

# Molluscan Fauna in Bang Taboon Mangrove Estuary, Inner Gulf of Thailand: Implications for conservation and sustainable use of coastal resources

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**Abstract.** Molluscan fauna, dealt with diversity and abundance of gastropods and bivalves in Bang Taboon mangrove estuary, Inner Gulf of Thailand was investigated seasonally. Totally 3,337 individuals, representing 18 species (6 bivalves and 12 gastropods) with two dominant species, *Assiminea brevicula* and *Tegillarca granosa*. The mean density of overall molluscs was  $11.79 \pm 0.47$  n/m<sup>2</sup>, recorded in September. The highest value of diversity was  $0.78 \pm 0.53$ , recorded in March. The most species-rich and individuals were recorded in the large mudflat within intertidal mangrove zone and formed a distinct community structure in the vegetated area at 15 cm depth. Results from the Analysis of the Similarity (ANOSIM) showed a clearly significant difference of species diversity and abundance at different areas, depths and seasons ( $P = 0.001$ ). Although Bang Taboon estuary is impacted by human activities, the habitat remains an important nursery ground for numerous molluscs including many commercial species. The findings of this study can be taken as a base data that would help maximizing mangrove and fisheries resources conservation and utilization in a sustainable way in Bang Taboon estuary and adjacent areas in the inner Gulf of Thailand.

## 1 Introduction

Mangroves are recognized to be among the world's most productive ecosystems which provide important nursery and feeding grounds for juvenile fish and invertebrate species [1-2]. Molluscs are one of the main macroinvertebrates that play major ecological role in nutrient dynamics in the mangrove ecosystem because they form an important link within the food web as predators, herbivores, detritivores and filter feeders [3-4]. They are useful bioindicators of environmental pollution, due to their methods of filter feeding [5]. Many species of which are linked directly, or indirectly, to valuable fisheries, which have a great commercial importance.

Bang Taboon estuary is part of the Ban Laem coastal area, Phetchaburi Province and to be known as one of the most productive fishing areas in the inner Gulf of Thailand [6]. The estuarine ecosystem by influence of the currents that blow the deposition of mud lane. Mangroves occur on the muddy tidal flats along the shoreline on the side of the river mouth. Mangrove forests in the area are currently threatened by exploitation and coastal development, especially converted to shrimp and blood cockle farmings, along with urbanization and reclamation effluents into the Bang Taboon estuary represent environmental concerns. To provide a better understanding of the role of mangrove ecosystem in supporting coastal resources

communities, and to date, the limited number of studies have been to observe the seasonal diversity and abundance of molluscs in this area [7]. Therefore, this work is aimed to assess the diversity and abundance of bivalve and gastropod molluscs in Bang Taboon mangrove estuary, Inner Gulf of Thailand and characterized different areas, depths and seasons which affect the patterns of mollusc assemblage in Bang Taboon estuary.

## 2 Materials and methods

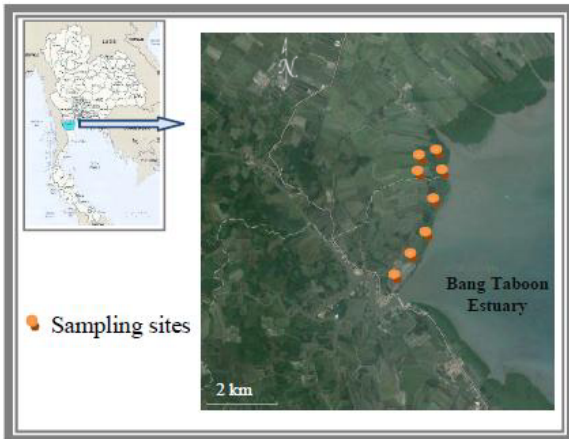
### 2.1 Study area and sample collections

Bang Taboon estuary covers an area of about 59 km<sup>2</sup>. The latitude and longitude is N 13° 16' 7.608" and E 99° 56' 54.708" respectively, located in Bang Taboon Subdistrict, Ban Laem District, Phetchaburi Province, Thailand. The area is dominated by intertidal mangrove-fringed, mostly two species of *Avicenia* sp and *Rhizophora* sp., and totally covered by muddy alluvium.

Samplings were performed at low tide from 8 stations (Fig. 1) in November, March, July and September, between November 2012 and September 2013, using a core sample (6 cm in diameter, 15 cm and 30 cm depth). All gastropod and bivalve samples were preserved immediately in 5-7% neutralized formalin,

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identified to species level according to [8-9], counted and weighted.



**Figure 1.** Map of Bang Taboon estuary showing location of sampling sites.

## 2.2 Assemblage analysis

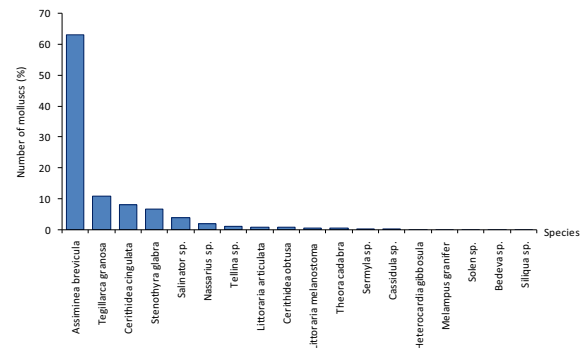
Species diversity and abundance including diversity index were analysed. Non-parametric multivariate analyses contained in the PRIMER (Plymouth Routines In Multivariate Ecological Research) Version 6.0 [10] were used in the analysis of non-parametric community structure data. Analysis of Similarity (ANOSIM) was tested for comparing and classifying whether bivalve and gastropod assemblages separated a priori into vegetated or non-vegetated areas, depths and seasons differed statistically.

## 3 Results and discussion

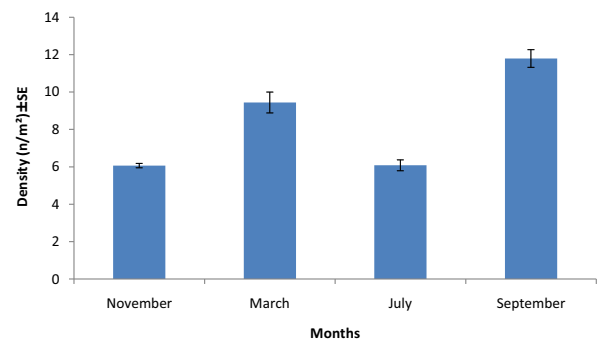
### 3.1 Species diversity and density

A total of 3,337 individuals representing 16 families and 18 species were recorded during the study period (Fig. 2). Of the recorded species, 12 species (87.24 % individuals) belonged to gastropods, 6 species (12.76% individuals) belonged to bivalves. Among species found, assimineid red snail *Assiminea brevicula* showed the highest individual molluscs (63.08%)(Fig. 2), found to occur throughout the study period in all stations and seasons, followed by blood cockle, *Tegillarca granosa* (10.94%) and *Cerithidea cingulata* (8.12%), which found in all seasons and showed consistency in four stations. The 6 species, viz., *Cassidula* sp., *Melampus granifer*, *Heterocardia gibbosula*, *Solen* sp., *Bedevea* sp. and *Siliqua* sp. were presented by less than 10 individuals. Variation in mean density (number of individuals per m<sup>2</sup>) of molluscs showed the highest (11.79±0.47 n/m<sup>2</sup>) in the vegetated area at 15 cm depth recorded in September (Fig. 3). There were 10 species found in all seasons, namely, *Assiminea brevicula*, *Tegillarca granosa*, *Cerithidea cingulata*, *C. obtusa*, *Stenothyra glabra*, *Salinator* sp., *Nassarius* sp., *Tellina* sp., *Littoraria articulata* and *L. Melanostoma*. The

study was reported earlier by many research workers who pointed out that the predominantly mangrove-associated bivalves and gastropods of localities within the Indo-Pacific consists predominantly of the families Arcidae, Tellinidae, Amphibolidae, Ellobiidae, Nassariidae, Assimineidae, Stenothyridae, Littorinidae, and Potamididae [11-15].



**Figure 2.** Number of mollusc species (%) recorded in Bang Taboon estuary.



**Figure 3.** Mean density (number of individuals per m<sup>2</sup>) ±SE of molluscs between November 2012 and September 2013 in Bang Taboon estuary.

The study showed numbers of bivalve species that were less than of gastropods, similar were the findings of Iwahig River-Estuary, Palawan, the Philippines [14] and Raigad district, Maharashtra, West coast of India [15]. This was due to bivalves which mostly live in the mud, confined to a narrow seaward zone, unlike gastropods which occupy a wide range of ecological niches and are known to climb mangrove trees, usually inhabit the trunk of trees and stilt roots [16-17]. Therefore, they are more adapted to the very changing and harsh mangrove environment.

Diversity index is commonly used to characterized species abundance relationship in a biological system. From the study, diversity index was calculated per site and among seasons (Table 1). The highest value of diversity was 0.78±0.53, recorded in March. The results showed the mollusc species fluctuated seasonally from a high between March and July to low during September and November. The diversity index value in November is lower than in March might be that July to October dominated by southwest monsoon in

Thailand [18] that caused temperature and salinity changed. The salinity acts as a limited factor which made the condition opposed to the molluscs and probably exceeded an optimal intermediate level of disturbance, reflecting absence of species using estuaries as nursery areas [19]. However, the mollusc density was at its peak in September during late monsoon period. It is clearly that the post monsoon is the most favourable time for the new inflow of mollusc species [14].

**Table 1.** Average diversity index ( $\pm$ SE) in various seasons in Bang Taboon estuary, S1-8= station 1-8.

M	BS-1	BS-2	BS-3	BS-4	BS-5	BS-6	BS-7	BS-8	Ave
Nov 2012	00.25	00.39	00.47	00.22	11.07	00.47	00.35	00.00	0.40 $\pm 0.10$
Mar 2013	00.22	00.00	00.00	00.47	11.76	11.01	11.78	11.01	0.78 $\pm 0.53$
Jul 2013	00.00	00.28	00.00	00.11	11.10	00.92	11.96	00.00	0.55 $\pm 0.51$
Sep 2013	00.86	00.25	00.50	00.05	11.47	00.23	11.58	00.48	0.68 $\pm 0.33$

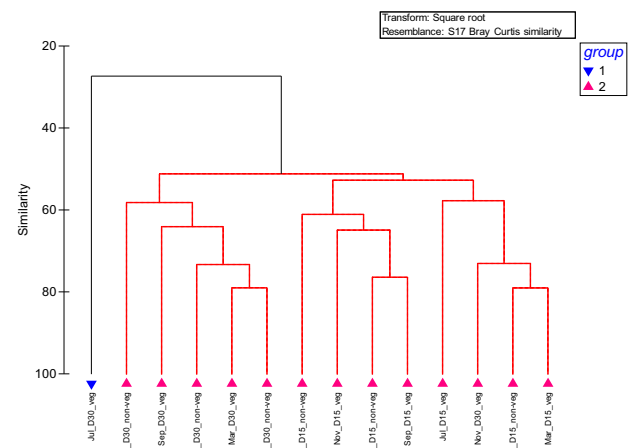
### 3.2 Variabilities of mollusc assemblages

A classification carried out using Bray-Curtis similarity (Fig. 4) and non-metric multi dimensional scaling (MDS) (Fig. 5) revealed the same groupings as recognized in the cluster within the vegetated and non-vegetated areas, depths and seasons, given by the presence and abundance of common species. The 2D stress value (0.14) indicated that the results were credible. Results of the analysis of similarity (ANOSIM) determined that there was significant difference in species numerical abundance of mollusc in different areas, depths and seasons ( $R=0.959$ ,  $P = 0.001$ ). There were generally 2 groupings on the dendrogram. The largest was comprised of three dominant molluscs (*Assiminea brevicula*, *Cerithidea cingulata* and *Tegillarca granosa*) in the Bang Taboon estuary. This group mostly comprised molluscs those were spreaded all over mangrove region at 15 cm depth samplings. Results based on species numerical abundance of the similarity percentage (SIMPER) analysis indicated that Bang Taboon estuary was dominated with *Assiminea brevicula*. The average dissimilarity in different areas, depths and seasons was 72.72%, and the taxa which together contributed of *Assiminea brevicula* (35.55%), *Cerithidea cingulata* (12.86%) and *Tegillarca granosa* (10.66%).

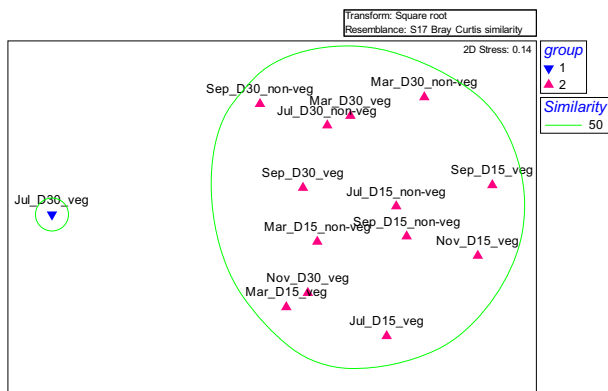
The dominant gastropod species, assimineid red snail, *Assiminea brevicula*, which accounts for 26.31, 13.84, 12.1 and 10.81 percents of total individuals in September, November, March and July respectively. This species has a wider range of distribution and can be found on the surface of muddy sediment. *Assiminea brevicula* can be used as an indicator of the mangrove ecosystem health because its sensitivity to the physical-chemicals environment, especially to the proportional of organic content in the mangrove forest [20]. A large number of blood cockle, *Tegillarca granosa* can be found in all seasons inhabiting in mudflats on mangrove

strands, where it lies partially buried in the sediment. This species plays a vital role in local people those are living on the coastal regions and is being cultured for commercialization [14]. *Cerithidea* sp, was observed to the mud banks, mud flats, mud forest, sandy muddy, mud swamps, tree trunks, fallen wood, prop-roots and pneumatophores [14, 19, 21] and also known to be abundant in eulittoral zone and shallow-water [16]. Cerithiids were among the most abundant gastropod molluscs in the seaward part and seaward edge of a mangrove forest in a study in Phuket Island, Thailand [20, 22].

There have been several reports described earlier that mollusc diversity and abundance varies seasonally and also depends on locality and depth, and is related to sediment rate, tidal inundation, flowing current, evaporation, rainfall, groundwater input, temperature, salinity, dissolved oxygen, organic carbon, nutrients, pollution, habitat destruction, over- exploitation and predation [1, 19, 20, 22-23]. In the present study, salinity seemed to be one of a limiting factors which determine the diversity and abundance of molluscs in the estuary during monsoon season. The present study did not show characteristic relationship between salinity and mollusc distribution. The variation of salinity at study sites was probably due to freshwater runoff, evaporation and rain that influenced the diversity and abundance of molluscs since these factors may vary with seasons.



**Figure 4.** Cluster analysis of sampling different areas, depths and seasons based on species numerical abundance. veg=vegetated area, non-veg= non-vegetated area; D15= 15 cm depth, D30=30 cm depth.



**Figure 5.** Ordination (nMDS) of sampling different areas, depths and seasons based on species numerical abundance. veg=vegetated area, non-veg= non-vegetated area; D15= 15 cm depth, D30=30 cm depth.

The results showed a large number of molluscs at 15 cm depth more than those at 30 cm depth in the sediment of vegetated mud habitats (mangrove zone). As it is the zone at the land water and marine-estuarine interface zone, true estuarine species may find this zone a better shelter from the open estuary. Availability of decomposed material of the plant litter and also the adequate safety can be the factors that govern a large number of diverse epifauna species in this mangrove zone. Some snails, *Bedeva* sp., *Cassidula* sp., *Melampus* sp., *Littoraria* sp. and *Cerithidea* sp. were recorded in the present study as well and found restricted to the mangrove zone. It was known that these species are instantly climb down from the tree trunks or prop roots to the mangrove floor for feeding when the ebb tide starts and again climb up during the high tide [24].

## Conclusions

The molluscs have a significant role to play in the mangrove ecosystems in term of ecosystem health and comprise an important trophic component of detrital food webs. Although, Bang Taboon estuary has been threatened by anthropogenic activities which result in the loss of mangrove and contribute to the reduction of mollusc communities, the results from this study support moderately high species diversity with high numbers of individuals, indicate fairly good health of the sediment in the area. The dominant species, assimineid red snail, *Assiminea brevicula* shows the integrity bioindicator of the mangrove ecosystem and blood cockle, *Tegillarca granosa*, which has a great commercial importance. Therefore, the data presented in this study can be taken as a base line data that would help maximizing mangrove and fisheries resources conservation and utilization in a sustainable manner in Bang Taboon estuary and adjacent areas in the inner Gulf of Thailand.

## Acknowledgement

The authors are grateful to everyone involved in the sampling and data collections. Thanks are also due to

the Faculty of Liberal Arts and Science and Graduate School, Kasetsart University for financial support for participation in the IEEA 2016 conference at which this paper was presented.

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