bivalves can lead to novel trophic interactions with predators, which can influence invasion success of the prey (Skein et al. 2018; Joyce et al. 2019) leading to potentially greater impacts on recipient ecosystems. However, such knowledge is lacking with regards to *M. strigata* introductions throughout Asia.

While current populations of *M. strigata* in Hong Kong appear small, the potential for populations of this species to expand should not be underestimated. Further research is required to document the full spatial extent of this species, identify its population characteristics, and monitor its spread within the region. Additionally, the interactions of *M. strigata* with native species, both through competitive interactions with native bivalves as well as trophic interactions with potential consumers, should be investigated to quantify the ecological impacts of this species in Hong Kong and throughout Asia.

## Acknowledgements

We thank Summer Szeto Yuan, Thomas Yin Chung Law, and Fiona Yue for assistance with the field surveys that led to the discovery of this species in Hong Kong. We also thank two anonymous reviewers for their comments which have improved the manuscript.

## Funding

Thanks also to the Environment and Conservation Fund, Hong Kong (Grant number: ECF 2021-82) for funding the initial survey.

## Authors' contribution

Research conceptualization: P.W.S.J. and L.J.F.; sample design and methodology: P.W.S.J.; investigation and data collection: P.W.S.J., S.Y.L. and L.J.F.; funding provision: L.J.F and P.W.S.J; writing – original draft: P.W.S.J.; writing – review and editing: P.W.S.J, S.Y.L. and L.J.F.

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