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THE SPECIES AND ABUNDANCE OF BIVALVIA SPAT IN MANGROVE FOREST SUBSTRATE IN RUPAT ISLAND, BENGKALIS

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ABSTRACT

The availability of bivalve spat has a strategic role in ensuring the sustainability of bivalve communities in aquatic ecosystems. This study aims to determine the species, abundance, and timing of bivalve spat settled on the basic substrate of mangrove forest in the intertidal zone of Rupat Island. This research was conducted in June - October 2017. The research was located in the intertidal zone, which is divided into three subzones: upper, middle, and lower. To collect spat bivalve using a net collector, like a tray. This research method was a survey method. The results showed that the bivalve spat had three types: *Pilsbryoconcha exilis* spat, *Polymesoda expansa, and Pharella acutidens*. The average abundance is 4.06 ind/m^2; the highest abundance of bivalve spats was at the lower subzone, 2.13 ind/m^2. The lower subzone was adjacent to the sea and was affected by the tides. From the monthly sampling, October was the highest, with an average abundance of 1.2 ind/m^2. Spat catches in June-October were low, and the possibility of a recruit peak of bivalve spat had not happened yet.

Keywords: Spat, Bivalvia, Abundance, Mangrove, *Polymesoda expansa*

1. INTRODUCTION

Southeast Asian mangrove areas are inhabited by various species of bivalves, such as the blood cockle (*Anadara granosa*), the short-necked clam (*Pharella acutidens*), the green mussel (*Mytilus viridis*), and the lokan clam (*Polymesoda erosa*), which are widely distributed across intertidal zones, including coastal areas, river estuaries, and swamps that develop on muddy substrates associated with mangrove trees[1].

The early life stage of mangrove bivalves, before adulthood, is known as the "spat" stage. Spats are juveniles that have settled on the benthic substrate in a given habitat; they are small but exhibit shell morphology similar to adults[2]. Spatially grown mature bivalves occur within mangrove ecosystems in brackish intertidal zones. The natural availability of spat depends on the number of broodstock currently or soon to be spawning near the estuarine floor[3,4]. Bivalve broodstock first reaches reproductive maturity at around six months[5] and typically measures 6 to 9 cm in shell length[6].

Given the high economic value of bivalves, the availability of natural spat is critical. Understanding the species composition, abundance, and life cycle of bivalves is essential for determining the optimal timing of bivalve collection in a given ecosystem. Harvesting at the correct time is a key step in effective aquaculture practices. Dolorosa & Dangan-Galon[1] reported that the highest percentage of *Polymesoda (Geloina) erosa* spat collection from mangrove substrates occurred in April (14.41%) and September (12.18%). In bivalve aquaculture, natural spat availability is especially valuable, as spat tends to grow at significantly higher rates than wild populations[2].

Bivalves inhabiting mangrove ecosystems are rich in nutritional value and hold substantial economic significance.

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Consequently, many local communities, particularly those whose livelihoods depend on fishing, rely heavily on mangrove bivalves as a primary resource. However, anthropogenic activities in the coastal waters of Rupat Island may alter aquatic habitats that are home to various aquatic organisms. Excessive harvesting activities can change habitat conditions and alter the population structure of bivalve communities. Changes in a population's abundance and spatial distribution during the early stages of benthic life may also result from subsequent settlement processes[7]. Such environmental changes can disrupt the life cycle and reproductive patterns of bivalves.

Habitat changes affect adult individuals and early developmental stages, such as larvae and juveniles[5]. Therefore, a deeper understanding is necessary to support sustainable mangrove bivalve aquaculture, including knowledge of species composition, abundance, and the timing of spat settlement. Currently, there is no available data on the species, abundance, and spat settlement period of bivalves on mangrove forest substrates along the coast of Rupat Island. Based on this rationale, a study is required to investigate the species composition, abundance, and spat settlement timing of bivalves inhabiting mangrove substrates on the coast of Rupat Island, which is administratively located within Bengkalis Regency, Riau Province.

2. RESEARCH METHOD

Time and Place

This study was conducted over five months, from June to October 2017, along the eastern coastal waters of Rupat Island, Bengkalis Regency, Riau Province, Indonesia (Figure 1). The sampling period was selected to capture the temporal variability in bivalve spat occurrence under differing environmental conditions such as temperature, salinity, pH, and water transparency. Laboratory analyses were conducted at the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau. A survey method involved direct field observation and sampling, laboratory species identification and abundance analysis.

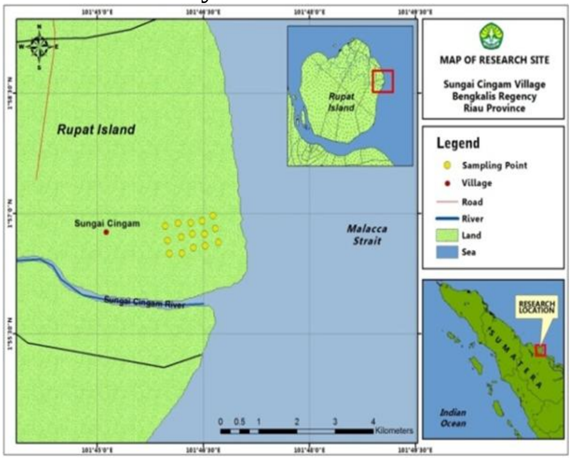

Figure 1. Study site map

Method

Sampling locations were selected using a purposive sampling technique based on tidal zones within the mangrove ecosystem. Three subzones were defined as follows:

Subzone 1: Upper intertidal zone (highest tidal reach); Subzone 2: Middle intertidal zone (area between high and low tide); Subzone 3: Lower intertidal zone (lowest tide line adjacent to open water). Each subzone was spaced 20 m apart. A total of 15 sampling stations were established, with five transects per subzone. Each transect contained a square collector unit (1 m × 1 m) made of netting (mesh size 1 mm × 1 mm), suitable for capturing bivalve spat from mangrove sediments.

Sampling was conducted during low tide. Collectors were retrieved and rinsed in a basin to dislodge spats from the net. This procedure was repeated monthly from June to October. Collected spats were placed into a filtering bucket, sieved using a 1 mm mesh, preserved in 10% formalin solution, and transported to the laboratory for washing, counting, and taxonomic identification.

Procedures

Proximate Analysis Observations

Water samples were collected during high tide using 1000 mL bottles, stored in an ice box, and subsequently analyzed in the laboratory. Total Suspended Solids (TSS) were determined gravimetrically using Whatman 42 filter paper, following the method described by Muccha et al. in Kurniawan[8]. Initially, the filter paper was oven-dried for 10–15 minutes, cooled in a desiccator, and weighed to obtain the initial mass (B). A 1000 mL water sample was then filtered through the prepared paper, which was subsequently dried at 100°C for one hour. After cooling in a desiccator, the filter paper was reweighed to obtain the final mass (A). The TSS concentration was calculated based on the difference between the final and initial weights of the filter paper. TSS was calculated as:

$$TSS = \frac{A - B \times 1000}{V}$$

Description:

TSS	=	Total Suspended Solids (mg/L)
A	=	Weight of filter paper with residue (mg)
B	=	Weight of empty filter paper (mg)
V	=	Volume of water sample (mL)

Sediment Type Analysis

Sediment samples were collected at a depth of 10 cm using a hand trowel, placed in plastic bags (500 g), and stored in an ice box[9]. The analysis included sediment fraction (gravel, sand, mud) and organic content.

The procedure followed Rifardi[10] for sediment analysis. A 100 g sediment sample was weighed, dried at 90–105°C, ground, and mixed with 3% hydrogen peroxide (H_2O_2) to remove organic matter. The sample was then sieved through a series of mesh sizes to separate different particle size fractions. Fractions smaller than 63 µm were further treated by soaking in 3% H_2O_2 for 24 hours to ensure complete oxidation of organic content. Subsamples were taken at intervals of 4, 15, and 30 minutes, then oven-dried for 24 hours. Sediment types were subsequently classified using the Shepard ternary diagram based on their texture composition.

Sediment Organic Matter Content

The method by Alaerts & Santika in Kurniawan[8] was applied for organic content analysis. An empty crucible was dried at 105°C, cooled in a desiccator, and weighed to obtain its initial weight (b). A 50 g sediment sample was dried and weighed with the crucible (a). The sample was combusted at 550°C for 3 hours in a muffle furnace to burn off organic matter, which was cooled and reweighed (c). The organic content was calculated based on the weight loss during combustion. The organic matter percentage was calculated using:

$$\text{Organic Matter} = \frac{a - c}{a - b} \times 100\%$$

Description:
a = Weight of crucible + dried sample (g)
b = weight of empty crucible (g)
c = weight after combustion (g)

Water Quality Parameters

Water quality measurements were taken during high tide near each subzone: pH was measured using pH indicator strips. Water transparency was measured using a Secchi disk, calculated as follows:

$$\text{Transparency} = \frac{\text{Depth of Disappearance} + \text{Depth of Reappearance}}{2}$$

Salinity was measured with a handheld refractometer. Temperature and tidal patterns were obtained from secondary data[11], to determine the submersion time of collectors and local tidal types.

Bivalve Analysis

Species composition was analyzed by identifying the number of species and individuals found at each sampling site. Data were tabulated monthly to observe trends in species occurrence and relative abundance. Bivalve abundance was calculated using Odum's[12] formula:

$$K = \frac{ni}{A}$$

Description:
K = Species abundance (individuals/m²)
N = Number of individuals found
A = Area of sampling plot (m²)

Relative abundance was calculated as the percentage contribution of each species to the total number of individuals:

$$K = \frac{ni}{N} x\ 100\%$$

Description:

n = Number of individuals of a particular species

N = Total number of individuals of all species.

3. RESULT AND DISCUSSION

Study Area Description

According to data from the BPS[13], Rupat Subdistrict is part of Bengkalis Regency, located along the eastern coastal zone of Sumatra Island, between 01°55'10" – 01°59'30" N and 101°43'50" – 101°47'10" E. The total area of Rupat Subdistrict covers approximately 896.35 km², with a population of 31,759 inhabitants. The region's soil types are peat, fluvial deposits, and swamp sediments. Several rivers flow through this area, including Penebak River, Rempang River, Morong River, and Injab River, whose estuaries are bordered by diverse mangrove vegetation.

Sungai Cingam Village, situated in a coastal zone dominated by mangrove forests, is significantly influenced by tidal fluctuations. The tidal pattern in the Rupat Subdistrict is classified as mixed, mainly semidiurnal. A distinctive feature of the tidal system in Sungai Cingam is the delayed rise of the water level during high tide, where water flows first through rivers and drainage channels. Once the tide peaks, water inundates the mangrove forest via natural irrigation canals. The dominant mangrove species in the coastal area include *Sonneratia alba*, *Rhizophora* sp, and *Avicennia* sp.

Water Quality and Sediment Characteristics

Water quality parameters are critical determinants for the survival of aquatic organisms, particularly within mangrove ecosystems that serve as a natural habitat for bivalve spat[14]. The environmental parameters measured in this study include temperature, salinity, pH, water transparency, and current velocity. The water quality measurements in the study area revealed the following results: the water temperature was recorded at 32°C, with a salinity level of 23‰, indicating brackish water conditions typical of mangrove coastal environments. The pH level was 7, showing a neutral condition suitable for most aquatic organisms. The water transparency reached 34 cm, reflecting moderate light penetration that suspended particles may influence the water. The current velocity was observed at 0.27 m/s, which suggests a relatively calm water flow adequate for sediment deposition and mangrove root stability.

The sediment characteristics and water quality parameters in the mangrove forest of Sungai Cingam Village exhibit notable spatial variations across different subzones. The organic matter content in sediments is highest in Subzone 1 at 33.66%, followed by 17.80% in Subzone 2, and lowest in Subzone 3 at 2.37%, as determined using the method developed by Alaerts & Santika in Kurniawan[8].

Sediment analysis reveals a dominance of sand-type sediments across all subzones, with an average composition of 98.00% sand and 2.00% silt/mud, based on sampling methods following Rifardi10. Furthermore, the concentration of Total Suspended Solids (TSS) in the area ranges from 200 to 900 mg/L, with the highest concentration observed in Subzone 3 (900 mg/L) and the lowest in Subzone 1 (200 mg/L). These TSS values significantly exceed the marine biota water quality threshold, which is set at <20 mg/L according to the Decree of the Minister of Environment No. 51 of 2004[15].

Physico-Chemical Characteristics

The results of environmental parameter measurements, including water physicochemical parameters, organic matter content, and suspended solids, indicate that the area of Sungai Cingam Village is in optimal condition for the growth and development of bivalve seedlings. This is due to the generally good quality of physico-chemical parameters, although the organic matter content is very high and suspended solids are at moderate levels, resulting in somewhat turbid water.

Water temperature ranged between 31–32°C, salinity 21–23‰, pH 7, transparency 35–36 cm, and current velocity 0.18–0.37 m/s. These values represent a range of physico-chemical parameters supportive of bivalve life. Physico-chemical parameters act as limiting factors for bivalve seedling abundance at the research site. According to Krebs in Agususilo[5], temperature is a crucial parameter affecting the physico-chemical properties of water and impacts various life cycle stages of organisms. Temperature is also a limiting factor for species distribution, survival, reproduction, larval development, and metabolism. Meanwhile, Kennish in Agususilo[5] states that ocean currents influence planktonic larval distribution. The presence of juveniles and spat in parts of the river is also influenced by current velocity, which helps the dispersal of planktonic trochophore larvae within the mangrove ecosystem.

The sediment organic matter content ranged from 2.37 to 33.66%, classified as high. This variation is influenced by organic matter sources from mangrove leaf litter, differing among subzones. Suspended solids ranged from 200–900 mg/L, which is very high compared to the seawater quality standards per the Indonesian Ministry of Environment Regulation No. 51 of 2004[15], setting a maximum suspended solids limit of <20 mg/L for marine biota.

Sediment types in the mangrove forest area of Sungai Cingam Village were dominated by sand at 98% and mud at 2%. The presence of sandy sediment in the coastal area is due to waves transporting sand particles, rock fragments, and coral from the Malacca Strait. Mud sediment is influenced by the Morong River flow, which carries fine sediment from the land to the sea due to erosion. Suspended particles transported by freshwater and factors affecting aggregation and sedimentation, such as ocean currents, also play roles in sediment characteristics.

Bivalves in mangrove habitats prefer sandy sediments because of their elongated shell morphology and burrowing lifestyle. Sand enhances water mass exchange and oxygen availability, supporting bivalve growth and survival[14]. Sandy sediments have large pore water spaces, resulting in higher pressure that facilitates bivalves moving in and out of the sediment.

Types and Abundance of Bivalve Spat

The bivalve spat identified in the mangrove forest area of Sungai Cingam Village consisted of three species. The bivalve spat in the study area belongs to three species from different families within Bivalvia. These include *P. acutidens* from the family Solenidae, *P. expansa* from Cyrenidae, and *P. exilis* from the family Unionidae. The abundance of bivalve spat organisms varied across each subzone. The highest average abundance was recorded in Subzone 3, with 2.13 ind/m², while the lowest was found in Subzone 2, at 1 ind/m². The graph of spat abundance in each subzone (Figure 2) indicates that the highest number of individuals was recorded in October, dominated by *P. acutidens* at 0.67 ind/m².

The highest relative abundance was observed for *P. expansa* in Subzone 2. In Subzone 3, *P.acutidens* was the most dominant species, and *Pilsbryoconcha exilis* was not found. *P. expansa* accounted for 71.43% of the total, making it the most dominant species, whereas *Pilsbryoconcha exilis* was the least abundant, with only 6.67%. In the upper subzone, *P. exilis* was not detected.

Bivalve Seed Abundance by Month

Figure 2 compares bivalve seed abundance, indicating that catches increased in September and October compared to June–August. However, only *P. acutidens* dominated the catches. Figure 2 shows that *P. acutidens* catches increased monthly, especially in subzone 1, with peak catches in September and October. *P. expansa* catches increased monthly, particularly in subzone 3, although the total numbers were lower than *P. acutidens*.

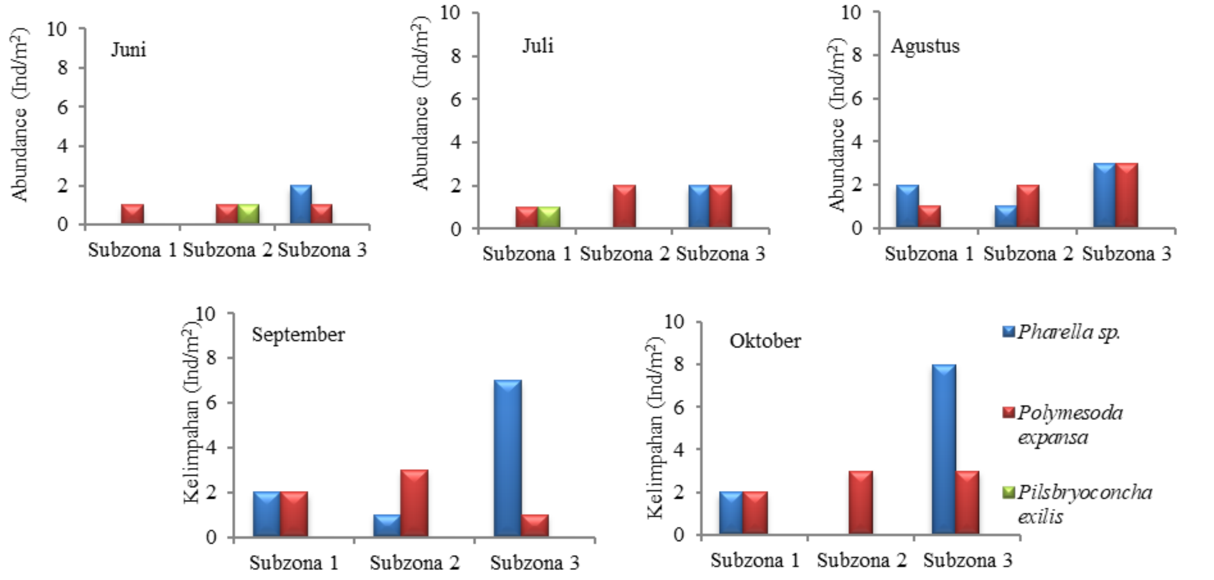

Figure 2. Abundance of bivalve spat in each subzone/month (June–October)

Based on Table 2, the bivalve seed species identified were *P. expansa* (Lokan), *P. acutidens* (Sipetang), and *P. exilis* (Kijing). According to Tanjung[16], the seed size of *P. acutidens* is 2 cm; Clemente[17] states that *P. expansa* seeds are 3 cm in size, while Anne[18] reports that *P. exilis* seeds are 2 cm. The bivalve seeds found were <2 cm for *P. acutidens* and *P.exilis* and <3 cm for *P.expansa*.

The average abundance of bivalve seeds in the mangrove forest area of Sungai Cingam Village was 4.06 individuals/m². The highest abundance was in subzone 3 (Lower), adjacent to the Morong River estuary. In this subzone, bivalve seeds are submerged in seawater for shorter durations, allowing them more time to feed and reducing exposure to predators. This supports Clemente & Baban[19] statement that tidal-influenced areas are ideal habitats for bivalve seeds.

The high number of bivalve seeds in Subzone three may also be influenced by the bivalve larval stage, which is planktonic and able to adapt well to the habitat characteristics of Subzone 3. Bivalve larvae are highly vulnerable to predators; thus, fewer predators result in higher seed abundance. Starr[20] stated that larvae are highly susceptible to predation during the planktonic stage. The life cycle of clams requires specific environmental conditions to support growth, gonad maturation, gametogenesis, and pre-larval metamorphosis into a trochophore. Post-settlement survival will be optimal if favourable environmental conditions allow clams to grow and develop into adult individuals.

The mangrove forest in Sungai Cingam Village spans approximately 180 m. The distance between each subzone is 50 meters. Bivalve seeds were found in all subzones, but the most abundant were in subzone 3 (Lower), which is rarely submerged due to the absence of water basins yet highly influenced by tidal dynamics. During high tide, seawater currents push larvae toward the estuary, and during low tide, river water flows to the estuary, causing larvae to be trapped in the area. According to Dody in Efriyeldi[21], water movement carries food particles and water masses of varying quality, which may or may not suit aquatic organisms. This movement also influences larval distribution, allowing larvae to reach suitable or unsuitable habitats. Tidal effects in distributing bivalve larvae lead to greater seed abundance in subzone 3. Sarong et al.[22] stated that bivalve seed distribution is affected by current velocity and tidal activity.

According to interviews with local communities, the timing of bivalve seed abundance cannot be predicted. Locals usually collect seeds during full moon and dry land conditions, as seawater recedes far into the sea. Harvesting is done using an iron tool approximately 25–30 cm long with a sharpened tip.

The highest relative abundance was recorded in subzone 3 (lower), likely due to its proximity to the Morong River estuary. The estuary brings in nutrients both from upstream during ebb tides and from the sea during high tides. This aligns with Ali et al.[3], who stated that estuarine areas contain three times more seeds than other regions. Interestingly, although subzone 3 is close to a river branch, it is the least submerged area due to the lack of water basins. Meanwhile, the lowest relative abundance was found in subzone 1 (upper), possibly because it is always submerged by water, which increases the number of predators like fish that prey on bivalves. Clemente[17] stated that ideal bivalve habitats are those with proper water circulation.

Bivalve Seed Abundance by Month

The abundance level of bivalve seeds fluctuated from month to month. A significant increase occurred in September, peaking in October, with the highest value recorded for *P. acutidens* at 0.67 ind/m². In contrast, June was the period with the lowest catch. This phenomenon indicates that the peak recruitment period for bivalve seeds occurred in September–October. However, overall catch levels remained low, suggesting that June–October cannot yet be considered the absolute peak of recruitment. The dominant factor likely influencing this pattern is the spawning period of adult bivalves, which may not have reached its maximum.

According to several sources, *P. acutidens* spawns throughout the year, with gonad development increasing from February to April and spawning from May to June[21]. The primary spawning season typically falls between July and August[5]. Clemente[17] also states that larvae can be found year-round, although their peak presence coincides with the breeding season. The variation in seed sizes supports the notion of continuous spawning throughout the year; however, environmental factors significantly influence recruitment success. Adverse weather conditions in July–August, such as storms and high waves, are believed to reduce the number of seeds that successfully settle on the substrate. In contrast, calmer sea conditions during September–October support settlement processes and increase seed catch rates. Tanjung[16] stated that calm water conditions enhance the chances of larval settlement, while high waves can lead to physiological stress or excessive predation.

Seasonal Factors

With its tropical climate, Indonesia has two seasons: the dry season (April–September) and the rainy season (October–March). The rainy season, which is more humid and supplies soft substrates and nutrients from river runoff, supports increased sexual activity in bivalves[21]. Therefore, the increase in seed abundance observed in September–October may be part of the preparation for a more active spawning period during the wet season.

4. CONCLUSION

Three species of bivalve seeds were identified: *P. exilis*, *P. expansa*, and *P. acutidens*. The highest seed abundance was recorded in subzone 3 (lower intertidal) at 2.13 ind/m², while the lowest was observed in subzone 2 (middle intertidal) at 0.93 ind/m². Settlement intensity increased during September and October compared to June–August. The highest mean monthly abundance occurred in October at 1.2 ind/m², whereas the lowest was in June at 0.4

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ind/m². The average abundance of bivalve seeds over the five-month observation period was 4.1 ind/m². Among the species, *P. acutidens* exhibited the highest average seed density at 2 ind/m², while *P. exilis* had the lowest at 0.13 ind/m². Seed collection from June to October remained relatively low, indicating that the peak bivalve recruitment period had not yet occurred. Therefore, this period is not optimal for seed harvesting. The mangrove forest area in Sungai Cingam Village, Bengkalis Regency, Riau Province, continues to provide a suitable habitat for aquatic biota.

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