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Caption: Malabar Slender Loris *Loris lydekkerianus malabaricus* © Dileep Anthikkad.



Bivalves (Mollusca: Bivalvia) in Malaysian Borneo: status and threats

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Abstract: Species checklists enlist the species existing within a distinct geographical biome and assist as an indispensable input for evolving conservation and administration strategies. The arenas of conservation ecology and biology face the challenge of exaggerated biodiversity, accredited to the non-recognition of taxonomic inconsistencies. The study's goals are to organize all scattered taxonomic information regarding bivalve molluscs from Malaysian Borneo, i.e. Sarawak and Sabah, under one umbrella. Available literature regarding Malaysian Borneo was reviewed. The published taxonomic data on bivalve species, conservation status, inconsistencies, habitats (marine, fresh, and brackish), research aspects, threats, and conservation strategies are presented. A critical review of the checklists and distributional records of the class Bivalvia from Malaysian Borneo and subsequent validation of species names with the World Register of Marine Species (WoRMS) database revealed that currently 76 bivalve species from 12 orders and other entities, 18 superfamilies, and 27 families have been recorded from the area. Twenty-six inconsistencies with WoRMS were found, and the corrected names are presented. The study indicates most of the enlisted bivalve species have not been evaluated by the IUCN Red List authority and have 'Least Concern' or 'Data Deficient' status for Malaysian Borneo. To date, published documents on conservation decision strategies and guidelines for future research are not good enough. Nevertheless, potential threats and their remedies for bivalves in the enriched Malaysian Borneo ecosystems are discussed herein.

Keywords. Biodiversity conservation, checklist, database, double-shelled molluscs, IUCN Red List, taxonomic inconsistency.

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INTRODUCTION

The establishment of a database and checklist of regionally present species is crucial in managing and conserving them from alpha to global ecosystem (Amano & Sutherland 2013). The lack of sufficient information at the local level regarding rare and/or endemic species potentially at risk of extinction may lead to strategies taken by different organizations, including the government, that are inadequate to avoid their extinction (Işik 2011). Nowadays, humankind faces some traumatic events, including the so-called “sixth extinction crisis”. The previous five extinctions were caused by massive atmospheric, climatic, and universal phenomena, but the prediction of the next mass extinction is putting the finger on human interference in natural ecosystems (Braje & Erlandson 2013).

At regional and local level, species decline faster than the prediction of ecologists (Collen et al. 2011; Işik 2011), but this can be modified to a sustainable level if the conservation efforts would focus on protecting certain species (Reydon 2019). For example, some aquatic animal recovered their extinction risk by the conservation approach with a proper policy, legislation, and effective conservation measures. Recently, the Bangladesh government and department of fisheries initiated the conservation of red fin mahseer (*Tor tor* Hamilton, 1822). The proper breeding program and management helped this species regain their confined population (Kabir et al. 2018). Similarly, the reproduction and conservation management of butter catfish *Ompok pabda* (Hamilton-Bouchanan, 1822) changes their IUCN status from ‘Near Threatened’ to ‘Endangered’ species (Chakraborty et al. 2010; IUCN Bangladesh 2015). Now, aquaculture is very extensive for *Ompok pabda* (Hamilton-Bouchanan, 1822) in Bangladesh and the Indian region (Chaklader et al. 2016; Alam et al. 2020).

Another is to protect specific areas with high biodiversity, including rare and/or endemic species. Now governments and third-party stakeholders recognize the value of biodiversity conservation, and they convey efforts, finances, and human resources to the conservation of nature. The first step in this process is to know the present status of biodiversity (Groves et al. 2002; Martin et al. 2016), where a checklist and relevant information are considered to be essential documents to step forward. Establishing a database of locally and regionally present species allows management of the national and transboundary continental conservation process (National Research Council 1992).

Bivalves (two valves), are abundant in marine,

brackish and freshwater ecosystems, both infaunal and epifaunal in nature. Most are filter-feeders, but some are carnivores. They influence food webs and aquatic ecosystems via nutrient cycling and habitat modification and act as a bio-indicator (Vaughn & Hoellein 2018). In many countries, bivalves are consumed by humans for which they are harvested from the wild, including freshwater and marine habitats (Köhler et al. 2012; Wijsman et al. 2019). As molluscs are rich in protein and fat, along with essential nutrients including vitamins and macro-micro nutrients, restaurants around the world serve them as delicious and luxury food (e.g., Venugopal & Gopakumar 2017; Olivier et al. 2020). Bivalve shells, including the waste of such meals, are also used as buffer material for soil fixation; for instance, Korean scientists applied oyster waste to increase soil pH and other micro-macro nutrients (Lee et al. 2008).

In East Malaysia (Sarawak and Sabah, including the federal territory of Labuan), bivalves are considered a delicacy, and highly nutritious consumable commodities (Hamli et al. 2012b). Some previous studies described the bivalve fauna of Peninsular Malaysia (Idris et al. 2012; Jasin 2015; Zieritz et al. 2016; Zieritz & Lopes-Lima 2018). Some studies have been conducted in the Malaysian province of Sarawak and Sabah covering different habitats, including mangroves (Hamli et al. 2015; Abu Hena et al. 2016), seagrass (Al-Asif et al. 2020), wetlands (Idris et al. 2021), and freshwater (Hamli et al. 2020). Noticeably, the bivalve species from freshwater environments have a more than four to six times higher risk of extinction than those in marine habitats (Agudo-Padrón 2011).

Currently there is no monograph of bivalves (or molluscs in general) covering Malaysian Borneo. Thus far only a small fraction of the bivalve fauna of Malaysian Borneo has been recorded. The first bivalves from modern history of Malaysian Borneo were recorded from the Pantai river, Sarawak (Turner & Santhakumaran 1989) and Sematan mangrove forest, Sarawak (Ashton et al. 2003), although the first record can be tracked back in 1791, from the Federal territory of Labuan (A small island near coast of Sarawak and Sabah in Malaysian Borneo), with the report of native bivalve species *Marcia japonica* (Gmelin, 1791) (reported as *Venus japonica* Gmelin, 1791) (Gmelin 1791). With time, the number of published documents (taxonomic and ecological studies) has increased, but the list of bivalve fauna from East Malaysia remains very incomplete. Numerous species are recorded in Huber (2010, 2015), but his records ‘north Borneo’ or just ‘Borneo’ are not specific enough to be included here. Similar taxonomic

and conservation work was published on fish species of Bangladesh in which the implementation of conservation measures on local fish habitats was proposed (Parvez et al. 2019). Similarly, the current investigation intends making a checklist of bivalves in the Malaysian part of Borneo, including their conservation status. This study also discusses the existing research initiatives, future research prospective, and recommended measures toward conserving this vital living resource.

MATERIALS AND METHODS

The current study is based on published records regarding Malaysian Borneo (Sarawak and Sabah; Figure 1), including monographs, reviews, checklists, catalogues, posters, conference papers and posters, websites, and fishery reports from 1791 and 2020, but no additional material was collected. For each reported species the scientific names were confirmed based on the World Register of Marine Species (WoRMS) 2021 and MolluscaBase eds (2021) (validating unaccepted names, emendations, alternate, and representations).

The identifications were not checked for correctness. In most cases this was not possible, as most publications contain no photographs of the recorded species. New records should be accompanied by photographs as misidentifications are commonplace.

The species list comprises, orders, superfamilies, family name, accepted name, unaccepted names, and emendations. The contribution (%) of different orders within the class Bivalvia and various superfamilies and families in the class was estimated. The statistical data, total species counts, and graphical presentation were analyzed using Microsoft Excel.

RESULTS

Bivalve diversity

A total of 76 species of bivalves from 12 orders/ infraclasses/ superorders/ subclasses, 18 superfamilies, and 27 families were reported from freshwater and marine habitats (seagrass meadow, intertidal, mangrove, freshwater, wetlands, and coastal region of Sarawak and Sabah) in Malaysian Borneo (Figure 2).

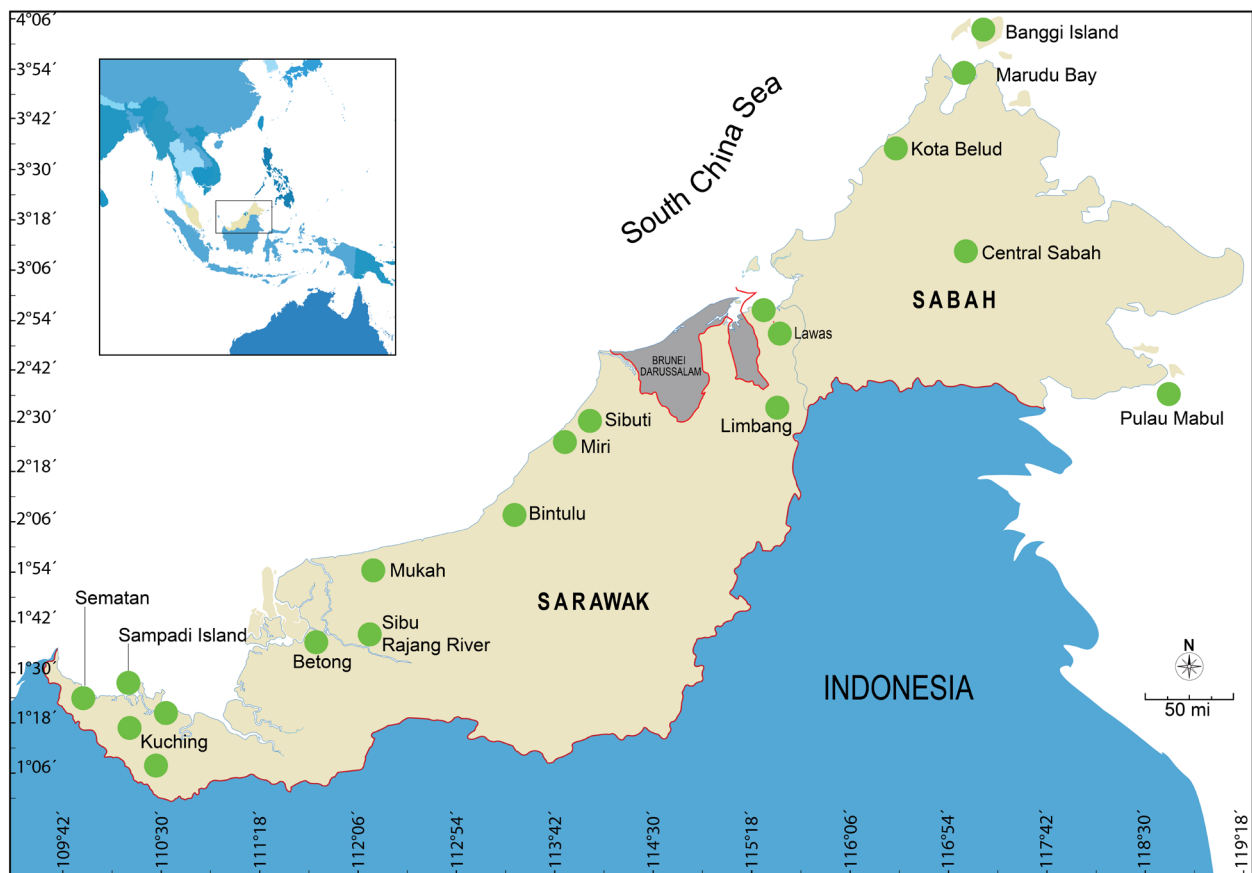


Figure 1. Map of the of the East Malaysian states showing Sarawak and Sabah (The green circles denote the areas covered the study).

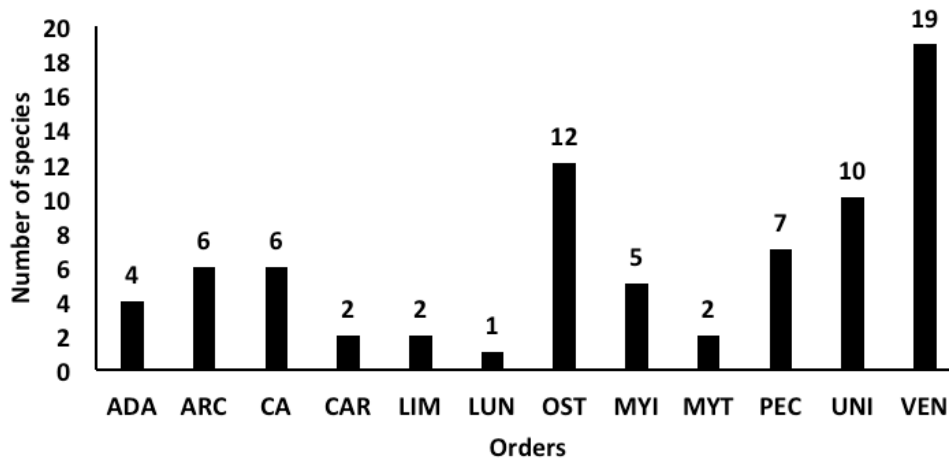


Figure 2. Number of Bivalves species based on the order recorded in Malaysian Borneo.

ADA—Adapedonta | ARC—Arcida | CA—Cardiida | CAR—Carditida | LIM—Limida | LUC—Lucinida | OST—Ostreida | MYI—Myida | MYT—Mytilida | PEC—Pectinida | UNI—Unionida | VEN—Venerida.

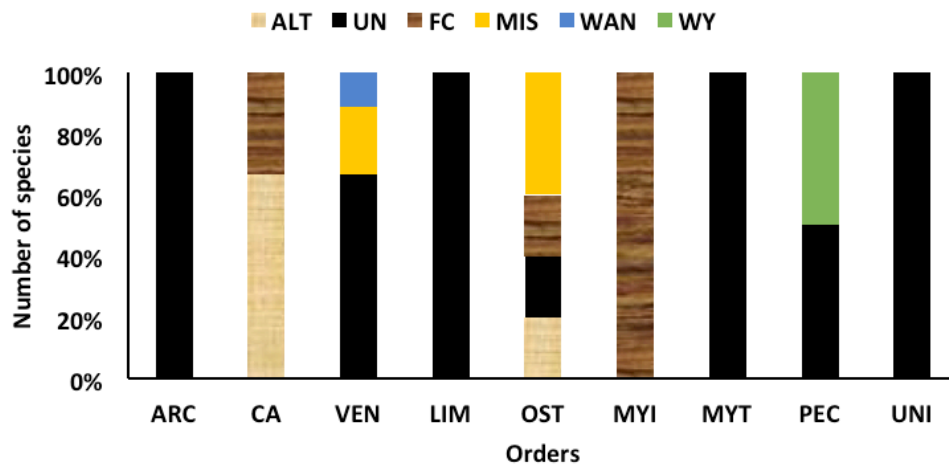


Figure 3. Extent of taxonomic inconsistencies in the orders of the class Bivalvia thus far recorded from Malaysian Borneo.

ARC—Arcida | Ca—Cardiida | Ven—Venerida | Lim—Limida | Ost—Ostreida | Myi—Myida | MYT—Mytilida | Pec—Pectinida | Uni—Unionida | ALT—Altnet representation | UN—Unaccepted | FC—Family changed | MIS—Misspelling | WAN—Wrong author name | WY—Wrong year.

A critical review of the published checklists revealed that the current literature included 26 incorrect names for bivalve species from nine orders/ infraclasses/ superorders/ subclasses and 14 families. Of these inconsistencies in the bivalve checklist over 53.84 % (14 species) was due to names not accepted in WoRMS (2021), spelling mistakes (15.38%; 4 entities), alternative representation and inconsistency in family name (both 11.54 %; 3 entities each), and inconsistencies in author and year (both 3.85 %; 1 entity each) (Figure 3).

Knowledge gap on bivalve research in Malaysian Borneo

In the current century, macro benthic surveys were first conducted in Malaysian territory in 1981

(Morris & Purchon 1981; Way & Purchon 1981). In East Malaysia, Turner & Santhakumaran (1989) and Ashton et al. (2003) performed the first baseline study of bivalves in the Pantai River and Sematan mangrove forest, Sarawak. After that, extensive taxonomic studies were conducted by Hamli et al. (2012b); whereas Wong & Arshad (2011) published a significant checklist of bivalves. In a publication that reported edible bivalves and gastropods from different markets in Sarawak and that was published very recently which dealt with the morphometric and diversity investigation, we excluded that publication from our checklist due to the time span (1791–2020) in which it was published; however, the paper reported one new record *Arcuatula arcuatula* (Hanley, 1843) and rest of the species were already



Table 1. Bivalve fauna in Malaysian Borneo.

Order/Infra Class/ Super Order/ Sub Class	Super Family	Family	Species	IUCN	Habitat	Ref	
Adapedonta	Solenioidea	Pharidae	<i>Sinonovacula constricta</i> (Lamarck, 1818)	NE	BW; MAR	Ashton et al. (2003)	
		Solenidae	<i>Pharella acutidens</i> (Broderip & Sowerby, 1829)	NE	BW; MAR	Hamli et al. (2012a,b)	
			<i>Solen lamarckii</i> Chenu, 1843	NE	BW; MAR	Hamli et al. (2012a,b)	
			<i>Solen regularis</i> Dunker, 1862	NE	BW; MAR	Hamli et al. (2012a,b)	
Arcida	Arcoidea	Arcidae	<i>Anadara antiquata</i> (Linnaeus, 1758)	NE	MAR	Al-Asif et al. (2020)	
			<i>Anadara indica</i> (Gmelin, 1791)	NE	MAR	Al-Asif et al. (2020)	
			<i>Anadara kagoshimensis</i> (Tokunaga, 1906)	NE	MAR	Al-Asif et al. (2020)	
			<i>Arca ventricosa</i> Lamarck, 1819	NE	MAR	Wong & Arshad (2011)	
			<i>Barbatia amygdalumtostum</i> (Röding, 1798)	NE	MAR	Wong & Arshad (2011)	
			<i>Tegillarca granosa</i> (Linnaeus, 1758)	NE	MAR	Hamli et al. (2012a, 2012b); Shabdin et al. (2014)	
Cardiida	Cardioidea	Cardiidae	<i>Tridacna crocea</i> Lamarck, 1819	LC	MAR	Wong & Arshad (2011)	
			<i>Tridacna maxima</i> (Röding, 1798)	LC	MAR	Wong & Arshad (2011)	
			<i>Tridacna squamosa</i> Lamarck, 1819	LC	MAR	Wong & Arshad (2011)	
	Tellinoidea	Donacidae	<i>Donax faba</i> Gmelin, 1791	NE	MAR	Al-Asif et al. (2020)	
			Solecurtidae	<i>Azorinus coarctatus</i> (Gmelin, 1791)	NE	BW; MAR	Al-Asif et al. (2020)
				Tellinidae	<i>Eurytellina lineata</i> (W. Turton, 1819) (Pink)	NE	MAR
Carditida	Carditoidea	Carditidae	<i>Beguinia semiorbiculata</i> (Linnaeus, 1758)	NE	MAR	Wong & Arshad (2011)	
	Crassatelloidea	Crassatellidae	<i>Bathytormus radiatus</i> (Sowerby, 1825)	NE	MAR	Al-Asif et al. (2020)	
Limida	Limoidea	Limidae	<i>Ctenoides philippinarum</i> Masahito & Habe, 1978	NE	MAR	Al-Asif et al. (2020)	
			<i>Ctenoides scaber</i> (Born, 1778)	NE	MAR	Wong & Arshad (2011)	
Lucinida	Lucinoidea	Lucinidae	<i>Lepidolucina venusta</i> (Philippi, 1847)	NE	MAR	Al-Asif et al. (2020)	
Ostreida	Ostreioidea	Ostreidae	<i>Crassostrea virginica</i> (Gmelin, 1791)	NE	MAR	Shabdin et al. (2014)	
			<i>Lopha cristagalli</i> (Linnaeus, 1758)	NE	MAR	Shabdin et al. (2014); Wong & Arshad (2011)	
			<i>Magallana bilineata</i> (Röding, 1798)	NE	BW; MAR	Shabdin (2010); Hamli et al. (2012b)	
			<i>Magallana rivularis</i> (Gould, 1861)	NE	BW; MAR	Raven (2019)	
			<i>Ostrea lurida</i> Carpenter, 1864	NE	MAR	Shabdin et al. (2014)	
			<i>Saccostrea scyphophilla</i> (Peron & Lesueur, 1807)	LC	MAR	Matsumoto et al. (2017)	
	Pterioidea	Isognomonidae	<i>Isognomon alatus</i> (Gmelin, 1791)	NE	MAR	Wong & Arshad (2011)	
			<i>Isognomon ephippium</i> (Linnaeus, 1758)	NE	MAR	Ashton et al. (2003); Hamli et al. (2012b)	
			<i>Isognomon nucleus</i> (Lamarck, 1819)	NE	MAR	Matsumoto et al. (2017)	
		Margaritidae	<i>Pinctada margaritifera</i> (Linnaeus, 1758)	NE	MAR	Wong & Arshad (2011)	
		Malleidae	<i>Malleus albus</i> Lamarck, 1819	NE	MAR	Wong & Arshad (2011)	
		Pteriidae	<i>Pteria colymbus</i> (Röding, 1798)	NE	MAR	Wong & Arshad (2011)	
		Myida	Pholadoidea	Pholadidae	<i>Pholas orientalis</i> Gmelin, 1791	NE	BW; MAR
<i>Lignopholas chengi</i> Turner & Santhakumaran, 1989	NE				MAR	Turner & Santhakumaran (1989)	
<i>Lignopholas rivicola</i> (G.B. Sowerby II, 1849)	NE				MAR	Turner & Santhakumaran (1989)	
<i>Lignopholas fluminalis</i> (Blanford, 1867)	NE				FW	Turner & Santhakumaran (1989)	
<i>Martesia striata</i> (Linnaeus, 1758)	NE				BW	Turner & Santhakumaran (1989)	
Mytilida	Mytiloidea	Mytilidae	<i>Byssogerdus striatulus</i> (Hanley, 1843)	NE	BW; MAR	Huber (2010); Raven (2019)	
			<i>Brachidontes variabilis</i> (Krauss, 1848)	NE	MAR	Raven (2019)	

Order/Infra Class/ Super Order/ Sub Class	Super Family	Family	Species	IUCN	Habitat	Ref
Pectinida	Anomioidea	Anomiidae	<i>Enigmonia aenigmatica</i> (Holten, 1802)	NE	BW; MAR	Ashton et al. (2003); Raven (2019)
		Placunidae	<i>Placuna placenta</i> (Linnaeus, 1758)	NE	BW; MAR	Hamli et al. (2012b)
	Pectinoidea	Spondylidae	<i>Spondylus gussonii</i> O.G. Costa, 1830	NE	MAR	Wong & Arshad (2011)
			<i>Spondylus squamosus</i> Schreibers, 1793	NE	MAR	Wong & Arshad (2011)
		Pectinidae	<i>Amusium pleuronectes</i> (Linnaeus, 1758)	NE	MAR	Hamli et al. (2012a,b)
			<i>Mimachlamys varia</i> (Linnaeus, 1758)	NE	MAR	Wong & Arshad (2011)
		<i>Pedum spondyloideum</i> (Gmelin, 1791)	NE	MAR	Wong & Arshad (2011)	
Unionida	Unionoidea	Unionidae	<i>Ctenodesma borneensis</i> (Issel, 1874)	NE	FW	Zieritz & Lopes-Lima (2018); Zieritz et al. (2020)
			<i>Monodontina walpolei</i> (Hanley, 1871)	NE	FW	Zieritz & Lopes-Lima (2018); Zieritz et al. (2020)
			<i>Pilsbryconcha exilis</i> (I. Lea, 1838)	LC	FW	Hamli et al. (2012b)
			<i>Pressidens insularis</i> (Drouët, 1894)	NE	FW	Zieritz & Lopes-Lima (2018); Zieritz et al. (2020)
			<i>Rectidens sumatrensis</i> (Dunker, 1852)	DD	FW	Zieritz & Lopes-Lima (2018)
			<i>Schepmania nieuwenhuisi</i> (Schepman, 1898)	NE	FW	Zieritz & Lopes-Lima (2018); Zieritz et al. (2020)
			<i>Schepmania parcesculpta</i> (von Martens, 1903)	NE	FW	Zieritz & Lopes-Lima (2018); Zieritz et al. (2020)
			<i>Simpsonella gracilis</i> (I. Lea, 1851)	NE	FW	Zieritz & Lopes-Lima (2018)
			<i>Sinanodonta lauta</i> (von Martens, 1877)	NE	FW	Zieritz et al. (2020)
			<i>Sinanodonta woodiana</i> (I. Lea, 1834)	LC	FW	Hamli et al. (2012a,b); Hamli et al. (2020); Zieritz & Lopes-Lima (2018)
Venerida	Veneroidea	Veneridae	<i>Callista erycina</i> (Linnaeus, 1758)	NE	MAR	Al-Asif et al. (2020)
			<i>Circe scripta</i> (Linnaeus, 1758)	NE	MAR	Hamli et al. (2012a,b)
			<i>Gafrarium pectinatum</i> (Linnaeus, 1758)	NE	BW; MAR	Al-Asif et al. (2020)
			<i>Lioconcha castrensis</i> (Linnaeus, 1758)	NE	MAR	Wong & Arshad (2011)
			<i>Marcia hiantina</i> (Lamarck, 1818)	NE	BW; MAR	Shabdin (2010)
			<i>Meretrix casta</i> (Gmelin, 1791)	NE	BW; MAR	Al-Asif et al. (2020)
			<i>Meretrix lusoria</i> (Röding, 1798)	NE	BW; MAR	Al-Asif et al. (2020)
			<i>Meretrix lyrata</i> (G. B. Sowerby II, 1851)	NE	BW; MAR	Al-Asif et al. (2020); Hamli et al. (2012a,b); Hamli et al. (2017)
			<i>Meretrix meretrix</i> (Linnaeus, 1758)	NE	BW ; MAR	Hamli et al. (2012a,b); Abu Hena et al. (2016); Hamli et al. (2016); Matsumoto et al. (2017)
			<i>Paphia rotundata</i> (Linnaeus, 1758)	NE	MAR	Wong & Arshad (2011)
			<i>Paratapes undulatus</i> (Born, 1778)	NE	MAR	Hamli et al. (2012a,b)
			<i>Placamen isabellina</i> (Philippi, 1849)	NE	MAR	Al-Asif et al. (2020)
			<i>Pelecypora exilium</i> (G. B. Sowerby III, 1909)	NE	MAR	Sowerby (1909)
	<i>Marcia japonica</i> (J. F. Gmelin 1791)	NE	MAR	Gmelin (1791)		
	Cyrenoidea	Cyrenidae	<i>Corbicula fluminea</i> (O. F. Müller, 1774)	LC	FW; BW	Shabdin & Alfred (2007)
			<i>Geloina bengalensis</i> (Lamarck, 1818)	LC	BW	Hamli et al. (2012a,b); Hamli et al. (2015)
			<i>Geloina expansa</i> (Mousson, 1849)	LC	BW	Hamli et al. (2012a,b); Shabdin & Alfred (2007); Shabdin (2010); Hamli et al. (2015)
		Glauconomidae	<i>Glauconome virens</i> (Linnaeus, 1767)	NE	MAR	Hamli et al. (2012a,b)
	Arcticoidea	Trapezidae	<i>Neotrapezium sublaevigatum</i> (Lamarck, 1819)	NE	MAR	Raven (2019)

NE—Not Evaluated | LC—Least Concern | DD—Data Deficient | FW—Freshwater | BW—Brackish water | MAR—Marine.

available in our checklist (Idris et al. 2021). There are now a total of 19 published publications accessible, including a book, on the subject (Zieritz & Lopes-Lima 2018). Among the published papers, 10 were published in Scopus indexed journals, the other nine in local non-indexed journals. Six published documents discuss marine bivalves, another six discuss brackish habitats; whilst the papers cover freshwater and freshwater-marine habitats.

DISCUSSION

A comprehensive checklist on Malaysian marine molluscs by Wong & Arshad (2011) documented 581 species. Before this, Way & Purchon (1981) and Morris & Purchon (1981) reported 398 species (330 gastropods and 68 bivalves) from Malaysia and its adjacent coastal waters. In our study, we found bivalves from order Venerida (19 species) has the highest number of species, followed by Ostreida (12) and the freshwater order Unionida (10 species), while the rest of the orders or other entities have less than ten members. Among superfamilies, the Veneroidea (14 species) has the highest number of species, followed by the freshwater Unionoidea (10 species), and the rest of the superfamilies has less than 10 species (Figure 4). The family Veneridae comprises 14 species which is the highest among all families, following that the freshwater family Unionidae (10 species) has the second-highest number and the remaining 25 families comprise less than ten species each (Table 1).

For several recorded species it is evident the names

are erroneous, as those species only occur in other continents. They are marked in the checklist (Table 2). The present findings suggested that some of the species were either misidentified or their introduction to Malaysian habitat might occurred; while observing their original distribution. For example, *Anadara kagoshimensis* (Tokunaga, 1906) is distributed in the temperate North Pacific (Zenetos et al. 2010), but the current study suggested that these species were found in the water of Malaysian Borneo (Al-Asif et al. 2020). The other distributional conflicts observed in *Ctenoides scaber* (Born, 1778) (Turgeon et al. 2009), *Ostrea lurida* Carpenter, 1864 (Polson et al. 2009), *Crassostrea virginica* (Gmelin, 1791) (Amaral & Simone 2014), *Isognomon alatus* (Gmelin, 1791) (Tëmkin 2010), and *Pteria colymbus* (Röding, 1798) (Tëmkin 2010) where all known distributions of abovementioned species are either North America or South America. The European *Spondylus gussonii* (O.G. Costa, 1830) (Gofas et al. 2001) was also reported from Malaysian habitat, and the geographic distribution should not be in Malaysian Borneo. Although *Saccostrea scyphophilla* (Peron & Lesueur, 1807) (reported as *Saccostrea mordax* (Gould, 1850), the materials were observed from the “Feejee Islands”(Fiji); and the species was originally described from Australia) is considered native in Australia but in 2004 the study of Lam & Morton (2004) reported from Hong Kong coast, which might be disperse from Hong Kong to Malaysia through ocean-going ships or other means.

Additionally, some species may have been misidentified, but this cannot be determined without photographs or voucher material. In the literature we

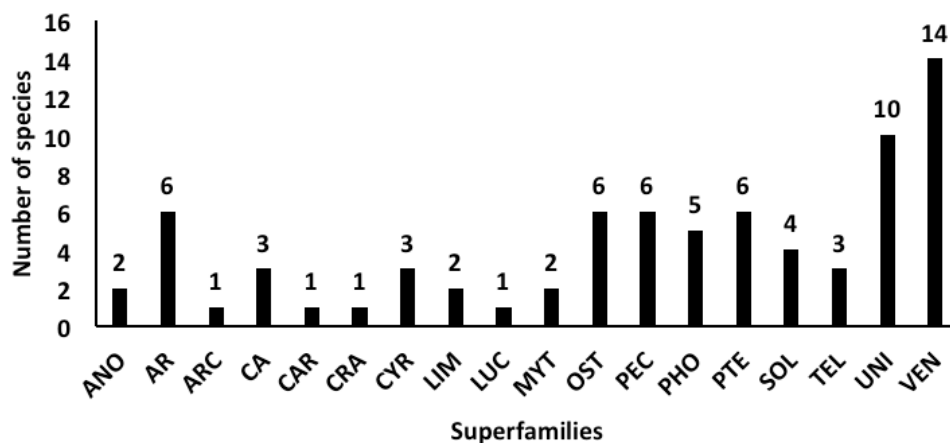


Figure 4. Number of species of bivalve superfamilies recorded from Malaysian Borneo.

Ano—Anomioidea | Ar—Arcoidea | Arc—Arcticoidea | Ca—Cardioidea | Car—Carditoidea | Cra—Crassatelloidea | Cyr—Cyrenoidea | Lim—Limoidea | Luc—Lucinoidea | Myt—Mytiloidea | Ost—Ostreioidea | Pec—Pectinoidea | Pho—Pholadoidea | Pte—Pterioidea | Sol—Solenioidea | Tel—Tellinoidea | Uni—Unionoidea | Ven—Veneroidea.

found many inconsistencies, while the present analysis revealed most inconsistencies were “unaccepted” according to WoRMS (2021) (i.e., the genus or species name is no longer valid); the rest were misspellings, alternative representations, changes in families, changes in author, and changes in year (Table 2). Moreover, there are taxonomic corrections: for instance, in freshwater family Unionidae there is no difference between *Pseudodon crassus* Drouet & Chaper, 1892 and *Pseudodon walpolei* (Hanley, 1871); therefore, WoRMS merges them into one single species *Monodontina walpolei* (Hanley, 1871). Similarly, in the Cyrenidae *Polymesoda erosa* auct. non Lightfoot, 1786 and *Polymesoda expansa* (Mousson, 1849) have recently been synonymized in WoRMS (Huber 2010) to the revised name *Geloina expansa* (Mousson, 1849). The study of Hamli et al. (2015) revealed morphological differences between these two taxa which lead to considered as they were both valid species.

The current study demonstrates that current bivalve research knowledge (ecological, taxonomic, and other aspects) are insufficient to serve as a foundation for academic, conservation, and aquaculture initiatives in Malaysian Borneo. A thorough literature search was conducted using a variety of databases (e.g., SCOPUS, Web of Science, university websites (for thesis), and CNKI), but the number of published papers on Borneo bivalves was determined to be insufficient. Bivalve research in Borneo is strongly encouraged, and areas such as populations, threats, life history, and breeding biology for aquaculture initiatives can all be considered significant research fields. While taxonomy, habitat ecology, conservation actions, area-based management initiatives, and approaches to recovery and reintroduction are all fundamental, harvesting trends are also critical (Lopes-Lima et al. 2018; Zieritz et al. 2020). A comprehensive checklist of bivalves in Malaysian Borneo is necessary to fill this knowledge gap. It is recommended that additional research on bivalves be conducted as a basis for conservation measures, as they contribute to both the ecology and economy of Malaysia.

PRESENT STATUS

IUCN status of bivalves in Borneo and their habitats

According to the IUCN red list status, 66 bivalve species have not been evaluated by the IUCN or any other institution that are present in Malaysian Borneo, and it is quite clear that a plethora of research work can be conducted to evaluate only the IUCN unevaluated species. Whereas nine species were determined to be least concerned and one species was determined to

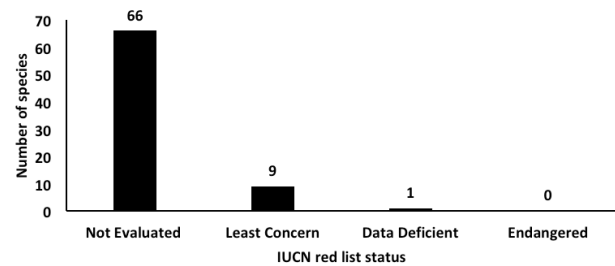


Figure 5. IUCN Red List status of bivalves in Malaysian Borneo.

have data deficiency (Figure 5). Thus, these species must be protected wherever they occur in Malaysian Borneo through the imposition of reserve areas, restricted areas, or national/regional conservation sites. It is observed that 76 species of bivalve fauna have been reported from Malaysian Borneo, including 61 marine species (17 species can be found in both marine and estuarine or brackish water), three brackish water, and 12 freshwater species (one species can be found in both fresh and brackish water).

Threats to the biodiversity of bivalve species

Sarawak and Sabah (the Malaysian portion of Borneo) are rich in biodiversity. Certain areas of Borneo Island remain pristine due to the lack of human intervention. Commercial logging and forest destruction due to palm plantations, on the other hand, have increased rapidly in various parts of these two provinces (Bryan et al. 2013; Shevade & Loboda 2019). As a result of soil runoff into the South China Sea, secondary pollution of marine and coastal ecosystems occurs (Morni et al. 2017). Harvesting edible bivalves from wild sources indiscriminately is also a significant threat to sustainable populations. Most importantly, there is no government or local government initiative to initiate commercial aquaculture of these bivalves in order to conserve their indigenous characteristics. A model of the global decline of bivalves was proposed by Lopes-Lima et al. (2018), in which they showed that in the Indo-Pacific region, pollution (45%) is the significant reason of decline in bivalve species, whilst freshwater bivalve species decline more rapidly than the marine species (Agudo-Padrón 2011). Other factors contributing to the decline of bivalve fauna include overexploitation (20%), habitat modification (15%), and urbanization (10%) (Figure 6), mining activities, agriculture and aquaculture, transportation infrastructure, climate change and temperature rise, recreational activities, and various geological events, such as tsunamis caused by earthquakes.



Conservation prospects

Conservation is critical to preventing the extinction of vulnerable species. After discussing possible causes of bivalve species decline in the Indo-Pacific region, including Malaysia, we propose some conservation strategies for sustainable use of bivalve natural bio resources based on the global model developed by Lopes-Lima et al. (2018) (Figure 8).

To begin, bivalves are aquatic Mollusca that cannot survive without water (marine, brackish, or freshwater), and thus protection of water and water-adjacent land (40 %) should be prioritized for bivalve species conservation. Additionally, awareness-raising among stakeholders (including government, the general public, universities, non-governmental organizations, and the local populace) and communication with the local populace must be implemented (25 %). Water and adjacent land management (12 %), species management (10 %), and incentives for local stakeholders who will carry out the conservation process (4 %) can all contribute significantly to the conservation of bivalves in Borneo. While the existing policies and regulations are sufficient for a sustainable conservation process, additional research is necessary to determine whether any revisions to those policies and regulations are necessary (3 %). Ex situ conservation (2 %) and proper enforcement of policies, legislation, and regulation (2 %). Any threatened species and those that have been suppressed by stressors, including human intervention, should be recovered through the application of appropriate management guidelines and procedures (1 %). Conservation strategies can be integrated into formal national curricula; consequently, future leaders and stakeholders should be concerned about bivalve biodiversity conservation (0.5 %). Reintroduction of species from another source is sometimes feasible. The general training received by common people, stakeholders, conservationists, and government officials is sufficient in the Indo-Pacific region and Malaysia, as there are ample training facilities and current conservation legislation is adequate, but conservation measures for bivalves should be prioritized.

Another research by Lopes-Lima et al. (2014) suggested that research on different aspects of taxonomy, systematics, anatomy, physiology, ecology, and conservation of freshwater bivalves will be helpful to conserve and reduce the extinction risk. Omics approach will also be helpful to conserve the bivalve fauna (Carducci et al. 2020). In contrast, a recent study from China suggested that awareness among people regarding ecological protections can be a helpful tool for

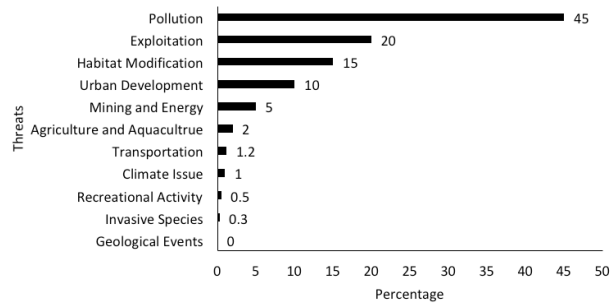


Figure 6. Reasons of bivalve decline in Malaysian Borneo (Indo-Pacific model). Adopted from Lopes-Lima et al. (2018).

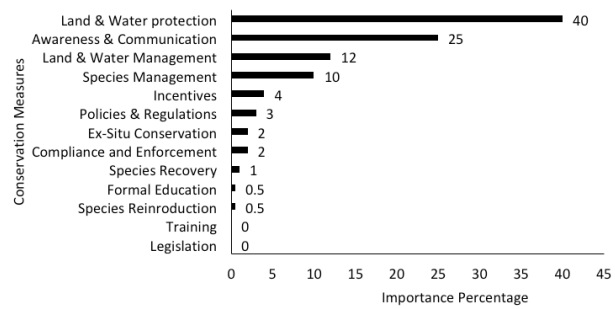


Figure 7. Conservation approach of bivalve fauna in Malaysian Borneo (Indo-Pacific Model). Adopted from Lopes-Lima et al. (2018).

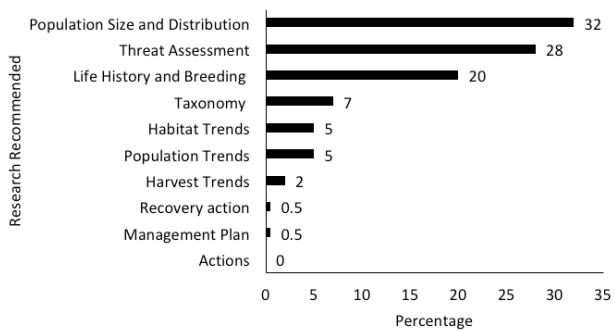


Figure 8. Recommended bivalve Research in Malaysian Borneo (Indo-Pacific Model). Adopted from Lopes-Lima et al. (2018).

protecting the habitat of bivalves. Reduce or suspend the commercial capture of wild bivalves, establish sanctuaries for habitat protection, extend the fishing or capture ban period which might helpful to conserve the bivalve fauna (Cao et al. 2018).

Prospects and future research

The status of bivalves in Malaysian Borneo as a whole has not yet been determined. Numerous research groups comprised of provincial governments, universities, and the federal government can work in various ecological niches to determine the true number

Table 2. List of taxonomic corrections in available bivalve species in Malaysian Borneo.

Given Family	Corrected Family	Given name of species	Corrected name of species	Type of inconsistency
Arcidae	Arcidae	<i>Anadara granosa</i>	<i>Tegillarca granosa</i> (Linnaeus, 1758)	Unaccepted
Arcidae	Arcidae	<i>Barbatia fusca</i> (Bruguère, 1789)	<i>Barbatia amygdalumtostum</i> (Röding, 1798)	Unaccepted
Cardiidae	Cardiidae	<i>Tridacna (Chametrachea) crocea</i> Lamarck, 1819	<i>Tridacna crocea</i> (Lamarck, 1819)	Alternative representation
Cardiidae	Cardiidae	<i>Tridacna (Chametrachea) maxima</i> (Röding, 1798)	<i>Tridacna maxima</i> (Röding, 1798)	Alternative representation
Tridacnidae	Cardiidae	<i>Tridacna squamosa</i> Lamarck, 1819	<i>Tridacna squamosa</i> Lamarck, 1819	Family changed
Cyrenidae	Cyrenidae	<i>Polymesoda bengalensis</i>	<i>Geloina bengalensis</i> (Lamarck, 1818)	Unaccepted
Cyrenidae	Cyrenidae	<i>Polymesoda expansa</i>	<i>Geloina expansa</i> (Mousson, 1849)	Unaccepted
Glauconomidae	Glauconomidae	<i>Gluconome virens</i>	<i>Glauconome virens</i> (Linnaeus, 1767)	Misspelling
Isognomonidae	Isognomonidae	<i>Isonomon nucleus</i>	<i>Isognomon nucleus</i> (Lamarck, 1819)	Misspelling
Isognomonidae	Isognomonidae	<i>Spondylus gussonii</i> OG. Costa, 1829	<i>Spondylus gussonii</i> (O.G. Costa, 1830)	Wrong year
Limidae	Limidae	<i>Ctenoides scabra</i> (Born, 1778)	<i>Ctenoides scaber</i> (Born, 1778)	Unaccepted
Mytilidae	Mytilidae	<i>Brachidontes striatulus</i> (Hanley, 1843)	<i>Byssogerdus striatulus</i> (Hanley, 1843)	Unaccepted
Pteriidae	Margaritidae	<i>Pinctada margaritifera</i> (Linnaeus, 1758)	<i>Pinctada margaritifera</i> (Linnaeus, 1758)	Family changed
Ostreidae	Ostreidae	<i>Crassostrea virginica</i>	<i>Crassostrea virginica</i> (Gmelin, 1791)	Misspelling
Ostreidae	Ostreidae	<i>Crassostrea iredalei</i>	<i>Magallana bilineata</i> (Röding, 1798)	Unaccepted
Ostreidae	Ostreidae	<i>Crassostrea rivularis</i> (Gould, 1861)	<i>Magallana rivularis</i> (Gould, 1861)	Alternative representation
Pectinidae	Pectinidae	<i>Chlamys varia</i> (Linnaeus, 1758)	<i>Mimachlamys varia</i> (Linnaeus, 1758)	Unaccepted (currently placed in genus <i>Mimachlamys</i>)
Myoida	Pholadidae	<i>Pholas orientalis</i>	<i>Pholas orientalis</i> (Gmelin, 1791)	Family changed
Unionidae	Unionidae	<i>Anodonta woodina</i>	<i>Sinanodonta woodiana</i> (I. Lea, 1834)	unaccepted (recombination)
Unionidae	Unionidae	<i>Pseudodon walpolei</i> (Hanley, 1871)	<i>Monodontina walpolei</i> (Hanley, 1871)	Unaccepted
Veneridae	Veneridae	<i>Meretrix lyrata</i>	<i>Meretrix lyrata</i> (G. B. Sowerby II, 1851)	Misspelling
Veneridae	Veneridae	<i>Paphia undulata</i>	<i>Paratapes undulatus</i> (Born, 1778)	Unaccepted
Veneridae	Veneridae	<i>Meretrix meretrix</i> Röding,	<i>Meretrix meretrix</i> (Linnaeus, 1758)	Wrong author name
Veneridae	Veneridae	<i>Paphia alapapilionis</i> Röding, 1798	<i>Paphia rotundata</i> (Linnaeus, 1758)	Unaccepted
Veneridae	Veneridae	<i>Dosinia exilium</i> (G.B. Sowerby III, 1909)	<i>Pelecypora exilium</i> (G.B. Sowerby III, 1909)	Unaccepted
Veneridae	Veneridae	<i>Venus japonica</i> Gmelin, 1791	<i>Marcia japonica</i> (J. F. Gmelin 1791)	Unaccepted

and species of bivalves in Malaysian Borneo in order to create a comprehensive checklist. Aquaculture of commercially valuable bivalve species may be another area of research that could help prevent indiscriminate harvesting of bivalves from Malaysian Borneo's diverse habitats. Pollution studies can be conducted to assess the biodiversity and ecological threats posed by various industrial zones, despite the fact that water, air, and soil pollution are increasing as a result of these two provinces' rapid industrialization. A strong legislative framework could be established and enforced to protect different habitats' ecological integrity and bivalve diversity. Strict enforcement of laws may aid in the conservation of bivalve species in Malaysian Borneo.

Regrettably, there is far too little information at the moment, but provincial governments could declare some species vulnerable and also establish some protected zones in accordance with the IUCN Red List. Numerous awareness campaigns, including posters, television programmes, telecasts, documentaries, films, and cartoons, can be produced to educate the public about the critical nature of bivalve conservation. For example, state governments can take steps similar to the Chinese Giant Panda conservation approach, which is called 'Panda Diplomacy' (Buckingham et al. 2013), where China showed public awareness and scientific efforts are effective in the conservation process. Lopes-Lima et al. (2018) proposed some research aspects that will help



retain the bivalve diversity's sustainability. According to them, the primary focus on bivalve research should be on the assessment of populations and their distribution (32 %), assessment of threats (28 %), and on studying their life history / breeding for future aquaculture purposes (20 %) (Figure 7). Whereas the taxonomy of specific bivalve species, the habitats and ecology of each species, the population trends of bivalves in Borneo, the harvest trends of fishers including aquaculture, recovery actions if any species faces imminent extinction, management plans for multi-ground stakeholders, and further action by various organizations can be considered as significant research arenas.

Kumar & Ravinesh (2016) recommended that the importance of taxonomic research be disseminated; thus, taxonomic knowledge can be included in national level curricula, for example, high school and college students can learn this science with joy. This initiative can be incorporated into the provincial and regional curricula of Malaysian Borneo. Additionally, they emphasized the importance of establishing accurate species databases and repositories, which will aid in future research and analysis. Kumar & Ravinesh (2016) also emphasized the resolution of scientifically dubious name categories, such as 'taxon inquirendum' and 'nomen dubium', which is commendable, and the protocols may be beneficial for the Malaysian Borneo ecosystem as well. They proposed that an integrative taxonomic approach incorporating detailed biogeography and evolutionary genetic materials could be beneficial for bivalve fauna conservation in Malaysian Borneo. Finally, citizen scientists and civil society approaches are very common and widely adopted in many developed countries; for this, a person does not have to be a scientist; rather, a keen interest in nature and biodiversity can also be beneficial for nature conservation. The research on the aforementioned criteria may be adopted and contribute to the conservation of biodiversity in Malaysian Borneo in the coming years and decades.

The current checklist is prepared by reviewing the previously published documents from Malaysian Borneo, although the published documents are few. Some of the papers we had collected were very general, and the author did not provide an appropriate format of species scientific names (Al-Asif et al. 2020). Misidentification is a widespread issue in taxonomy, and some published documents reported different bivalve species out ranged of their original distribution region. For example, the distribution of *Ctenoides scaber* (Born, 1778) (Turgeon et al. 2009) is well known from North America, but the previous study reported this species

from the southeastern Asian region. This might happen because the author found similarities with southeastern Asian bivalve species with North American species or is entirely misidentified.

On the other hand, we can say it is considered either misidentification of these species or they introduced to the Malaysian habitat. Most of the published papers we had handled did not provide any pictures of bivalve species, which can be considered a considerable gap of the bivalve research in Malaysian Borneo (Shabdin 2010). In contrast, the papers that were published on the ecological phenomena or on the ecological subject matter did not include photographs or appropriate scientific nomenclature, and the samples that had been gathered were not stored in a permanent and easily accessible repository for future study. The island of Borneo does not have a natural history museum, although there is a tiny part of the 'Sarawak State Museum' that is known as the 'Natural History Museum', but there are no depositing facilities or a permanent repository in the Malaysian part of this island (Al-Asif et al. 2020; Shabdin 2010). Given the foregoing, Malaysian Borneo urgently requires a permanent and accessible repository for the collection of samples. New expeditions to different rivers and creeks in the interior of Borneo can be conducted to determine the exact number of bivalve species found in Malaysian Borneo.

CONCLUSIONS

The current work produced a comprehensive checklist of bivalves recorded from Malaysian Borneo, crosschecked with WoRMS (2021) and MolluscaBase (2021). An accurate checklist of bivalves aids appropriate resource allocation for the conservation process, and at the same time has many other functions. Accurate data on bivalve species under one umbrella will provide insight which species are present in Malaysian Borneo. It will also help revise and update the national list of molluscan fauna and periodic update of bivalve taxonomic information.

REFERENCES

- Abu Hena, M.K., M.H. Idris, R.M.Y. Khairul, M.K.A. Bhuiyan, N. Hoque & U. Kumar (2016). Diversity of macro-benthos in the mangrove forest of Kuala Sibuti, Miri, Sarawak. In: *Malaysia International Biology Symposium (i-SIMBIOMAS 2016)*. Malaysia International Biology Symposium, Putrajaya International Convention Center, Putrajaya, Malaysia.
- Agudo-Adrón, I.A. (2011). Threatened freshwater and terrestrial

- molluscs (Mollusca, Gastropoda et Bivalvia) of Santa Catarina state, Southern Brazil: check list and evaluation of regional threats. *Biodiversity Journal* 2(2): 59–66.
- Al-Asif, A.A., H. Hamli, M.K. Abu Hena, M.H. Idris, G.J. Gerusu, J.B. Ismail & N.U. Karim (2020). Benthic macrofaunal assemblage in seagrass-mangrove complex and adjacent ecosystems of Punang-Sari estuary, Lawas, Sarawak, Malaysia. *Biodiversitas* 21(10): 4606–4615. <https://doi.org/10.13057/biodiv/d2111019>
- Alam, R., S. Sharmin, S.M. Majharul & A. Alam (2020). Salinity intrusion affects early development of freshwater aquaculture species pabda, *Ompok pabda*. *Aquaculture Reports* 18: 100476. <https://doi.org/10.1016/j.aqrep.2020.100476>
- Amano, T. & W.J. Sutherland (2013). Four barriers to the global understanding of biodiversity conservation: Wealth, language, geographical location and security. *Proceedings of the Royal Society B: Biological Sciences* 280(1756). <https://doi.org/10.1098/rspb.2012.2649>
- Amaral, V.S.D. & L.R.L. Simone (2014). Revision of genus *Crassostrea* (Bivalvia: Ostreidae) of Brazil. *Journal of the Marine Biological Association of the United Kingdom* 94(4): 811–836. <https://doi.org/10.1017/S0025315414000058>
- Ashton, E.C., D.J. Macintosh & P.J. Hogarth (2003). A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest, Sarawak, Malaysia. *Journal of Tropical Ecology* 19(2): 127–142. <https://doi.org/10.1017/S0266467403003158>
- Braje, T.J. & J.M. Erlandson (2013). Human acceleration of animal and plant extinctions: A late pleistocene, holocene, and anthropocene continuum. *Anthropocene* 4: 14–23. <https://doi.org/10.1016/j.ancene.2013.08.003>
- Bryan, J.E., P.L. Shearman, G.P. Asner, D.E. Knapp, G. Aoro & B. Lokes (2013). Extreme differences in forest degradation in Borneo: Comparing practices in Sarawak, Sabah, and Brunei. *PLoS ONE* 8(7): e69679. <https://doi.org/10.1371/journal.pone.0069679>
- Buckingham, K.C., J.N.W. David & P. Jepsen (2013). Environmental reviews and case studies: Diplomats and refugees: Panda diplomacy, soft cuddly power, and the new trajectory in panda conservation. *Environmental Practice* 15(3): 262–270. <https://doi.org/10.1017/S1466046613000185>
- Cao, Y.L., X.J. Liu, R.W. Wu, T. Xue, L. Li, C.H. Zhou, S. Ouyang & X.P. Wu (2018). Conservation of the endangered freshwater mussel *Solenia carinata* (Bivalvia, Unionidae) in China. *Nature Conservation* 26: 33–53. <https://doi.org/10.3897/natureconservation.26.25334>
- Carducci, F., M.A. Biscotti, E. Trucchi, M.E. Giuliani, S. Gorbi, A. Coluccelli, M. Barucca & A. Canapa (2020). Omics approaches for conservation biology research on the bivalve *Chamelea gallina*. *Scientific Reports* 10(1): 1–15. <https://doi.org/10.1038/s41598-020-75984-9>
- Chaklader, R., M. Abu, B. Siddik, A. Hanif, A. Nahar, S. Mahmud & M. Piria (2016). Morphometric and meristic variation of endangered pabda catfish, *Ompok pabda* (Hamilton-Buchanan, 1822) from Southern coastal waters of Bangladesh. *Pakistan Journal of Zoology* 48(3): 681–687.
- Chakraborty, B.K., Z.A. Mirza & A. Chakraborty (2010). Reproductive cycle of the endangered Pabda, *Ompok pabda* (Hamilton-Buchanan, 1822) in Bangladesh. *Asian Fisheries Science* 23(3): 301–320. <https://doi.org/10.33997/j.afs.2010.23.3.003>
- Collen, B., L. Mearns, S. Deinet, A. de Palma, T. Carranza, N. Cooper, J. Loh & J.E.M. Baillie (2011). Predicting how populations decline to extinction. *Philosophical Transactions of the Royal Society B: Biological Sciences* 366(1577): 2577–2586. <https://doi.org/10.1098/rstb.2011.0015>
- Gmelin J.F. (1791). Vermes, pp. 3021–3910. In: Gmelin J.F. (eds.). *Caroli a Linnaei Systema Naturae per Regna Tria Naturae*. Ed. 13. Tome 1(6). G.E. Beer, Lipsiae [Leipzig].
- Gofas, S., J. Le Renard & P. Bouchet (2001). Mollusca: European Register of Marine Species: a check-list of the marine species in Europe and a bibliography of guides to their identification. *Patrimoine Naturels* 50: 180–213.
- Groves, C.R., D.B. Jensen, L.L. Valutis, K.H. Redford, M.L. Shaffer, J.M. Scott, J.V. Baumgartner, J.V. Higgins, M.W. Beck & M.G. Anderson (2002). Planning for biodiversity conservation: putting conservation science into practice. *BioScience* 52(6): 499–512. [https://doi.org/10.1641/0006-3568\(2002\)052\[0499:PFBCPC\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2002)052[0499:PFBCPC]2.0.CO;2)
- Hamli, H., A.A. Rahim, M.H. Idris, M.K.A. Hena & W.S. King (2015). Morphometric variation among three local mangrove clam species of Corbiculidae. *Songklanakarin Journal of Science and Technology* 37(1): 15–20.
- Hamli, H., M.H. Idris, M.K.A. Hena, A. Rajaei & A. Arshad (2016). Inner shell as variation key of local hard clam *Meretrix* spp. *Journal of Environmental Biology* 37(Special): 641–646.
- Hamli, H., M.H. Idris, M.K.A. Hena & S.K. Wong (2012a). Diversity of edible mollusc (Gastropoda and Bivalvia) at selected division of Sarawak, Malaysia. *International Journal on Advanced Science, Engineering and Information Technology* 2(4): 5–7. <https://doi.org/10.18517/ijaseit.2.4.202>
- Hamli, H., M.H. Idris, A.H. Rajaei, M.K.A. Hena & M.N. Hoque (2017). Condition index of *Meretrix lyrata* (Sowerby 1851) and its relationship with water parameter in Sarawak. *Sains Malaysiana* 46(4): 545–551. <https://doi.org/10.17576/jsm-2017-4604-05>
- Hamli, H., M.H. Idris, M.K.A. Hena & S.K. Wong (2012b). Taxonomic study of edible bivalve from selected division of Sarawak, Malaysia. *International Journal of Zoological Research* 8(1): 5258.
- Hamli, H., N. Hashim & A. Al-Asif (2020). Isolation and potential culture of phytoplankton live feed for freshwater mussels *Sinanodonta woodiana* (Lea, 1834). *Asian Journal of Animal Sciences* 14(4): 127–136. <https://doi.org/10.3923/ajas.2020.127.136>
- Huber, M. (2010). *Compendium of Bivalves. A Full-color Guide to 3,300 of the World's Marine Bivalves. A Status on Bivalvia after 250 Years of Research*. ConchBooks, Hackenheim, 901 pp.
- Huber, M. (2015). *Compendium of Bivalves 2. A Full-color Guide to the Remaining Seven Families. A Systematic Listing of 8,500 Bivalve Species and 10,500 Synonyms*. ConchBooks, Harxheim, 907 pp.
- Idris, M.H., A. Arshad, S.M.N.N. Amin, S.B. Japar, S.K. Daud, A.G. Mazlan, M.S. Zakaria & F.M. Yusoff (2012). Age, growth and length-weight relationships of *Pinna bicolor* Gmelin (Bivalvia: Pinnidae) in the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia. *Journal of Applied Ichthyology* 28(4): 597–600. <https://doi.org/10.1111/j.1439-0426.2011.01807.x>
- Idris, M.H., H. Hamli, M.K.A. Hena, R.A. Lah & N.M.S.N. Jaafar (2021). Study of diversity and morphometry in edible bivalves and gastropods from a coastal wetland in Sarawak. *Songklanakarin Journal of Science and Technology* 43(3): 889–896.
- Işık, K. (2011). Rare and endemic species: Why are they prone to extinction? *Turkish Journal of Botany* 35(4): 411–417. <https://doi.org/10.3906/bot-1012-90>
- IUCN Bangladesh (2015). Red List of Bangladesh Volume 5: Freshwater Fishes. International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, 360 pp.
- Jasin, B. (2015). *Posidonomya* (Bivalvia) from northwest peninsular Malaysia and its significance. *Sains Malaysiana* 44(2): 217–223.
- Kabir, M.S.U., F. Arefin, M.M. Rahman, M.R.I. Sarder & M.F.A. Mollah (2018). Domestication of red fin mahseer (*Tor tor*) with supplementary feeds in captive condition in Bangladesh. *Journal of the Bangladesh Agricultural University* 16(3): 533–538. <https://doi.org/10.3329/jbau.v16i3.39451>
- Köhler, F., M. Seddon, A.E. Bogan, D.V. Tu, P. Sri-Aroon & D. Allen (2012). The status and distribution of freshwater molluscs of the Indo-Burma region pp. 66–89. In: Allen, D.J., K.G. Smith & W.R.T. Darwall (Eds.). *The Status and Distribution of Freshwater Biodiversity in Indo-Burma*. IUCN, Gland, Switzerland and Cambridge, UK.
- Kumar, B. & R. Ravinesh (2016). Taxonomy of marine molluscs of India: status and challenges ahead, pp. 67–88. In: Bijoy Nandan, P., G. Oliver, P.R. Jayachandran & C.V. Asha (Eds.) Training manual -1st International training workshop on taxonomy of bivalve molluscs. Cochin University of Science and Technology, Kochi. https://www.researchgate.net/publication/303333869_Taxonomy_of_Marine_Molluscs_of_India_Status_and_Challenges_Ahead.



- Lam, K. & B. Morton (2004). The oysters of Hong Kong (Bivalvia: Ostreidae and Gryphaeidae). *Raffles Bulletin of Zoology* 52(1): 11–28.
- Lee, C.H., D.K. Lee, M.A. Ali & P.J. Kim (2008). Effects of oyster shell on soil chemical and biological properties and cabbage productivity as a liming materials. *Waste Management* 28(12): 2702–2708. <https://doi.org/10.1016/j.wasman.2007.12.005>
- Lopes-Lima, M., A. Teixeira, E. Froufe, A. Lopes, S. Varandas & R. Sousa (2014). Biology and conservation of freshwater bivalves: Past, present and future perspectives. *Hydrobiologia* 735(1): 1–13. <https://doi.org/10.1007/s10750-014-1902-9>
- Lopes-Lima, M., L.E. Burlakova, A.Y. Karatayev, K. Mehler, M. Seddon & R. Sousa (2018). Conservation of freshwater bivalves at the global scale: Diversity, threats and research needs. *Hydrobiologia* 810(1): 1–14. <https://doi.org/10.1007/s10750-017-3486-7>
- Martin, J.L., V. Maris & D.S. Simberloff (2016). The need to respect nature and its limits challenges society and conservation science. *Proceedings of the National Academy of Sciences of the United States of America* 113(22): 6105–6112. <https://doi.org/10.1073/pnas.1525003113>
- Matsumoto, M.B., E. Saleh, Z. Waheed, S. Muhammad Ali & J. Madin (2017). *Marine profiling of Marudu Bay, Sabah, Malaysia: Final Report*. Sabah, 88 pp.
- MolluscaBase (2021). Bivalvia. <http://molluscabase.org/aphia.php?p=taxdetails&id=105> on 2021-08-10
- Morni, W.Z.W., S.A.K.A. Rahim, T. Masron, R. Rumpet, J. Musel & R. Hassan (2017). Continental shelf sediments of Sarawak, Malaysian Borneo. *Scientific World Journal* 2017(4853048): 1–10. <https://doi.org/10.1155/2017/4853048>
- Morris, S. & R.D. Purchon (1981). The marine shelled mollusca of West Malaysia and Singapore part 3, Bivalvia. *Journal of Molluscan Studies* 47(2264): 322–327. <https://doi.org/10.1093/oxfordjournals.mollus.a065575>
- National Research Council (1992). *Conserving Biodiversity: A Research Agenda for Development Agencies*. The National Academies Press, Washington, DC, 138 pp.
- Parvez, I., M.A. Alam, M.M. Hassan, Y. Ara, I. Hoshan & A.S.M. Kibria (2019). A checklist of fish species from three rivers in northwestern Bangladesh based on a seven-year survey. *Journal of Threatened Taxa* 11(6): 13786–13794. <https://doi.org/10.11609/jott.4303.11.6.13786-13794>
- Polson, M.P., W.E. Hewson, D.J. Eernisse, P.K. Baker & D.C. Zacherl (2009). You say conchaphila, I say lurida: Molecular evidence for restricting the Olympia Oyster (*Ostrea lurida* Carpenter 1864) to temperate western North America. *Journal of Shellfish Research* 28(1): 11–21. <https://doi.org/10.2983/035.028.0102>
- Raven, J.G.M. (2019). Notes on molluscs from N.W. Borneo - dispersal of molluscs through nipa rafts. *The Festivus* 51(1): 3–10.
- Reydon, T.A.C. (2019). Are species good units for biodiversity studies and conservation efforts? p. 452. In: Wolfe, C.T., P. Huneman & T.A.C. Reydon (Eds.). *From Assessing to Conserving Biodiversity: Conceptual and Practical Challenges*. Springer.
- Shabdin, M.L. (2010). Macrofauna of Rajang River, Sarawak, Malaysian Borneo. *Journal of Tropical Biology and Conservation* 7(1): 11–30.
- Shabdin, M.L. & A. Alfred (2007). Commercial molluscs distribution of the western part of Sarawak. *The Sarawak Museum Journal* 63: 167–178.
- Shabdin, M.L., A. Azizil, F. Abg, S. Atiqah & A. Rahim (2014). Marine gastropod and bivalves of Sampadi Island, Lundu, Sarawak, pp. 75–87. In: *Proceedings of Aquatic Science Colloquium on Pulau Sampadi Marine Life Expedition*. Department of Aquatic Science, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Sarawak.
- Shevade, V.S. & T.V. Loboda (2019). Oil palm plantations in Peninsular Malaysia: Determinants and constraints on expansion. *PLoS ONE* 14(2): e0210628. <https://doi.org/10.1371/journal.pone.0210628>
- Sowerby, G.B. III. (1909). Descriptions of new species of *Terebra*, *Pleurotoma*, *Trochus*, *Tellina*, *Dosina*, and *Modiola*. *Proceedings of the Malacological Society of London* 8(4): 198–201.
- Olivier, A.V.D.S., L. Jones, L.L. Vay, M. Christie, J. Wilson & S.K. Malham (2020). A global review of the ecosystem services provided by bivalve aquaculture. *Reviews in Aquaculture* 12(1): 3–25. <https://doi.org/10.1111/raq.12301>
- Tëmkin, I. (2010). Molecular phylogeny of pearl oysters and their relatives (Mollusca, Bivalvia, Pterioidea). *BMC Evolutionary Biology* 10(1): 342. <https://doi.org/10.1186/1471-2148-10-342>
- Turgeon, D.D., W.G. Lyons, P. Mikkelsen, G. Rosenberg & F. Moretzsohn (2009). Bivalvia (Mollusca) of the Gulf of Mexico pp. 711–744. In: Felder, D.L. & D.K. Camp (Eds.). *Gulf of Mexico—Origins, Waters, and Biota. Biodiversity*. Texas A&M Press, Colleg.
- Turner, R.D. & L.N. Santhakumaran (1989). The genera *Martesia* and *Lignopholas* in the indo-pacific (Mollusca: Bivalvia: Pholadidae). *Ophelia* 30(3): 155–186. <https://doi.org/10.1080/00785326.1989.10430842>
- Vaughn, C.C. & T.J. Hoellein (2018). Bivalve impacts in freshwater and marine ecosystems. *Annual Review of Ecology, Evolution, and Systematics* 49: 183–208. <https://doi.org/10.1146/annurev-ecolsys-110617-062703>
- Venugopal, V. & K. Gopakumar (2017). Shellfish: Nutritive value, health benefits, and consumer safety. *Comprehensive Reviews in Food Science and Food Safety* 16(6): 1219–1242. <https://doi.org/10.1111/1541-4337.12312>
- Way, K. & R.D. Purchon (1981). The marine shelled mollusca of West Malaysia and Singapore Part 3, Bivalvia. *Journal of Molluscan Studies* (47): 313–321. <https://doi.org/10.1093/oxfordjournals.mollus.a065575>
- Wijsman, J.W.M., K. Troost, J. Fang & A. Roncarati (2019). Global production of marine bivalves. Trends and challenges pp. 1–26. In: Smaal, A., J. Ferreira, J. Grant, J. Petersen & Ø. Strand (Eds.). *Goods and Services of Marine Bivalves*. Springer, Cham.
- Wong, N.L.W.S. & A. Arshad (2011). A brief review on marine shelled mollusca (Gastropoda and Bivalvia) record in Malaysia. *Journal of Fisheries and Aquatic Science* 6(7): 669–699. <https://doi.org/10.3923/jfas.2011.669.699>
- WoRMS (2021). Bivalvia. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=105> on 2021-08-10
- Zenetos, A., S. Gofas, M. Verlaque, M.E. Cinar, J.E. Garcia Raso, C.N. Bianchi, C. Morri, E. Azzurro, M. Bilecenoglu, C. Froggia, I. Siokou, D. Violanti, A. Sfriso, G. San Martin, A. Giangrande, T. Katagan, E. Ballesteros, A.A. Ramos-Espla, F. Mastrototaro, O. Ocana, A. Zingone, M.C. Gambi & N. Streftaris (2010). Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science* 11(2): 381–493. <https://doi.org/10.12681/mms.7>
- Zieritz, A. & M. Lopes-Lima (2018). *Handbook and National Red-List of the Freshwater Mussels of Malaysia*. IUCN, Kuala Lumpur, 1–29pp.
- Zieritz, A., M. Lopes-Lima, A.E. Bogan, R. Sousa, S. Walton, K.A.A. Rahim, J.J. Wilson, P.Y. Ng, E. Froufe & S. McGowan (2016). Factors driving changes in freshwater mussel (Bivalvia, Unionida) diversity and distribution in Peninsular Malaysia. *Science of the Total Environment* 571: 1069–1078. <https://doi.org/10.1016/j.scitotenv.2016.07.098>
- Zieritz, A., H.Taha, M. Lopes-Lima, J. Pfeiffer, K.W. Sing, Z. Sulaiman, S. McGowan & K.A. Khairul (2020). Towards the conservation of Borneo's freshwater mussels: rediscovery of the endemic *Ctenodesma borneensis* and first record of the non-native *Sinanodonta lauta*. *Biodiversity and Conservation* 29(7): 2235–2253. <https://doi.org/10.1007/s10531-020-01971-1>



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