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A comparative study of bivalves in intertidal area of Southeast Asia and along the Coastline of Arabian Sea: A Review

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ABSTRACT

The intertidal zone of the island is characterized predominantly by sand with minor gravel. The intertidal zone creates a suitable habitat for living things that bury themselves under the sand, including bivalves. Bivalves have an economic role because they can be processed as food and their shells can be used as decoration. Other than that, bivalves can also be pollutant bio-filters. The total number of Bivalves family identified in the intertidal zone is still unknown. Thus, this article presents a review of the biodiversity of bivalve family in the intertidal zone in Southeast Asia and along the coastline of Arabian Sea from 2010-2020. Published data on the distribution of bivalve family in the intertidal zone were listed and checked using online databases and datasets from international organizations. A total of 35 bivalve families in the intertidal zone are found in 10 Southeast Asian countries also and a total of 45 bivalve families have been found in 8 countries (bordering) the Arabian Sea. This review serves as basic information for the biodiversity of Bivalves family in Southeast Asia and the Arabian Sea for future studies.

Key words : *Arabian Sea, Bivalves, Intertidal area, Southeast Asia*

Introduction

Bivalves is a class of mollusks that includes all shellfish. Bivalves, or pelecypods, are a very large class of mollusks. One of the characteristics of recognizing bivalves is seen from the shell. As the name suggests, bivalves are organisms that have two shells. A number of attributes of bivalves have led to their use as "monitors," "sentinels," or "indicators" of environmental stress. The role of bivalves in food supply (provisioning services) is a growing recognition of the wider ecosystem benefits of bivalve aquaculture in coastal waters. Other than that, bivalves have an economic role because they can be processed as food and their shells can be used as decoration. One of the places where the bivalves spread is in the intertidal zone (Tantikamton *et al.,* 2017). According to Hamli *et al.* 2018, research on the abundance of bivalves in the intertidal zone is very important, because it can determine the influence of fluctuating environments on the distribution of bivalves.

In the intertidal zone, the interaction between organisms is also high (Hamza *et al.,* 2018). The ex-

istence of bivalves in the intertidal zone also has a role to maintain ecosystem balance. This coil stabilized tropical intertidal benthic communities throughout the year, even in areas with distinct dry and rainy seasons. Bivalve as one of benthic communities has survival ability to live in wide temperature range. Bivalves can live at 31 - 38ºC because of its shells. Suspension feeding marine bivalves can tolerate a range of salinity and turbid water (Satheeshkumar and Khan, 2012). This condition gives bivalves ability to live in intertidal zone. The substrate of intertidal zone dominated by sand with a low percentage of gravel and mud. Sand sediments, high level of TOM and phosphate were found to be favorable to bivalves in the intertidal area (Satheeshkumar and Khan, 2012). The unique characteristics of bivalves are the shallowness of the selected localities, the relatively high temperature; high oxygen content, low wave energy and the semi enclosed nature of the habitat. Bivalves are benthos organism lives in marine and fresh water and they used as bio indicators of aquatic quality.

The functional role of bivalves in intertidal area

Species of marine in-vertebrates ability to accumulate the pollutant in a sedentary manner without being killed make them to be a bio-indicator. One of those marine invertebrates is bivalves. According to Newell (2004), marine bivalves are important organisms, they are acting as water quality and nutrient dynamic regulators by capturing food such as phytoplankton, planktonic larvae, and particulate organic matter. Therefore, marine bivalves take a role to stabilize the substrate, promote habitat complexity, and decrease erosion. Bivalve also give effects to increased organic load to the sediment from bio- deposition, habitat modification associated with culture gear and consequent changes in local fauna.

The role of marine bivalves in the CO_2 cycle has been commonly evaluated as the balance between respiration, shell calcium carbonate sequestration, and CO_2 release during biogenic calcification; however, this individual-based approach neglects important ecosystem interactions that occur at the population level, for example the interaction with phytoplankton populations and benthic-pelagic coupling, which in turn can significantly alter the CO_2 cycle. Bivalves provide direct benefits to modern cultures as food, building materials, and jewelry and provide indirect benefits by stabilizing shorelines and mitigating nutrient pollution (Vaughn and Hoellein, 2018).

Biodiversity of Bivalves in the intertidal area of Southeast Asia and Arabian Sea

Southeast Asia is in the tropical climate and crossed by the equator line. The present-day global maximum for marine biodiversity has been located in Southeast Asia since at least the earliest Miocene (Johnson *et al.,* 2015). In Southeast Asia, about 1211 species of bivalves was reported, and it is the highest diversity for bivalves compared to 29 regions around the world. It is believed that seasonal pattern in the Southeast Asia such as monsoonal rainfall provides nutrients enriched environment for these filter feeder organisms which eventually help to increase the number of Mollusca diversity in this area. The environmental parameters around Southeast Asia is around ±30,88 ºC for temperatures, ±6,45 for pH, and 30 ppt for salinity (Halim *et al.,* 2019; Hamli *et al.,* 2012). A total of 35 Bivalve families in the intertidal zone are found in 10 Southeast Asian countries. Marine bivalves are not found in Laos because Laos is the only Southeast Asian country with no sea area. The most common intertidal zone bivalve families are found in Indonesia, Malaysia, and Singapore. Meanwhile, the least bivalve families were found in Timor-Leste and Brunei Darussalam where only 1 Bivalvia family was found in Timor-Leste and 2 bivalve families in Brunei Darussalam. Although Singapore is a country with the shortest coastline (exc. Laos), Singapore has a high bivalve diversity, namely 34% of the bivalve families from the data in Table 2. All the Bivalve families found in Southeast Asian countries, Veneridae, Tellinidae, Lucinidae, and Cardiidae are the most common families found. Veneridae are found in 9 out of 10 Southeast Asian countries, Tellinidae and Lucinidae are found in 6 out of 10 countries, and Cardiidae are found in 5 out of 10 countries. Data on bivalves from Brunei Darussalam, Cambodia, Myanmar, and Timor Leste are limited but can be obtained from online databases at the Worldwide Mollusca Species Data Base (Galli, 2016) and the Global Biodiversity Information Facility (GBIF, 2020). Indonesia and Malaysia have the highest bivalve diversity that is 42%. All the common families above that found in Southeast Asian countries usually an in-faunal group of bivalves that can be found in the shores, either they deep buried in the sand, sandy mud, dead coral al-

gae or fine gravel. One of the most distributed family in Southeast Asia is Tellinidae. Tellinidae are known as a deep burrower in mud or sand and they can be found in clean silty sand and in intertidal zone (Creutzberg, 1986).

The northern Arabian Sea seems to have the highest diversity of Mollusca, on some of the literature that has been explored, but areas along the Pakistan coastline also showed high diversities of the species. The studies on mollusks were initiated in the northern Arabian Sea during the 18th century (Aslam *et al.*, 2020). A total of 45 bivalve families have been found in 8 countries (bordering) along the Arabian Sea: Western India, UAE, Pakistan, Kuwait, and Saudi Arabia. The highest number of Bivalves families was found in Kuwait followed by Pakistan and Oman. Whereas, the least bivalve families were found in Iran, Bahrain, and the United Arab Emirates. Although Kuwait has the shortest coastline, it has the highest diversity of bivalves in the intertidal zone. Among the countries bordering the Arabian Sea, India has the longest coastline but with less bivalve diversity than Kuwait. Veneridae are a family of bivalves that are mostly found in in

Table 1. Identified Bivalves in Intertidal Area in Southeast Asia (/: present, -: not available). Laos is the only Southeast Asia Country with no sea area (Tamtikamton *et al*., 2017; Asadi *et al*., 2018; Halim *et al*., 2019; Do Van Tu *et al*. 2019; Dolorosa *et al*., 2015; Jumawan *et al*., 2015; Aji and Widyastuti, 2017; Tan and Yeo, 2010; GBIF, 2020; Galli, 2016)

No.	Family	Malaysia	Brunei	Indonesia	Myanmar	Timor Leste	Phillipines	Cambodia	Singapore	Vietnam	Thailand
1	Arcidae	/	-	/	-	-	/	/	-	/	-
2	Cardiidae	-	-	/	/	-	/	-	/	/	-
3	Corbiculidae	/	-	-	-	-	-	-	/	-	-
4	Corbulidae	/	-	-	-	-	-	-	-	-	-
5	Cyrenidae	-	-	-	/	-	-	/	-	-	-
6	Donacidae	/	-	/	-	-	-	-	-	-	/
7	Galcommatidae	-	-	-	-	-	-	-	/	-	-
8	Glaucomidae	-	-	-	/	-	-	-	-	-	-
9	Gluconomidae	/	-	-	-	-	-	-	-	-	-
10	Isognominidae	-	-	/	-	-	-	-	-	-	-
11	Laternulidae	/	-	-	-	-	-	-	-	-	-
12	Lucinidae	-	/	/	-	-	/	-	/	/	/
13	Mactridae	-	-	/	/	-	/	/	/	-	-
14	Mesodesmatidae	-	-	/	/	-	/	-	-	-	-
15	Myidae	/	-	-	-	-	-	-	-	-	-
16	Mytilidae	/	-	/	-	-	-	-	/	/	-
17	Nuculidae	-	-	-	-	/	-	-	-	-	-
18	Ostreidae	-	-	-	-	-	/	/	-	/	-
19	Pectinidae	/	-	-	-	-	-	-	-	-	-
20	Pharidae	-	-	-	-	-	-	-	-	-	/
21	Pharidae	-	-	/	-	-	-	-	/	-	-
22	Pinnidae	-	-	-	-	-	-	-	/	-	-
23	Placunidae	-	-	-	-	-	-	-	-	-	-
24	Psammoblidae	-	-	/	-	-	/	-	-	-	-
25	Ptreidae	-	-	/	-	-	-	-	-	-	-
26	Solecurtidae	/	-	-	-	-	-	-	-	-	-
27	Solenidae	/	-	-	-	-	-	-	/	-	-
28	Sphaeriidae	-	-	-	/	-	-	-	-	-	-
29	Spondylidae	-	-	/	-	-	-	-	-	-	-
30	Tellinidae	/	-	/	-	-	/	/	/	-	/
31	Thyasiridae	-	-	-	-	-	-	-	-	-	-
32	Tridacnidae	-	-	/	/	-	-	-	-	-	-
33	Ungulinidae	/	-	-	-	-	-	-	-	-	-
34	Veneridae	/	/	/	/	-	/	/	/	/	/
	Total	15	2	15	5	1	9	6	12	7	6

several countries in the Arabian Sea because the seasonal winds, current regimes and high concentration of nutrients in Arabian Sea provide an ideal place to live for marine organisms (Pawar and Al-Tawaha, 2017). Mytilidae has two main modes of living although both depend on byssal attachment,

Table 2. Identified Bivalves in Intertidal Area Along the Coastline of Arabian Sea (/: present, -: not available) (El-Sorogy *et al.,* 2020; NRC, 2010; Galli, 2016; Aslam *et al.,* 2020; Ghani *et al.,* 2018; Al-Kandari *et al.,* 2020; Hamza, 2018; Dave and Chudasama, 2018; Khade and Mane, 2012; Rahman and Barkati, 2012, Al-Yamani *et al.,* 2009; Pawar and Al-Tawaha, 2017)

No.	Family	UAE	SAUDI ARABIA	PAKISTAN	OMAN	IRAN	KUWAIT	BAHRAN	INDIA
1	Arcidae	-	/	/	/	-	/	-	/
2	Cardiidae	-	-	/	/	-	/	-	-
3	Carditidae	-	/	/	/	-	/	-	-
4	Chamidae	-	-	/	-	-	/	-	-
5	Condylocardiia	-	-	-	/	-	/	-	-
6	Corbiculidae	-	-	-	-	-	/	-	/
7	Corophiidae	-	-	-	-	-	/	-	-
8	Docanidae	-	-	/	/	-	/	-	-
9	Galcommatidae	-	-	-	-	-	/	-	-
10	Gastrochaenidae	-	-	-	-	-	/	-	-
11	Glyeymerididae	-	-	-	-	-	/	-	
12	Gryphaeidae	-	-	-	-	-	/	-	-
13	Hiatellidae	-	-	-	-	-	/	-	-
14	Isognomonidae	/	-	-	-	-	/	-	-
15	Lasacidae	-	-	-	-	-	/	-	-
16	Laternulidae	-	-	-	/	-	/	-	-
17	Limidae	-	-	-	-	-	/	-	-
18	Lucinidae	/	/	-	-	-	/	/	-
19	Mactridae	-	-	/	/	/	/	-	-
20	Malleidae	-	-	-	-	-	/	-	-
21	Margaritidae	-	/	-	-	-	-	-	-
22	Mesodesmatidae	-	-	-	-	-	-	/	-
23	Myidae	-	/	-	-	-	-	-	-
24	Mytilidae	/	-	/	/	-	/	-	/
25	Neotiidae	-	-	/	-	-	/	-	-
26	Nuculidae	-	-	-	/	-	/	-	-
27	Ostreidae	-	-	/	/	-	/	-	/
28	Pectinidae	-	-	/	/	-	/	-	/
29	Pharidae	-	-	/	-	-	/	-	-
30	Pholadidae	-	-	/	-	-	/	-	-
31	Pinnidae	-	-	/	/	-	/	-	-
32	Placunidae	-	-	-	-	-	/	/	-
33	Plicatulidae	-	/	-	-	/	/	-	-
34	Psammobidae	/	-	-	-	-	/	-	/
35	Pteriidae	-	-	-	-	-	/	-	-
36	Semelidae	/	-	-	/	-	/	-	-
37	Solecurtidae	-	-	-	-	-	/	-	-
38	Solenidae	-	-	/	/	-	/	-	-
39	Spondylidae	-	-	-	-	-	/	-	-
40	Tellinidae	/	-	/	/	-	/	-	-
41	Thraciidae	-	-	-	-	-	/	-	-
42	Trapezidae	-	-	/	-	-	/	-	-
43	Tridacnidae	-	-	-	/	-	-	-	-
44	Ungulinidae	-	/	-	-	-	/	-	-
45	Veneridae	/	/	/	/	-	/	-	/
46	Yoldidae	-	-	-	-	-	/	-	-
	Total	7	8	17	17	1	42	1	10

this bivalve family is one of the Mediterranean mussels. Because its invasion, Mytilidae can be found along the coastline of Arabian sea which has rocky shores and muds to gravel sediment. Seasonally, the whole biodiversity of Bivalves family along the coastline of Arabian Sea recorded was highest in pre monsoon season and then lessen in monsoon and post-monsoon periods. The highest number of species that have been observed and collected is in April. Although, pre monsoon was the season with the highest richness. The coast is influenced by the repeated reversal of monsoon periods, which causes deep convective mixing, mainly during the northeast monsoon bringing nutrient rich water to the surface supporting high productivity in the Arabian Sea.

Southeast Asia and the Arabian Sea are regions with different climates. Southeast Asia has a tropical climate while the countries around the Arabian sea have a sub-tropical climate. This causes differences in the biodiversity of marine species including bivalves in the intertidal zone. Apart from climate, differences in marine species biodiversity can be influenced by differences in salinity, temperature, tides and availability of oxygen. The diversity of Bivalves at the family level along the coastline of Arabian Sea and Arabian Gulf is greater than the diversity of bivalves in Southeast Asia. The data in Table 2 show that 46% of the families of the total 53 families are found in Southeast Asia and along the coastline of Arabian Sea. Although Southeast Asia and the Arabian Sea have differences in climate, geographical conditions, and physical and chemical parameters, this occurs because bivalves are micro invertebrates with wide range of physical and chemical parameters tolerance. From 53 families, 26 families of bivalves can be found both in Southeast Asia and along the coastline of Arabian Sea.

Donacidae, Mactridae, Myidae, Pharidae, Solenidae, and Veneridae are the most widely distributed marine bivalve families. Of the 6 families distributed globally, only Mactridae and Veneridae are found in New Zealand. In contrast, Doncaidae, Myidae, Pharidae, and Solenidae are not found in New Zealand and the Pacific Islands. According to Saeedi and Costello (2012), Myidae is a family with the most limited distribution, which is only found in America to the northeast of the Atlantic Ocean, but this family was found in Southeast Asia, precisely in Malaysia in 2019 (Hamli *et al*., 2012). According to Mikkelsen and Bieler (2008) Arcidae which can be found in Southeast Asia and the waters of the Arabian Sea is a family of marine bivalves that can be found in warm, shallow waters, and inhabit tropical seas around the world. This family occupies the lower intertidal zone to the sublittoral. Lucinidae is a family of bivalves that live in the subtropical area of Cardiidae which is only found in Southeast Asia, which is a widely distributed family of bivalves that can be found along the western coast in the eastern sea (Sea of Japan) (Lutaenko and Noseworthy, 2019). The Pacific oyster *M. gigas* (Ostreidae) originated in Japan but it can be found both in Southeast Asia and along the coast of Arabian Sea. The data from Table 2 shows that Bivalves family in Southeast Asia and along the coastline of Arabian Sea has 51% similarity.

Conclusion

The biodiversity of marine bivalves along the coastline of Arabian Sea shows a higher biodiversity than in Southeast Asia according to the data in this review. Bivalves family in Southeast Asia and along the coastline of Arabian Sea has 51% similarity. This shows that Bivalves widely distributed because of its ability to survive in different conditions. Different families found in Southeast Asia and along the coastline of Arabian Sea are influenced by many factors such as temperature, sea wave, salinity, turbidity, and geographic condition. The data of marine Bivalves family biodiversity is important for the development of conservation and sustainable management policies.

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