



Handbook and National Red-List of the Freshwater Mussels of Malaysia

June 2018



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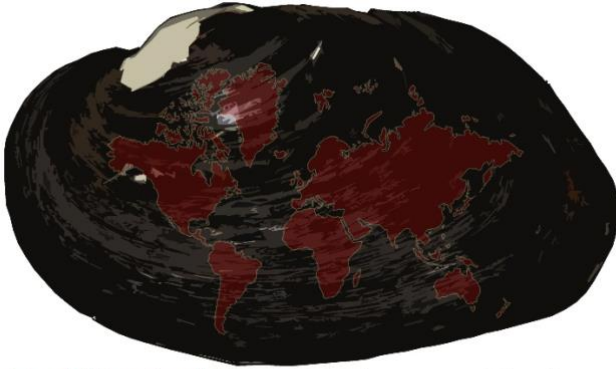
IUCN SPECIES SURVIVAL COMMISSION Mollusc Species Specialist Group

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Red List Authority Freshwater Bivalves
Mollusc Specialist Group  

Picture on Title Page: The Baram River in Sarawak (photograph by Dr. Khairul Adha Rahim)

Introduction

Freshwater mussels of the order Unionida, also known as freshwater clams, pearly mussels or naiads, and Kupang or Kijing in Bahasa Malay, comprise about 800 species worldwide. These molluscs are bottom-dwelling filter feeders in various freshwater habitats, including rivers, channels, lakes and ponds across the globe. They serve crucial ecological functions, such as water clearance, nutrient transport, bioturbation and oxygenation of sediments, and providing habitat for other organisms (Vaughn & Hakenkamp, 2001; Chowdhury, Zieritz & Aldridge, 2016). Particularly in Asia, freshwater mussels are also used by humans as a food source (Figure 1), and as raw materials for a variety of end products ranging from cosmetics to jewellery and medicine (Fiske & Shepherd, 2007).



Figure 1. Freshwater mussels and snails being sold in a market in Sarawak, Malaysia (photograph by Dr. Khairul Adha Rahim)

Unfortunately, freshwater mussels are also considered to be amongst the most threatened freshwater animals in the world (Bogan, 1993; Lydeard *et al.*, 2004). In North America, for example, about 10% of the species are already presumed extinct (IUCN, 2016). Most important causes for their decline include habitat deterioration, loss and fragmentation, river flow alterations, loss of host fishes (see Figure 2) and the introduction of non-native species (Bogan, 1993).

Over the past decades, a growing recognition of the endangered status and ecological importance of freshwater mussels has resulted in a steep increase in scientific study and improvement of knowledge on the freshwater mussel fauna of North America and Europe. In contrast, our knowledge on these animals in Southeast Asia including Sundaland (= Malay Peninsula, Borneo, Sumatra, Java and Bali) is poor. For Malaysia, a near complete absence of scientific study over the past 60 years or more has resulted in a lack of even the most basic knowledge, such as number and identities of species in the region (Zieritz *et al.*, 2018a).

The scientific study of freshwater mussels and other molluscs in Malaysia started in the late-19th century (Tenison-Woods, 1888; Aldrich, 1889; Schepman, 1896; Smith, 1899). In the mid-20th century, Van Benthem Jutting (1948, 1949, 1960) and Berry (1963, 1974) wrote a number of short articles on freshwater gastropods and mussels in Malaysia, but these works deal with only a few of the most common species on Peninsular Malaysia. The only significant works available on this fauna until recently were Haas (1969) and Brandt (1974), monographs on the whole order and freshwater mussels of Southeast Asia (predominantly Thailand), respectively.

Almost 50 years later, in 2015 and 2016, the authors of the present Handbook carried out the first comprehensive survey of freshwater mussels across Malaysia. This project included, for the first time, molecular species identification (barcoding), which resulted in a number of changes in our understanding of Malaysian freshwater mussel diversity and distribution (Zieritz *et al.*, 2016, 2018b). Based on the current scientific knowledge, Malaysia comprises 17 native and 1 non-native freshwater mussel species (Table 1).

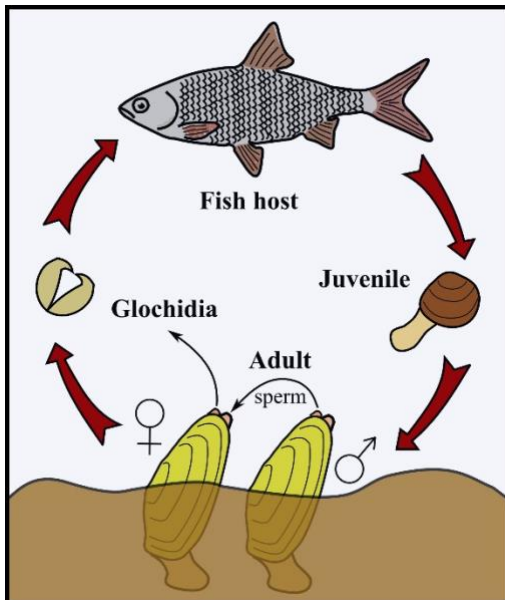


Figure 2. The freshwater mussel life cycle. Sperm released by an adult male is infiltrated by the female. In her gills (marsupia), fertilised eggs develop into mature larvae (glochidia), which are released into the water column. Glochidia attach and encyst into the gills, fins or scales of freshwater fishes. After this parasitic phase, the juvenile mussel drops off the fish and begins its life in the sediment.

Our objective herein is to provide an up-to-date summary of the current knowledge on the diversity, distribution, ecology and threats of the freshwater mussels of Malaysia. This is achieved through review of historical data from museum collections (Graf & Cummings, 2015) and the literature, as well as modern scientific

data mostly collected by the authors. Based on the information collected, we further determine the National Conservation Status according to IUCN criteria and guidelines (IUCN, 2012), and recommend conservation actions and future research directions related to each freshwater mussel species in Malaysia.

Table 1. Taxonomic classification, distribution and conservation status of freshwater mussel (Unionida) species in Malaysia. Abbreviations: CR, critically endangered; DD, data deficient; EN, endangered; NA, not applicable; NE, not evaluated; NN, non-native to Malaysia; VU, vulnerable.

Taxon	Conservation status		Present in		% of global population in Malaysia
	National	Global	Peninsular Malaysia	Malaysian Borneo	
Family Unionidae					
Subfamily Anodontinae					
Tribe Cristariini					
<i>Sinanodonta woodiana</i> (Lea, 1834)	NA	LC	X (NN)	X (NN)	NA
Anodontinae incertae sedis					
<i>Simpsonella gracilis</i> (Lea, 1850)	DD	NE		X	0.2
Subfamily Rectidentinae					
Tribe Contradentini					
<i>Contradens contradens</i> (Lea, 1838)	LC	LC	X		7
<i>Physunio superbus</i> (Lea, 1843)	VU	LC	X		7
Tribe Rectidentini					
<i>Ensidens ingallsianus</i> (Lea, 1852)	CR	LC	X		0-10
<i>Hyriopsis bialata</i> Simpson, 1900	EN	LC	X		100
<i>Rectidens sumatrensis</i> Dunker, 1852	NT	DD	X	X	30
Tribe Pseudodontini					
<i>Pilsbryconcha compressa</i> (Martens, 1860)	VU	NE	X		20
<i>Pilsbryconcha exilis</i> (Lea, 1838)	LC	LC	X		7
<i>Pseudodon cambodjensis</i> (Petit, 1865)	VU	DD	X		11
<i>Pseudodon crassus</i> Drouet & Chaper, 1892	VU	NE		X	100
<i>Pseudodon cumingii</i> (Lea, 1850)	VU	NE	X		50
<i>Pseudodon vondembuschianus</i> (Lea, 1840)	LC	LC	X		7
<i>Pseudodon walpolei</i> (Hanley, 1871)	NT	NE		X	96
Unionidae incertae sedis					
<i>Ctenodesma borneensis</i> (Issel, 1874)	VU	NE		X	21
<i>Pressidens insularis</i> (Drouet, 1894)	DD	NE		X	100
<i>Schepmania nieuwenhuisi</i> (Schepman, 1898)	DD	NE		X	50
<i>Schepmania parcesculpta</i> (Martens, 1903)	DD	NE		X	50

Conradens conradens (Lea, 1838)

SHELL DESCRIPTION

Shell more or less ovate (Figure 3), but shape variable and dependent on habitat conditions, yellowish to dark-brown in colour. Umbos prominent, with zigzag sculpture, which can extend down the disc of the shell. Hinge structure (interior shell): left valve with one small, compressed pseudocardinal tooth and two long, thin lamelliform lateral teeth; right valve with two short pseudocardinals and one long lateral (Haas, 1969; Brandt, 1974).



Figure 3. *Conradens conradens* from the Sungai Pahang, Malaysia

DISTRIBUTION

Widespread in Peninsular Malaysia, known from several sites in the Perak, Pahang, Kelantan, Kesang, Muar, Perlis, Muda and Semerak River basins in the Federal States of Perlis, Kedah, Perak, Pahang, Negeri Sembilan, Malacca, Johor and Kelantan (Zieritz *et al.*, 2016) (Figure 4). Reaching densities of about 70 mussels/m² at many sites, particularly in the Pahang basin (A. Zieritz, pers. obs.). Recruitment good in several locations, as indicated by presence of juvenile specimens (A. Zieritz, pers. obs.).

Also present in Cambodia, Indonesia (Java, Sumatra), Laos, Thailand, Vietnam and potentially Myanmar (Zieritz *et al.*, 2018a).

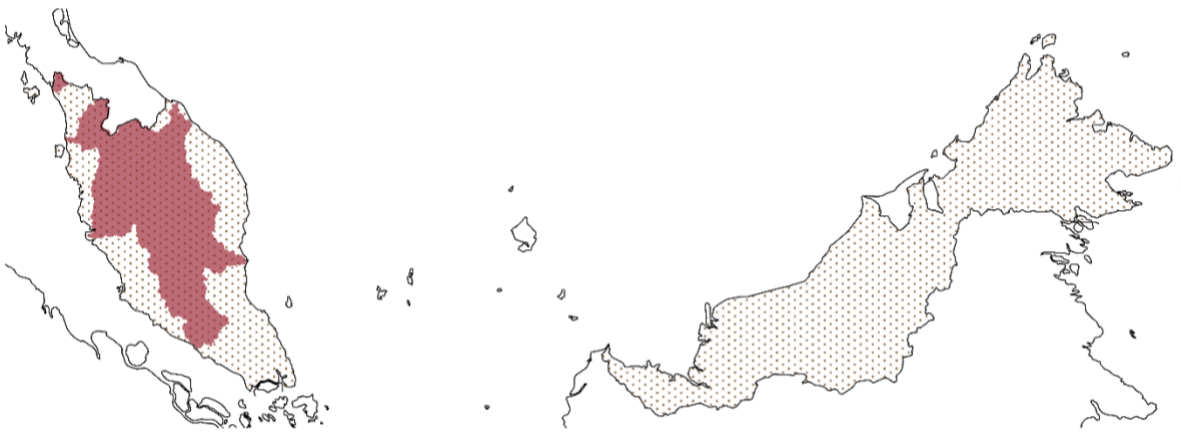


Figure 4. Distribution of *Conradens conradens* in Malaysia.

ECOLOGY

In Peninsular Malaysia, found in relatively unpolluted streams, rivers and channels with stable, usually muddy substrate (Zieritz *et al.*, 2016). Due to its relatively wide distribution and ecological range, associated with a number of different species.

MAJOR THREATS

Habitat pollution due to insufficient or complete lack of water treatment in rural areas. Other potential threats may be habitat modification (e.g. concrete channels, dams) and non-native species introductions.

NATIONAL RED-LIST STATUS MALAYSIA

Conradens conradens is assessed as Least Concern in view of its widespread distribution in Malaysia. The species may have been declining in urban and agriculture areas due to urbanisation, lack of wastewater treatment and palm oil plantations but no data on population trends are available to confirm this.

RESEARCH AND CONSERVATION ACTION NEEDS

Water treatment should be improved to minimise pollution. Although it is widespread, *C. conradens* is poorly known, and information regarding its basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Ctenodesma borneensis (Issel, 1874)

SHELL DESCRIPTION

Shell delicate, very compressed, elongated-elliptical in outline, light to dark-brown in colour (Figure 5). Umbos with very fine W-shaped sculpture developing to rows of very fine ridges of nodules further away from the umbo. Hinge structure: pseudocardinal teeth elongated; lateral teeth short (Haas, 1969).

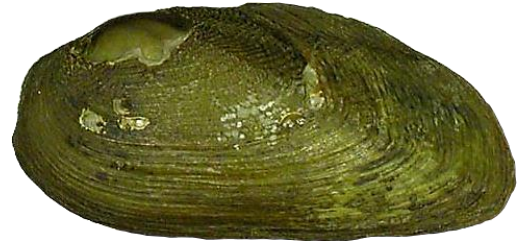


Figure 5. Holotype of *Ctenodesma borneensis* (Natural History Museum London, specimen 1965.156)

DISTRIBUTION

Ctenodesma borneensis is endemic to Borneo but has not been found in the past 50 years. It was last found in the Malaysian part of Borneo in the 1960s at Gomantong, Sandakan Residency in Sabah (specimen 116932, Chicago Field Museum) indicating presence in the Kinabatangan basin (Figure 6). We are aware of only two additional specimens of this species collected from Malaysia in the 1930s/40s (specimen 174117, Museum of Comparative Zoology, Harvard; specimen 2723, Muséum National d'Histoire Naturelle, Paris) with the general location "Sarawak". Extensive surveying across 21 river basins in central Sarawak and northern Sabah in 2016 was unsuccessful in locating any *C. borneensis* populations in Malaysia (Zieritz *et al.*, 2018b).

Also recorded from Kalimantan (Zieritz *et al.*, 2018a).

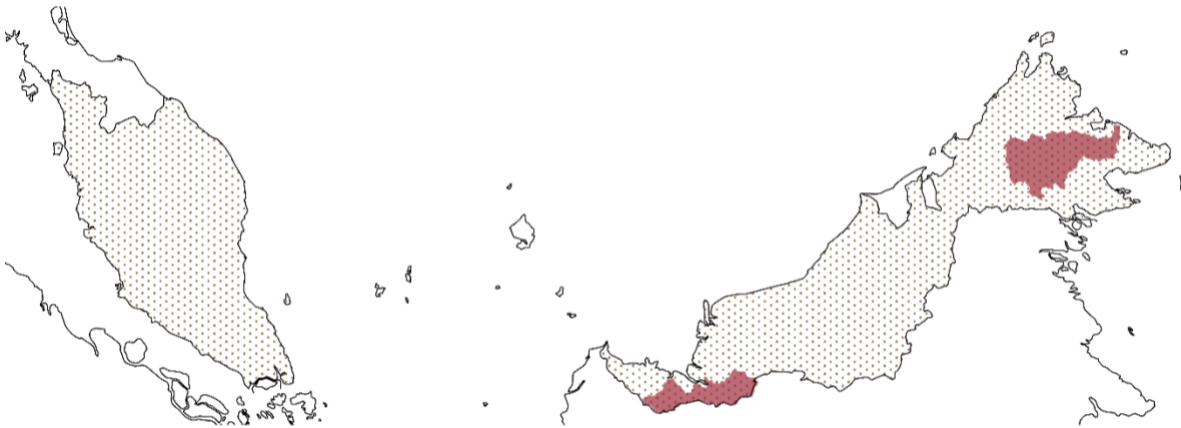


Figure 6. Presumed current distribution of *Ctenodesma borneensis* in Malaysia.

ECOLOGY

No information available.

MAJOR THREATS

The species has in all likelihood suffered extensive population losses since the 1970s as a consequence of intensive deforestation, large-scale conversion of primary forest to agricultural monocultures, impoundment of rivers and introduction of non-native species. All of these threats are likely to affect any potentially remaining populations now and in the future.

NATIONAL RED-LIST STATUS MALAYSIA

Ctenodesma borneensis is assessed as Vulnerable VU A2c in Malaysia since it was not detected in recent surveys on 36% of its whole extent of occurrence in the country. The remaining distribution has not been surveyed and so the decline may be much greater. If further declines are recorded, a higher threat status might be confirmed.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys – particularly in the Kinabatangan and Sarawak basins - are needed to determine if the species is already locally extirpated in Malaysian Borneo or if any populations remain. If surviving populations would be found in the future, the respective reaches and river basins should be placed under immediate protection. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Ensidens ingallsianus Lea, 1852

SHELL DESCRIPTION

Shell elongate, cuneiform, with rounded anterior end and pointed posterior, greyish or olive-green in colour (Figure 7). Umbonal sculpture W-shaped. Hinge structure: each valve with two pseudocardinal teeth and long, lamelliform lateral teeth (Haas, 1969; Brandt, 1974).



Figure 7. Holotype of *Ensidens ingallsianus* (Smithsonian National Museum, specimen 84708)

DISTRIBUTION

No populations of this species found in Malaysia for the past 40 years despite fairly intensive survey efforts in 2015 (Zieritz *et al.*, 2016). Historical records from Lake Chini (last record 1977, specimen d081, Natural History Museum, London), Kelantan (last record 1976, specimen d280, Natural History Museum, London) and Perak (last record 1965, specimen 389074, Academy of Natural Sciences, Philadelphia) (Figure 8). However, these could not be confirmed in a survey in 2015, indicating decreasing population sizes in the best case scenario and local extinction of this species in Malaysia in the worst case scenario.

Widespread and common in Thailand; also present in Singapore (possibly introduced), Vietnam, Cambodia, Laos and Myanmar (Zieritz *et al.*, 2018a).

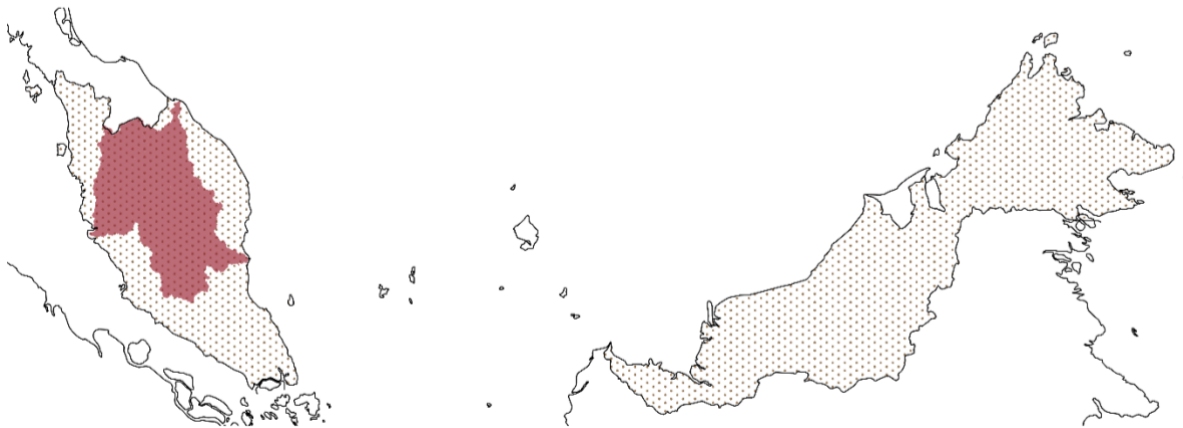


Figure 8. Current potential distribution of *Ensidens ingallsianus* in Malaysia.

ECOLOGY

Historically found in rivers and lakes (Lake Chini).

MAJOR THREATS

Potential threats for this species are urbanisation, alteration of flow regime through dams and extreme flooding events (especially in Kelantan), pollution and land-use change of riparian vegetation.

NATIONAL RED-LIST STATUS MALAYSIA

The species is quite likely regionally extinct in Malaysia since no remaining populations were found. Therefore, the distribution area / area of occupancy is unclear at this point. Several threats are suggested for the dramatic decline of the species in Malaysian territory, e.g. dams, deforestation, land-use change. The species is being assessed as Critically Endangered A2a.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys including interviews with locals needed to detect remaining populations of this species in Malaysia or to confirm extinction of the species in Malaysia. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Hyriopsis bialata (Simpson, 1900) Malay name: Layar

Taxonomic notes: *Hyriopsis bialata* used to be regarded as widespread and common in Southeast Asia. However, molecular data revealed that the Malaysian populations, which are restricted to the lower reaches of the Pahang River, represent a separate, cryptic species endemic to the peninsula (Zieritz *et al.*, 2016). Since the species' type locality is Malaysia, *H. bialata* populations outside the Malaysian Peninsula are not considered conspecific and therefore excluded from the present assessment.



Figure 9. *Hyriopsis bialata* from Sungai Pahang, Malaysia

SHELL DESCRIPTION

Shell very slenderly elongate, lanciform, with large posterior and small anterior wing, and one or two posterior ridges (Figure 9). Colour greenish to blackish. Umbonal sculpture consists of irregular nodules and ridges. Hinge structure: one large pseudocardinal tooth in right and two in left valve, and one strong lamelliform lateral in the right valve and two thinner ones in left valve (Haas, 1969; Brandt, 1974).

DISTRIBUTION

Museum records indicate that the species used to be distributed throughout southern Peninsular Malaysia but is now restricted to the lower sections of the Pahang River in Peninsular Malaysia (Figure 10). Historical records from southern Peninsular Malaysia and Singapore (e.g. Specimen 8382, Chicago Field Museum of Natural History, Philip P. Carpenter Collection, collected from a "creek near Singapore, Malay Peninsula"; Specimen 184026, University of Michigan Museum of Zoology, E.V. Rippon Collection from "Singapore"), all of which date to <1950, could not be confirmed in recent surveys (Zieritz *et al.*, 2016).

Endemic to Malaysia (Zieritz *et al.*, 2016).

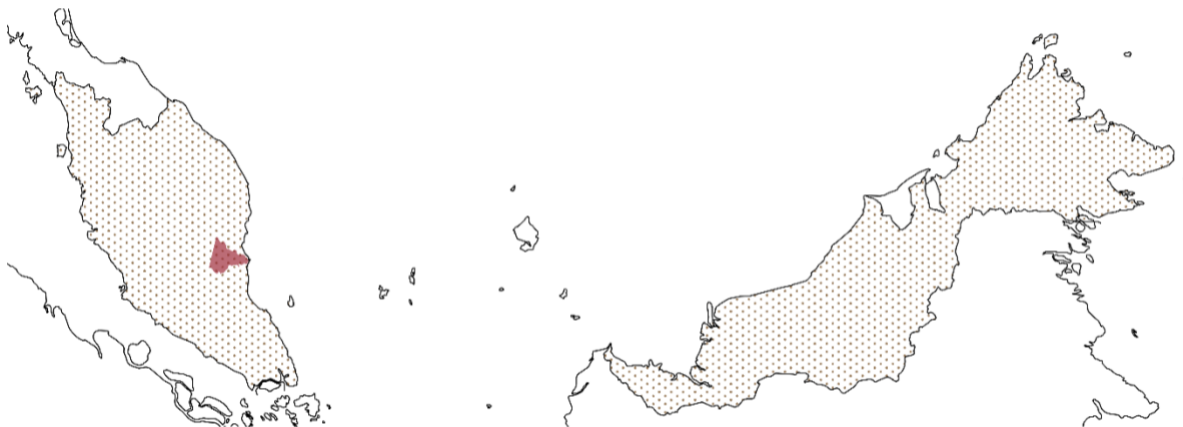


Figure 10. Current distribution of *Hyriopsis bialata*.

ECOLOGY

The scarce data available indicate that the species is confined to very large rivers with soft sediment and requires pH values around 7.5. It is associated with *Physunio superbus* and *Contradens contradens*, and appears to be inhabiting comparatively deeper depths than those species.

MAJOR THREATS

Urbanisation, bauxite and sand mining, eutrophication and pollution.

NATIONAL RED-LIST STATUS MALAYSIA

The species is present in only one location in a lower stretch of the River Pahang at low densities. The whole section is being threatened by urbanisation, pollution and other minor threats. Probably due to the same reasons, the species lost 96.4% of its extent of occurrence. In consideration of these reasons, *Hyriopsis bialata* is assessed as Endangered (EN) B1ab(i)+2ab(i).

RESEARCH AND CONSERVATION ACTION NEEDS

Acidification and eutrophication in the river reaches occupied by *H. bialata* could be minimised by establishing riparian buffers for the river and its tributaries passing through agricultural and residential lands. Prevention of dam construction in the lower Pahang is imperative for preventing this species' extinction. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Physunio superbus (Lea, 1843) Common Malay name: Mangkuk

SHELL DESCRIPTION

Shell thin, very inflated and ovate in outline, and yellowish-green in colour (Figure 11). Umbonal sculpture consists of irregular nodules and ridges. Hinge structure: one pseudocardinal teeth in left valve and two short lamellae in the right valve; lateral teeth short (Haas, 1969; Brandt, 1974).



Figure 11. *Physunio superbus* from Sungai Pahang, Malaysia

DISTRIBUTION

In Malaysia, restricted to the lower and middle reaches of the Sungai Pahang in Pahang State, Peninsular Malaysia (Zieritz *et al.*, 2016) (Figure 12). Rare in middle reaches, but can be common at suitable sites in the lower Pahang (A. Zieritz, pers. obs.), reaching up to several dozens of individuals/m².

Also present in Cambodia, Java, Laos, Sumatra, Thailand and Vietnam (Zieritz *et al.*, 2018a).

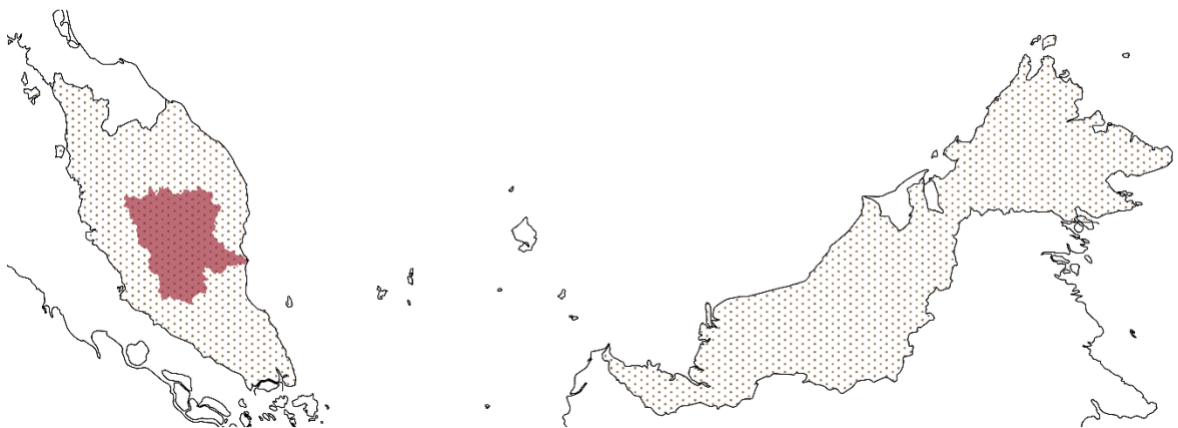


Figure 12. Distribution of *Physunio superbus* in Malaysia.

ECOLOGY

The species is found in unpolluted, medium- to large-sized rivers with muddy/silty substrate and requires pH values around 7.5, which is at the very high end for Peninsular Malaysia. It is associated with *Conradens conradens* and *Hyriopsis bialata*.

MAJOR THREATS

Urbanisation, bauxite and sand mining, eutrophication and pollution.

NATIONAL RED-LIST STATUS MALAYSIA

The species is here assessed as Vulnerable D2 in Malaysia. It was only detected in the middle and lower reaches of the Pahang River at <5 locations. Due to mining, eutrophication and alteration of flow regime this species could quickly become Critically Endangered or Regionally Extinct.

RESEARCH AND CONSERVATION ACTION NEEDS

Acidification and eutrophication in the river reaches occupied by this species could be minimised by establishing riparian buffers for the river and its tributaries passing through agricultural and residential lands. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pilsbryconcha compressa (Martens, 1860)

Taxonomic notes: In the previous IUCN assessment, *Pilsbryconcha compressa* was considered a synonym of *Pilsbryconcha exilis*. However, molecular data confirmed the separate status of these two species (Zieritz et al. 2016). Considering the difficulties in morphological separation between these two species, historical distribution data for this genus should be interpreted with caution.



Figure 13. *Pilsbryconcha compressa* from Sungai Perak basin, Malaysia.

SHELL DESCRIPTION

Shell thin, very compressed and elongately linguiform in outline, blackish-green in colour (Figure 13). Umbonal sculpture weak, double-looped to concentric. Hinge structure: only one extremely small pseudocardinal tooth – in the right valve. Difficult to separate from *P. exilis* (Haas, 1969; Brandt, 1974).

DISTRIBUTION

In Malaysia, the species is restricted to small tributaries of the Sungai Perak in Peninsular Malaysia (Zieritz et al., 2016) (Figure 14). No historical records for this species exist in Malaysia, most likely due to confusion with *Pilsbryconcha exilis*.

Also present in Thailand and possibly more widespread in Southeast Asia (Zieritz et al., 2018a).

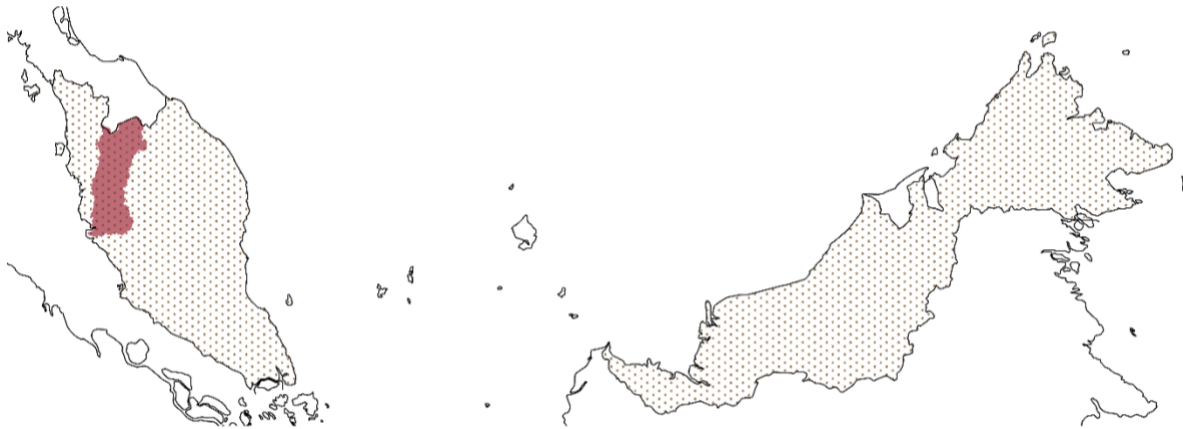


Figure 14. Distribution of *Pilsbryconcha compressa* in Malaysia.

ECOLOGY

The species is confined to small streams and rice-paddy channels with muddy/sandy sediment. It can be associated with *Sinanodonta woodiana*.

MAJOR THREATS

Interspecific competition with the non-native *S. woodiana*, human-induced acidification, habitat degradation and modification might lead to loss of the few, geographically restricted Malaysian populations of this species.

NATIONAL RED-LIST STATUS MALAYSIA

In Malaysia, the species is known from only two small tributaries of the Sungai Perak and threatened by invasive species, human-induced acidification and habitat degradation. Due to its highly restricted distribution to only two locations, the species is here considered as Vulnerable D2. If the impacts to the river continue the species can quickly reach the thresholds for Critically Endangered or Regionally Extinct.

RESEARCH AND CONSERVATION ACTION NEEDS

Acidification and eutrophication in the river reaches occupied by this species could be minimised by establishing riparian buffers for the river and its tributaries passing through agricultural and residential lands. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pilsbryconcha exilis (Lea, 1838)

Taxonomic notes: In the previous IUCN assessment, *Pilsbryconcha compressa* was considered a synonym of *Pilsbryconcha exilis*. However, the separate species status of these two species has been confirmed by molecular data (Zieritz et al., 2016). Considering the difficulties in morphological separation between these two *Pilsbryconcha* species, historical distribution data for this genus should be interpreted with caution.



Figure 15. *Pilsbryconcha exilis* from Kedah, Malaysia

SHELL DESCRIPTION

Shell elongately linguiform but usually less narrow than *P. compressa*, blackish-green in colour (**Error! Reference source not found.**). Umbonal sculpture double-looped to concentric. Hinge without dentition or a very rudimentary pseudocardinal tooth in each valve. Difficult to separate from *P. compressa* (Haas, 1969; Brandt, 1974).

DISTRIBUTION

In Malaysia, the species can be found in small rivers and channels of the Kedah, Perlis and Semerak-basins in Perlis, Kedah and Kelantan (Figure 16). In addition, as revealed by molecular data, at least one introduced population present in a fish pond in Negeri Sembilan (not depicted in map) (Zieritz et al., 2016).

Also present in Cambodia, Java, Laos, Sumatra, Thailand, Vietnam and Singapore (possibly introduced) (Zieritz et al., 2018a).

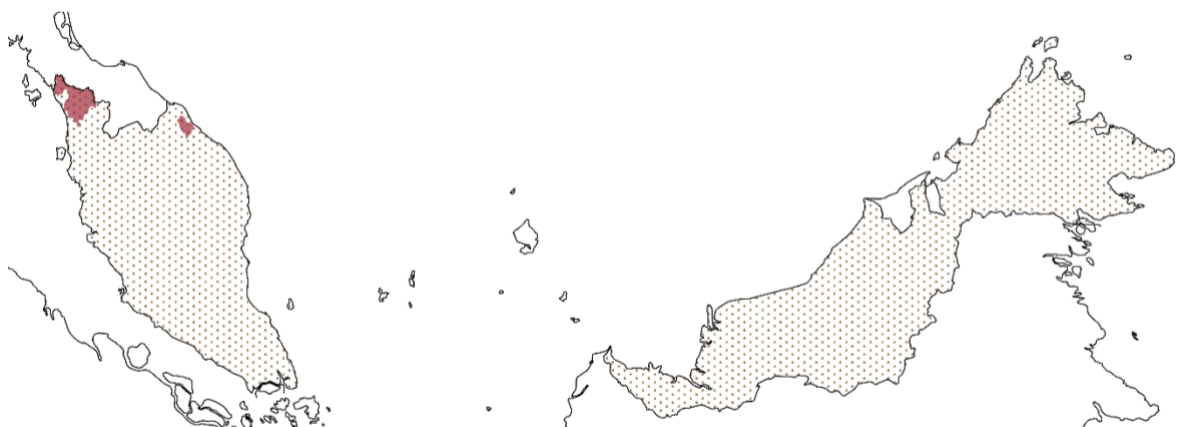


Figure 16. Distribution of *Pilsbryconcha exilis* in Malaysia (excluding isolated, introduced populations in artificial fish ponds).

ECOLOGY

The species is confined to small streams and rice-paddy channels with muddy/sandy sediment. Often associated with *Sinanodonta woodiana*. Species can be fairly abundant at some sites, reaching densities of up to 10 specimens/m² (A. Zieritz, pers. observation). Recruitment ongoing, as several young specimens were found in recent surveys.

MAJOR THREATS

Interspecific competition with the non-native *S. woodiana*, human-induced acidification and habitat degradation might lead to a loss of the Malaysian populations of this species.

NATIONAL RED-LIST STATUS MALAYSIA

P. exilis is assessed as Least Concern in Malaysia because it is still well distributed and it seems to do well in disturbed and anthropogenically modified habitats.

RESEARCH AND CONSERVATION ACTION NEEDS

Current populations should be monitored to detect any decrease or loss of populations. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pressidens insularis (Drouet, 1894)

DD

Taxonomic notes: Potentially conspecific with the other two *Pressidens* species currently recognised, *Pressidens exanthematicus* (Borneo) and *Pressidens moellendorffi* (Palawan Island).

SHELL DESCRIPTION

Shell delicate and oval in outline. Umbonal sculpture double-looped. Hinge structure: one pseudocardinal and one lateral tooth in each valve (Haas, 1969) (Figure 17).



Figure 17. Syntype of *Pressidens insularis* (Senckenberg Museum Frankfurt, specimen 3602)

DISTRIBUTION

Pressidens insularis is endemic to Banggi (alternative spelling: Banguey) Island within the Kudat division of Sabah, Malaysia (Figure 18). To our knowledge, no attempts have been made to confirm presence of this species on Banggi Island since the early 20th century (specimen 21774, Chicago Field Museum of Natural History; specimen 92-7-20-1-3, Natural History Museum, London; specimen 3602, Senckenberg Museum Frankfurt).

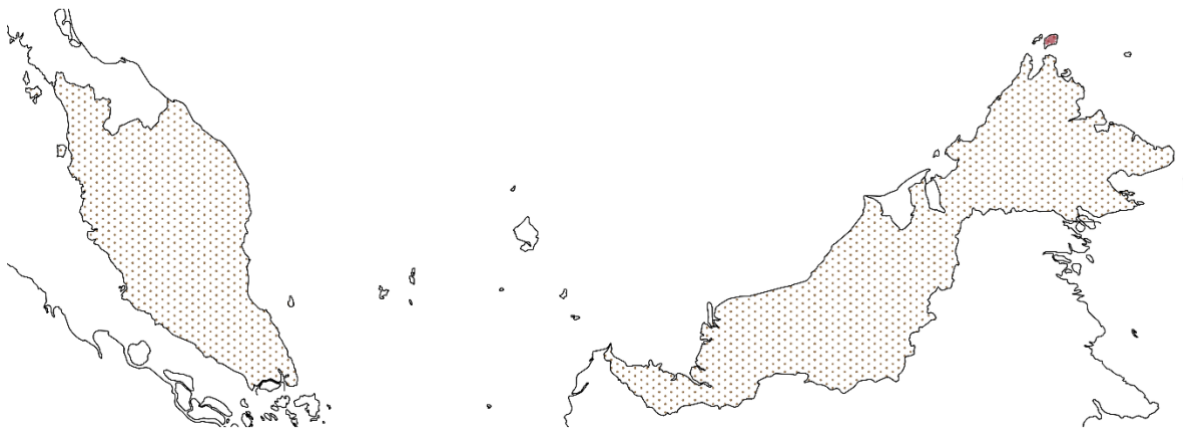


Figure 18. Distribution of *Pressidens insularis*.

ECOLOGY

No information available.

MAJOR THREATS

Not known but potentially development in Banggi Island.

NATIONAL RED-LIST STATUS MALAYSIA

Data Deficient. No attempts have been made since the early 20th century to confirm current presence of this species in its known range.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys are needed to locate any potentially remaining populations of *P. insularis* in Banggi Island. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. Taxonomic and molecular studies are needed to clarify the status of this and the other *Pressidens* species. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pseudodon cambodjensis (Petit, 1865)

SHELL DESCRIPTION

Shell typically compressed, oval-shaped and rounded in outline, yellowish-brown to blackish-brown in colour, and smooth and often appearing glossy (Figure 19). Young specimens winged. Hinge structure: one smooth pseudocardinal tooth in each valve. Morphological separation from other *Pseudodon* species difficult (Haas, 1969; Brandt, 1974).



Figure 19. *Pseudodon cambodjensis* from Perak River, Malaysia

DISTRIBUTION

In Malaysia, known from the Perak, Kelantan and Golok river basins in northern Peninsular Malaysia (Figure 20). Considering the difficulties in morphological separation between *Pseudodon* species, historical distribution data for this genus should be interpreted with caution.

Also present in Cambodia, Thailand and Vietnam. Due to difficulties in separation from other *Pseudodon* species, the detailed distribution of *P. cambodjensis* outside Malaysia is unknown.

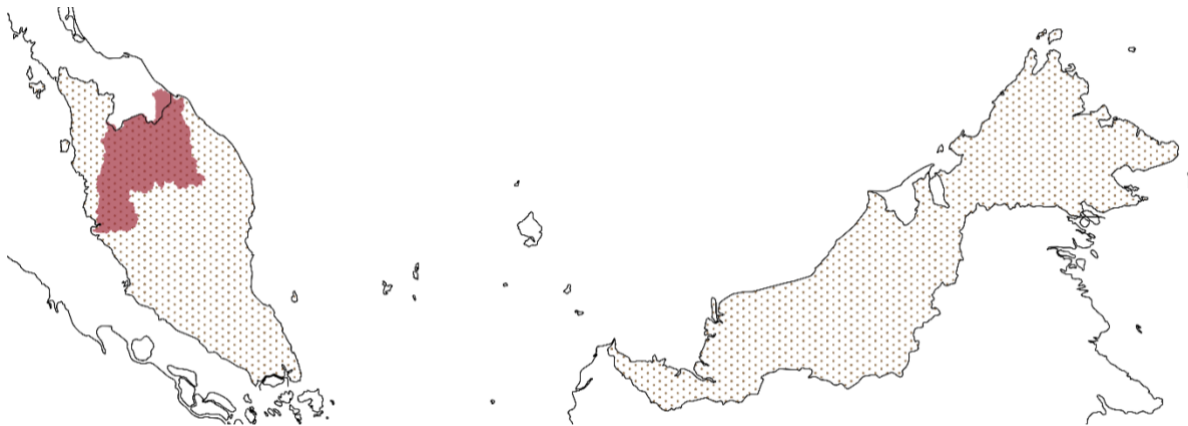


Figure 20. Distribution of *Pseudodon cambodjensis* in Malaysia.

ECOLOGY

In Peninsular Malaysia, only found in clean, unpolluted streams and rivers with low suspended sediment concentrations and heterogenous substrate (Zieritz *et al.*, 2016). In the Perak River, the species is associated with *Rectidens sumatrensis*, *Pseudodon vondembuschianus* and *Conradens Conradens*. In Kelantan, the species was not found to be associated with other unionoids.

MAJOR THREATS

Habitat pollution due to insufficient or complete lack of water treatment in rural areas. Extreme flooding events, potentially associated with climate change, and altered hydrological regimes of rivers. Other potential threats may be habitat modification (e.g. concrete channels, dams) and non-native species introductions.

NATIONAL RED-LIST STATUS MALAYSIA

Vulnerable D2. The species is known from only three sites with many threats. There is reason to believe that the species has suffered a strong decline. There is a high risk if the threats persist that the species will become quickly CR or RE.

RESEARCH AND CONSERVATION ACTION NEEDS

Considering the restricted distribution of this species, protection of the habitats in Peninsular Malaysia and Thailand are crucial for the survival of this species. In Peninsular Malaysia, this would have to involve public outreach. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pseudodon crassus Drouet & Chaper, 1892

SHELL DESCRIPTION

Shell thick, inflated, elongated rhomboid in outline, blackish in colour (Figure 21). Hinge structure: right valve with two pseudocardinal teeth of similar size, left valve with one cardinal tooth. Morphological separation from other *Pseudodon* species difficult (Haas, 1969).



Figure 21. Type specimen of *Pseudodon crassus* (taken from original description by Drouet & Chaper, 1892)

DISTRIBUTION

Pseudodon crassus is considered endemic to Malaysian Borneo, but no records are available since its description in 1892. We are thus aware of only one known location of this species, i.e. the Sarawak River in western Sarawak (type locality) (Figure 22). To our knowledge, no attempts have been made to confirm presence of this species in either the type locality or anywhere else since its description.

There are no known locations outside of Malaysian Borneo.

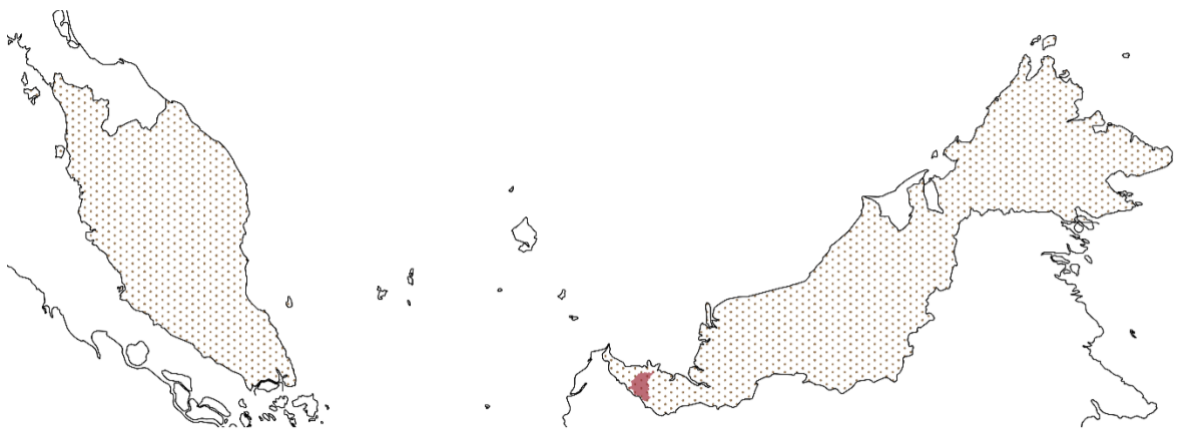


Figure 22. Presumed distribution of *Pseudodon crassus*.

ECOLOGY

No information available.

MAJOR THREATS

The species has in all likelihood suffered extensive population losses since it has last been recorded as a consequence of urban development (the city of Kuching and adjacent settlements and industries), which has been accompanied by deforestation, land-use change, pollution and regulation of rivers. All of these threats are likely to affect any potentially remaining populations now and in the future.

NATIONAL RED-LIST STATUS MALAYSIA

Vulnerable D2. The species is known from only a single location, the Sarawak River, where it was last recorded in 1892. Since then, the type locality has suffered severe alterations including the development of the city Kuching. Due to the threats present across the species' distribution range, there is a strong probability that the species may fall rapidly in either Critically Endangered or Extinct.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys in the River Sarawak and adjacent basins are needed to locate any potentially remaining populations of *P. crassus*. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pseudodon cumingii (Lea, 1850)

Taxonomic notes: In previous IUCN assessments, *Pseudodon cumingii* was considered a synonym of *Pseudodon insocularis*. However, molecular data (Zieritz *et al.*, 2016; J. Pfeiffer, unpublished data) indicate that these two species are separate. Since the type specimen was described from Malacca (=Peninsular Malaysia), the Malay populations in the Northwest of the peninsula are considered as *P. cumingii*.



Figure 23. *Pseudodon cumingii* from Kedah, Malaysia

SHELL DESCRIPTION

Shell moderately inflated, ovate in outline, rather solid, brownish to black in colour (Figure 23). Hinge structure: strong pseudocardinal tooth in each valve. Morphological separation from other *Pseudodon* species difficult (Haas, 1969).

DISTRIBUTION

In Malaysia, restricted to two small river basins in northwest Peninsular Malaysia (Kedah and Perlis State) (Figure 24). Considering the difficulties in morphological separation between *Pseudodon* species, historical distribution data for this genus should be interpreted with caution.

Also known from a location in northern Thailand (J. Pfeiffer, unpublished data).

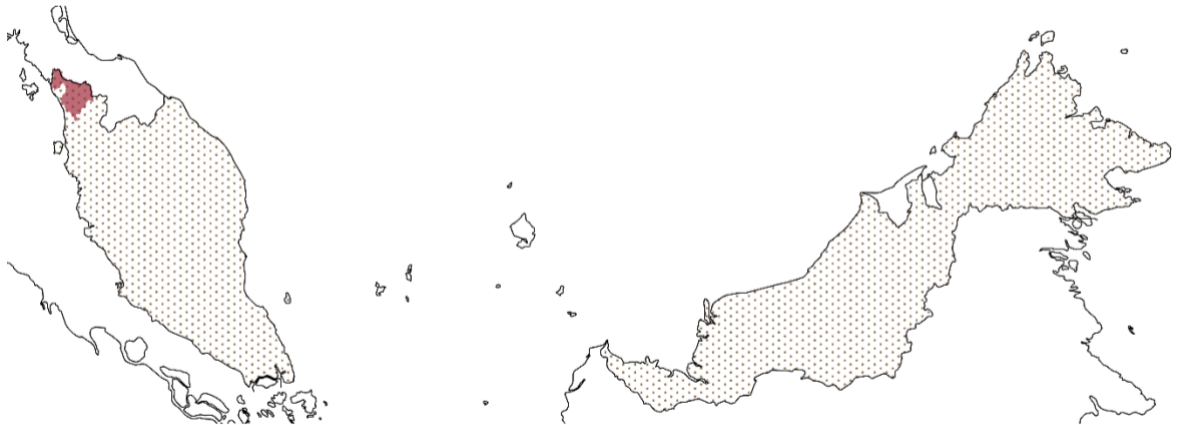


Figure 24. Distribution of *Pseudodon cumingii* in Malaysia.

ECOLOGY

Pseudodon cumingii is confined to small rivers and channels in between rice paddy fields with muddy/sandy sediment. The species is associated with *Pilsbryconcha exilis* and the non-native *Sinanodonta woodiana*.

MAJOR THREATS

In Peninsular Malaysia, the species is only present in semi artificial streams in between paddy fields and are therefore sensitive to water diversion and crop management activities. They may also be particularly threatened by interspecific competition with *S. woodiana*.

NATIONAL RED-LIST STATUS MALAYSIA

Vulnerable D2. Records are restricted to only two locations in the Kedah river and Perlis river basin in northwest Peninsular Malaysia. Due to crop management of rice paddies and to the transitory nature of associated streams, this species could quickly become Critically Endangered or Regionally Extinct.

RESEARCH AND CONSERVATION ACTION NEEDS

Considering the restricted distribution of this species, protection of the habitats in NW-Peninsular Malaysia are crucial for the survival of this species. The potential threat of interspecific competition (e.g. host fishes, space and food resources) with *S. woodiana* requires further research. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Pseudodon vondembuschianus (Lea, 1840)

SHELL DESCRIPTION

Shell variable, fairly compressed to moderately inflated, outline variable but usually elongately elliptical, dark-brown in colour (Figure 25). Young specimen winged. Umbos with zigzag sculpture. Hinge structure: one thin and long pseudocardinal tooth in each valve. Morphological separation from other *Pseudodon* species difficult (Haas, 1969; Brandt, 1974).



Figure 25. *Pseudodon vondembuschianus* from Pahang basin, Malaysia

DISTRIBUTION

Widespread and common in Peninsular Malaysia, and known from the Perak, Pahang, Muar and Kesang basins (Figure 26), reaching densities of about 50 mussels/m². Considering the difficulties in morphological separation between *Pseudodon* species, historical distribution data for this genus should be interpreted with caution.

Also present in Cambodia, Indonesia (Java, Sumatra), Laos, Thailand, Vietnam and Singapore (possibly introduced).

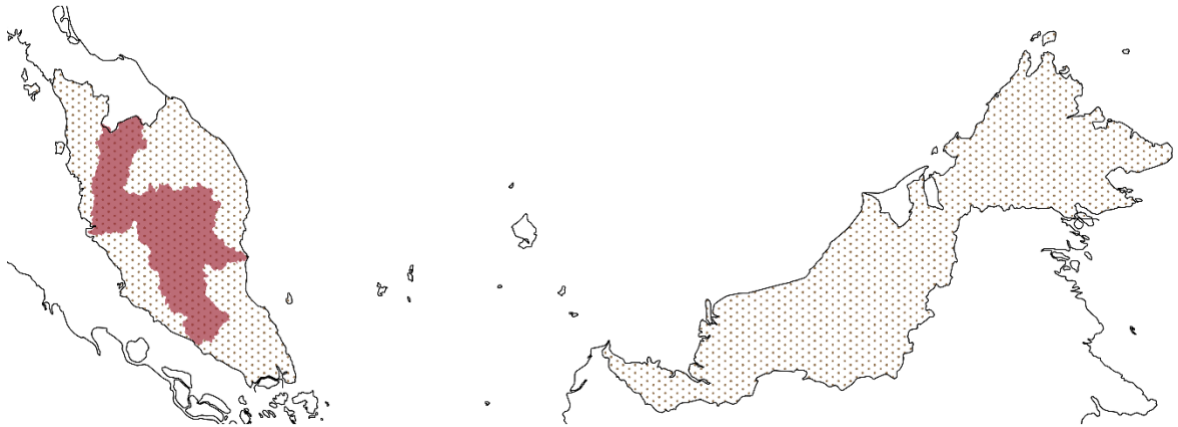


Figure 26. Distribution of *Pseudodon vondembuschianus* in Malaysia.

ECOLOGY

In Peninsular Malaysia, found in relatively unpolluted streams and rivers with stable substrate of various grain sizes (mud to gravel) (Zieritz *et al.*, 2016). Regularly associated with *Conradens Conradens*.

MAJOR THREATS

Habitat pollution due to insufficient or complete lack of water treatment in rural areas. Other potential threats may be habitat modification (e.g. concrete channels, dams) and non-native species introduction.

NATIONAL RED-LIST STATUS MALAYSIA

Least Concern.

RESEARCH AND CONSERVATION ACTION NEEDS

Although it is widespread, the species is still poorly known and information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed. Water treatment should be improved to minimise pollution.

Pseudodon walpolei (Hanley, 1871)

SHELL DESCRIPTION

Shell solid, inflated, rhomboid in outline, brown to blackish in colour, and slightly glossy (Figure 27). With wing and two posterior ridges. Umbonal sculpture wrinkled. Hinge structure: both valves with one short, rounded pseudocardinal tooth. Morphological separation from other *Pseudodon* species difficult (Haas, 1969).



Figure 27. Lectotype of *Pseudodon walpolei* (Museum of Comparative Zoology Harvard, specimen 175577)

DISTRIBUTION

Pseudodon walpolei is considered endemic to northern Borneo with multiple historical records from the Malaysian State of Sarawak and the adjacent Kingdom of Brunei. According to these records, historical distribution of the species used to range from Kuching in western Sarawak to Brunei, located about 500 km to the northeast. However, the species has not been found since the early 20th century, and extensive surveying across central and northeast Sarawak in 2016 was unsuccessful in locating any current *P. walpolei* populations in Malaysia (Zieritz *et al.*, 2018b). This suggests that if the species is still present in Sarawak at all, it is probably confined to the westernmost basins of the state (Figure 28).

Also recorded from Brunei.

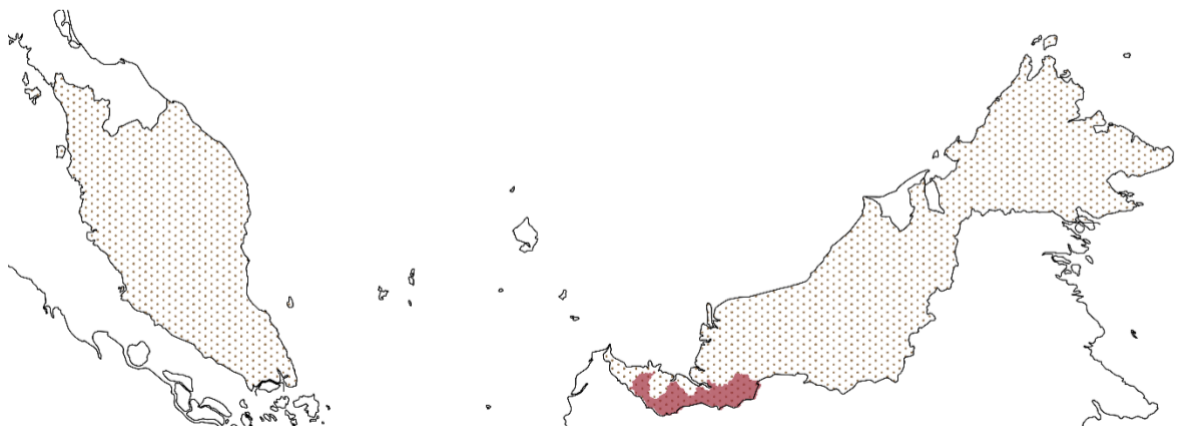


Figure 28. Potential distribution of *Pseudodon walpolei* in Malaysia.

ECOLOGY

No information available.

MAJOR THREATS

The species has in all likelihood suffered extensive population losses since it has last been recorded. Urban development (the city of Kuching and adjacent settlements and industries), extensive deforestation, land-use change, pollution and regulation of rivers are likely to affect remaining populations now and in the future.

NATIONAL RED-LIST STATUS MALAYSIA

Pseudodon walpolei is here assessed as Near Threatened in Malaysia since it was not detected in recent surveys in the country and therefore has a confirmed decline of 22% in EOO almost reaching the threshold for Vulnerable VU A2c. The remaining distribution has not been surveyed and so the decline may be much greater and will probably lead to an Endangered or Critically Endangered status.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys – particularly in the River Sarawak - are needed to locate any remaining populations of *P. walpolei*. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Rectidens sumatrensis Dunker, 1852

NT

Taxonomic notes: Until recently, the genus *Rectidens* was considered to comprise two species, i.e. *Rectidens sumatrensis* Dunker, 1852 in Sumatra, Java and Peninsular Malaysia (type locality: Danau Luar, Sumatra), and *Rectidens lingulatus* (Drouet & Chaper, 1892) in Borneo (type locality: Kapuas basin, Kalimantan) (Haas, 1969; Graf & Cummings, 2007). However, molecular analyses revealed that specimens from Peninsular Malaysia and Sarawak in Borneo represent a single species. The current assessment therefore considers *R. lingulatus* a synonym of *R. sumatrensis*.



Figure 29. *Rectidens sumatrensis* from Sungai Perak, Malaysia

SHELL DESCRIPTION

Shell elongated, usually with parallel dorsal and ventral margins, and well-developed posterior ridge (Figure 29). Brown to blackish in colour. Umbonal sculpture double-looped. Hinge structure: long pseudocardinal and lateral teeth (Haas, 1969).

DISTRIBUTION

In Peninsular Malaysia, only known from a single site in the Perak River (Figure 30). Historical records in the Pahang River (e.g. specimen 99-9-4-1, Museum of Natural History, London) could not be confirmed in surveys in 2015 (Zieritz *et al.*, 2016). In Malaysian Borneo found in 2016 from several localities in four river basins in Sarawak, the Baram, Rajang, Suai and Kemena basins (Figure 30). Additional museum records are available from the Niah and Limbang basins. Historical records also from Singapore, northern Kalimantan, Sumatra and Java.

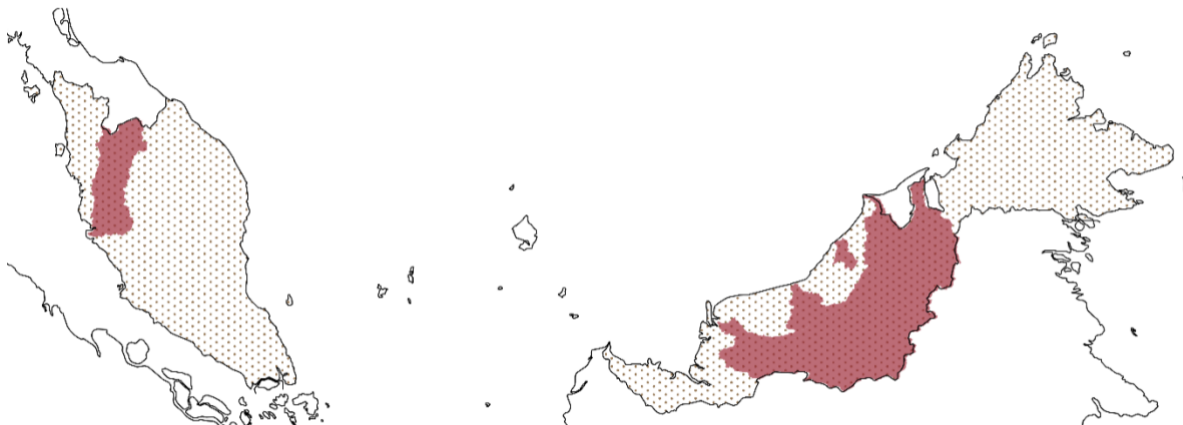


Figure 30. Current distribution of *Rectidens sumatrensis* in Malaysia.

ECOLOGY

R. sumatrensis is confined to unpolluted reaches of rivers with stable substrate, is particularly sensitive to eutrophication and requires a pH close to 7 (Zieritz *et al.*, 2016, 2018b). It is associated with *Pseudodon vondembuschianus*, *Pseudodon cambodjensis* and *Contradens contradens*, and at least in the Suai basin, with the non-native *Sinanodonta woodiana*.

MAJOR THREATS

Potential threats for this species are alteration of flow regime through dams and extreme flooding events, as well as eutrophication, acidification and alkalinisation of its habitat, which is linked to ongoing human disturbances in the region, such as deforestation, pollution, land-use change and fertilisation.

The threat posed by the non-native *S. woodiana* to native *R. sumatrensis* populations in Malaysia is currently limited due to the rather distinct ecological niches of the two species. However, ongoing spread of *S. woodiana* – particularly in Sarawak – could pose a significant threat to *R. sumatrensis* in the future, together with the deteriorating habitat conditions due to ongoing deforestation, land-use change, damming and pollution. *R. sumatrensis* populations in the Suai river might already be threatened by sympatrically living *S. woodiana*, which

has been shown to be able to outcompete native mussel populations in disturbed habitat (Paunovic *et al.*, 2006).

NATIONAL RED-LIST STATUS MALAYSIA

R. sumatrensis is assessed as Near Threatened in Malaysia. The species has apparently become extinct in the Pahang basin, reducing its EOO in the country by 36.7%, and can therefore be considered close to meeting criteria A2c.

RESEARCH AND CONSERVATION ACTION NEEDS

Comparison of current distribution data with historical data, which include records from the Pahang River as well as an undefined location in Singapore, indicates a severe decrease in range of *R. sumatrensis* on the Malay Peninsula. Efforts should be directed towards minimising eutrophication, acidification and alkalinisation at sites with remaining *R. sumatrensis* populations across Malaysia. Zieritz *et al.* (2018b) propose four distinct management units for this species, i.e. (1) Perak, (2) lower Rajang/Kemena, (3) Suai and upper Rajang, and (4) Baram basins, based on the molecular data available to date.

Effects of land-use change and pollution on water quality could be minimized by establishing riparian buffers for the river and its tributaries passing through agricultural and residential lands. The Suai basin unit is of particular concern due to its location within a Palm Oil plantation and the sympatric presence of *S. woodiana*. Halting or slowing down the spread of *S. woodiana* will first and foremost require a campaign to inform the public about the threats this and other non-native species pose to Malaysia's unique freshwater biodiversity.

As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Schepmania nieuwenhuisi (Schepman, 1898) & *Schepmania parcesculpta* (Martens, 1903)

Taxonomic notes: Haas (1969) argued that *Schepmania nieuwenhuisi* (Schepman, 1898) and *Schepmania parcesculpta* (Martens, 1903), both of which are considered endemic to eastern Borneo, probably represent a single species. Molecular analysis of populations from the two species' type locations (i.e. "Bloe-oe river" in the Mahakan basin and "Guleh river" in the Sangkulirang basin, both in East Kalimantan) will be needed to resolve this question. The current assessment treats the two "species" as a single taxonomic entity.

SHELL DESCRIPTION

Shell robust and rather thick, moderately inflated, somewhat squarely oblong in outline, and dark-brown in colour (Figure 31). With posterior ridge and sculpture of radiating folds. Hinge sculpture: one thick pseudocardinal tooth and one lamellar tooth in right valve, two pseudocardinal and lateral teeth in left valve (Haas, 1969).

DISTRIBUTION

S. nieuwenhuisi/parcesculpta is endemic to eastern Borneo, i.e. Sabah in Malaysia (Figure 32), and East and probably North Kalimantan in Indonesia. The species has been last collected from Sabah in 2003 (specimen 29085, North Carolina Museum of Natural Sciences) at Kampung Labang, but a revisit of that site including interviews with local residents in 2016 was unsuccessful in locating any specimens from that location (Zieritz *et al.*, 2018b). Nonetheless, several other relatively recent records from Sabah including Gomantong in 1987 (specimen 29163, North Carolina Museum of Natural Sciences) and Tungku river in 1962 (specimen 118893, Chicago Field Museum) suggest that populations of *S. nieuwenhuisi/parcesculpta* still exist in Sabah.

S. nieuwenhuisi/parcesculpta records from Kalimantan date at least 60 years back.

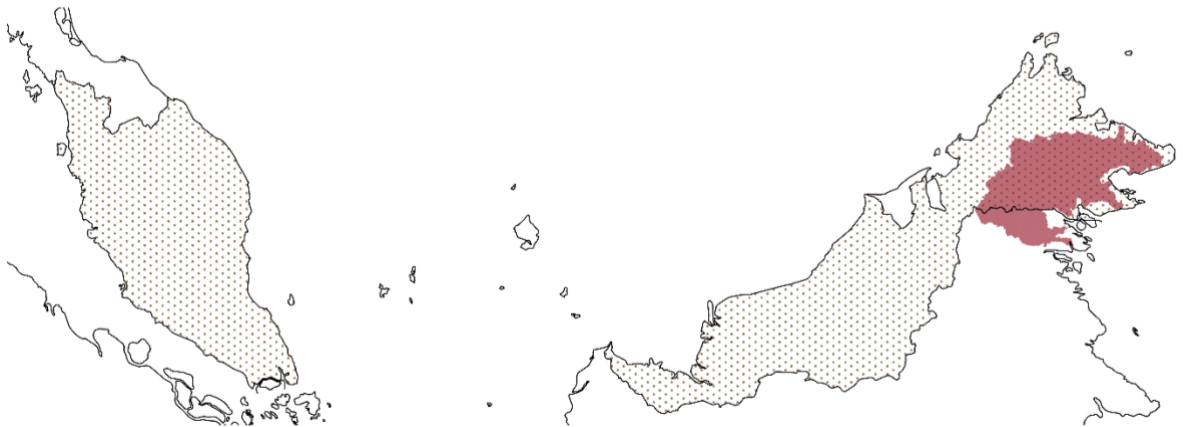


Figure 32. Presumed distribution of *Schepmania* spp. in Malaysia.

ECOLOGY

No information available.

MAJOR THREATS

The species has in all likelihood suffered extensive population losses since the 1970s as a consequence of intensive deforestation, large-scale conversion of primary forest to agricultural monocultures, impoundment of rivers and introduction of non-native species. All of these threats are likely to affect any potentially remaining populations now and in the future.



Figure 31. Type specimens of *Schepmania nieuwenhuisi* (above, taken from original description by Schepman, 1898) and *Schepmania parcesculpta* (below, Zoologisches Museum Berlin, specimen 108847).

NATIONAL RED-LIST STATUS MALAYSIA

Data Deficient. Due to the difficulties in conducting fieldwork in eastern Sabah's river basins, recent data on the distribution of *S. nienhuysi/parcesculpta* populations is very poor and contradicting. Relatively recent finds of this species from at least three different sites (i.e. Sepulut, Tungku and Kinabatangan basins) indicate that at least some populations have remained in Sabah. However, considering the past and current, immense habitat changes in the area, it is very likely that *S. nienhuysi/parcesculpta* has suffered considerable population losses over the past decades. Targeted and repeated surveys across Eastern Sabah will be needed to determine if the species is already locally extirpated in Malaysian Borneo or if any populations remain in the area.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys – particularly in the Tungku and Kinabatangan basins - are needed to locate any potentially remaining populations of *S. nienhuysi/parcesculpta* in Malaysia. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. The taxonomic status of both species needs to be validated by the aid of molecular tools. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Simpsonella gracilis (Lea, 1850)

SHELL DESCRIPTION

Shell delicate, inflated, elongately-ellipsoid in outline, and greenish to brownish in colour (Figure 33). Sometimes with wing. Umbonal sculpture W-shaped. Hinge without teeth (Haas, 1969).



DD

Figure 33. Type specimen of *Simpsonella gracilis* (Smithsonian National Museum, specimen 86602)

DISTRIBUTION

In Malaysia, *Simpsonella gracilis* is restricted to Banggi (alternative spelling: Banguay) Island within the Kudat division of Sabah (Figure 34), where it has been found at least once (specimen 128577, Smithsonian National Museum of Natural History). To our knowledge, no attempts have been made to confirm presence of this species on Banggi Island since the early 20th century.

The species is widespread across the Philippines.

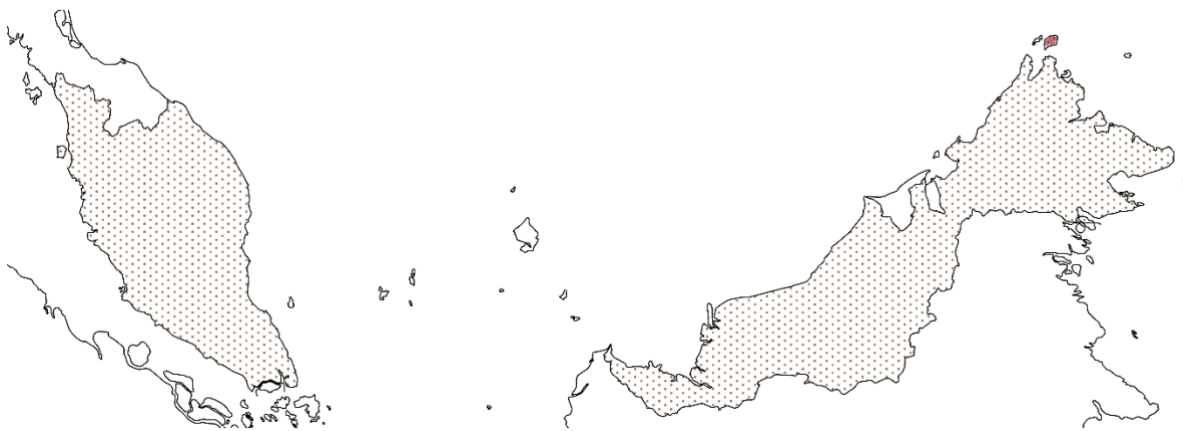


Figure 34. Distribution of *Simpsonella gracilis* in Malaysia.

ECOLOGY

No information available.

MAJOR THREATS

Not known but potentially development in Banggi Island.

NATIONAL RED-LIST STATUS MALAYSIA

Data Deficient. No attempts have been made since the early 20th century to confirm current presence of this species in its known range.

RESEARCH AND CONSERVATION ACTION NEEDS

Targeted surveys are needed to locate any potentially remaining populations of *P. insularis* in Banggi Island. If surviving populations of this species would be found in the future, the respective reaches and river basins should be placed under immediate protection. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution, population trends and threats is needed.

Sinanodonta woodiana (Lea, 1834)

Taxonomic notes: Whilst *Sinanodonta woodiana* is generally believed to be native to the Yangtze basin in China, the available Sundaland sequences do not closely match any of the *S. woodiana* sequences available on Genbank to date (Bolotov *et al.*, 2016; Zieritz *et al.*, 2018b). The question of the exact origin of these introduced populations as well as whether this tropical invasive lineage in fact represents a separate species to the temperate invasive lineage thus remains unanswered.



Figure 35. *Sinanodonta woodiana* from Perak basin, Malaysia

SHELL DESCRIPTION

Shell very variable, but usually thin to moderately thick, irregularly elliptical or ovate in shape, more or less inflated, and yellowish-green to dark brown in colour (Figure 35). Umbonal sculpture of parallel ridges that are sometimes slightly double-looped. Hinge without teeth (Haas, 1969)

DISTRIBUTION

In Malaysia, until recently known from only a few scattered records in artificial habitats in Kuala Lumpur, Peninsular Malaysia (specimen 4140, Muséum National d'Histoire Naturelle, Paris), and a market in Sabah, Borneo (Bogan & Schilthuizen, 2005). Unfortunately, surveys in 2015 and 2016 revealed that it is now the most widely spread and common freshwater mussel species in Malaysia (Zieritz *et al.*, 2016, 2018b). It is present in at least ten and six river basins in Peninsular Malaysia and Malaysian Borneo, respectively (Zieritz *et al.*, 2016, 2018b) (Figure 36). The ongoing spread of *S. woodiana* across Malaysia and probably much of remaining Sundaland has, in all likelihood, been driven predominantly by intentional introductions by people, who are utilising mussels as a food source and for ornamental purposes (A. Zieritz, pers. obs.).

Introduced, widespread and common in Europe, Asia and the Americas (Cummings, 2011).

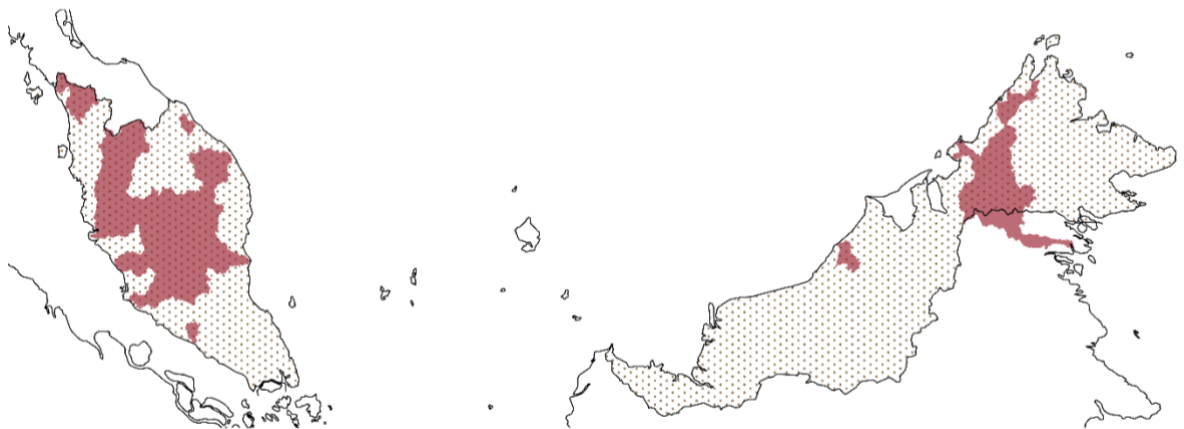


Figure 36. Known current distribution of *Sinanodonta woodiana* in Malaysia.

ECOLOGY

This species is a habitat generalist often found in heavily modified and artificial habitats, but also in small streams and medium-sized rivers, and is tolerant to eutrophication and high siltation rates (Paunovic *et al.*, 2006; Zieritz *et al.*, 2016, 2018b). *Sinanodonta woodiana* can outcompete native mussel species under certain scenarios (Paunovic *et al.*, 2006). This appears to be the case in Peninsular Malaysia and Sabah, where *S. woodiana* has been spreading rapidly, in the course of which several native species declined severely (Zieritz *et al.*, 2016, 2018b).

MAJOR THREATS

The species is not native to Malaysia.

NATIONAL RED-LIST STATUS MALAYSIA

The species is not native to Malaysia.

RESEARCH AND CONSERVATION ACTION NEEDS

Halting or slowing down the spread of *S. woodiana* in Malaysia would first and foremost require a campaign to inform the public about the potential threats this and other non-native species might pose to Malaysia's unique freshwater biodiversity. As for all Malaysian freshwater mussels, information regarding the species' basic biological and ecological traits (e.g. growth, age of maturity, host fishes), detailed distribution and population trends in Malaysia is needed.

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