Morphometric and growth of mudskipper (family: Gobiidae) in mangrove Pancer Karangantu, Banten

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Abstract. *Boleophthalmus pectinirostris* is one of three mudskipper species inhabiting the Pancer Mangrove ecosystem in Karangantu, alongside *Periophthalmus chrysospilos* and *Periophthalmodon schlosseri*. This study aimed to analyze the morphometric characteristics and growth of *B. pectinirostris* in relation to key environmental parameters. Field sampling and water quality measurements (temperature, salinity, and pH) were conducted in situ. Meanwhile, fish identification and morphometric analysis were conducted ex situ. The highest abundance of B. pectinirostris was recorded at Station 2 (72 individuals per 100 m²), indicating that this species can survive in aquatic conditions impacted by anthropogenic activity. Morphometric results revealed that salinity had a stronger correlation with pelvic fin length in females than in males. The growth pattern for male, female, and combined sexes was positively allometric, suggesting that body weight increases at a faster rate than body length. Growth parameters based on the von Bertalanffy growth model yielded $L\infty$ = 17.63 cm, K = 1.02 per year, and t_0 = –0.18 years, indicating rapid growth during early life stages.

1 Introduction

The Pancer Karangantu Mangrove Ecosystem is currently developing into one of the tourist destinations located in Kasemen District, Serang City, Banten. In addition to serving the community's economic interests through tourism, the Pancer Mangrove area also has important ecological functions. One of the ecological functions of mangroves is to provide habitat for various aquatic species. The mangrove forest ecosystem serves as a feeding ground, spawning area, and breeding site [1].

Fish that inhabit mangrove areas include the mudskipper. Mudskippers belong to the fish group from the family Gobiidae, subfamily Oxudercinae [2]. Muddy habitats, such as those found in mangrove ecosystems, are favored by mudskippers. According to [3], one of the morphological adaptations of mudskippers to their dry living environment during low tide is their ability to crawl through muddy areas. Mudskippers possess amphibian-like characteristics, enabling them to crawl on mud and climb mangrove roots [4].

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Mudskippers serve as bioindicators of soil quality or fertility, which is suitable for mangrove vegetation planting [5]. The condition of mudskippers can be used as an indicator of a healthy environment that is suitable for mangrove vegetation. According to [6], these fish are capable of absorbing and accumulating various types of pollutants, including industrial waste, agricultural runoff, household waste, and residues from transportation activities. Therefore, mudskippers have a relatively high level of resistance and tolerance to polluted water conditions. Physiological, histological, and other developmental changes in these fish can be used as indicators to evaluate water conditions in an ecosystem [6].

The condition of mangrove forests as a habitat for mudskippers can influence the physiological conditions of the fish, including their morphometrics and growth. The Pancer Karangantu Mangrove area currently faces waste-related problems that may reduce the ecological function of the mangroves. According to [7], the presence of accumulated waste in the Karangantu mangrove area inhibits the growth of new mangrove seedlings. [8] reported that the outer sediment of the Pancer Mangrove contains lead (Pb) at a concentration of 58.32 mg/kg. According to [9], mudskippers in the polluted Mtoni mangrove forest in Tanzania exhibited negative allometric growth patterns and deformities such as the absence of one eye, which were caused by urban and industrial waste contaminating the habitat.

Waste-related issues in mangrove forests can affect the morphometric conditions and growth of mudskippers in the Pancer Karangantu Mangrove area. According to [10], the morphometric characteristics of fish are influenced by environmental factors. The condition of aquatic environments contributes to changes in growth patterns among aquatic organisms [11]. The Pancer Karangantu Mangrove area presents various potential environmental challenges, thus necessitating a study on the morphometric conditions and growth of mudskippers in the area. Therefore, studying the morphometrics and growth patterns of mudskippers in the Pancer Karangantu Mangrove area is essential to understanding and optimizing the use of its biological resources. This study aims to identify and determine the morphometric characteristics and growth patterns of the dominant mudskipper species in the Pancer Mangrove ecosystem, Banten.

2 Methodology

2.1 Location and time of research

The research was conducted from February to March 2025. Fish sampling and water quality measurements (temperature, pH, and salinity) were carried out in situ at the Pancer Karangantu Mangrove, Kasemen District, Serang City, Banten Province. The determination of research station points was carried out using the purposive sampling method (intentional sampling selection). The station points were divided into two stations that represent the conditions of the Pancer Karangantu Mangrove ecosystem. Station 1 was chosen because it is located closest to the Karangantu Harbor pier and the entrance to the Pancer Karangantu Mangrove Area, and it contains a significant amount of trash within its mangrove vegetation. Meanwhile, Station 2 was chosen because it is located on Pancer Beach at a greater distance from the pier and has less human activity. Identification and determination of the dominant mudskipper species, length-weight measurements, morphometric measurements of mudskippers, and data analysis were conducted ex situ at the Laboratory of the Fisheries Science Study Program, Faculty of Agriculture, Sultan Ageng Tirtayasa University. The research location showed in **Fig 1**.

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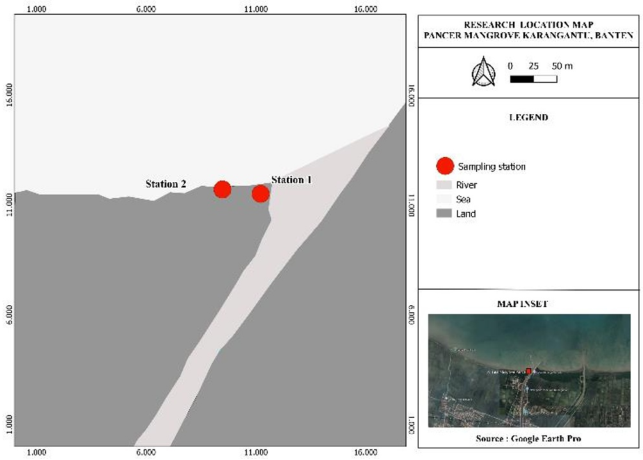

Fig. 1. Map of sampling locations.

2.2 Tools and materials

This study utilized various tools, including a fish scoop net, 1,75 inch span net 1 meter high fish packing plastic, raffia string, measuring tape, mobile phone camera, thermometer, styrofoam coolbox, plastic tub, pH meter, refractometer, dropper pipette, labels, writing instruments, ruler, caliper, analytical balance, graph paper, latex gloves, and a laptop. Materials used in the field included water samples, mudskippers, ice, 70% alcohol, seawater, distilled water, and tissue paper.

2.3 Fish sampling methods

Sampling of mudskipper was carried out by exploration and installing gill nets in the Pancer Karangantu Mangrove area. Exploration was carried out by taking mudskipper samples taken at each station. At each station, mudskipper samples were taken 4 times in 2 months with an interval of 2 weeks [12]. Sampling time was from 14.00 to 16.00 [13]. The transect at each station was 10 m x 10 m. Fish sampling used a scoop and a 1.75inch net with a height of 1 meter. Fish samples were packed using clear plastic and put into a coolbox. The fish were then transported to the laboratory using land transportation. Then the fish were identified and separated according to their species into plastic tubs. Then the fish were measured for length and weight and distinguished between males and females. After that the fish were put into plastic to be preserved using 70% alcohol [14].

2.4 Water quality measurement methods

The water quality measured is temperature, pH and salinity. Each water quality sample sampling was repeated 3 times [15].

2.5 Identification of mudskipper

Fish identification was carried out at the BDP Laboratory, Fisheries Department, Faculty of Agriculture, Sultan Ageng Tirtayasa University. Fish identification refers to [16].

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2.6 Data analysis

2.6.1 Fish abundance analysis

Abundance is defined as the number of individuals in an area [13]. According to [17], the higher or greater the abundance value, the more individuals there are in the area. This abundance value determines the type of mudskipper that is most abundantly found in the Karangantu mangrove area. The abundance value of mudskipper is calculated using the formula [18].

$$\text{Abundance} = \left(\frac{\text{Number of individuals of a species}}{\text{Sampling area}}\right) \qquad (1)$$

2.6.2 Morphometric characteristics

The morphometric characters studied refer to [19]. Morphometric characters were measured using a ruler and caliper. Morphometric identification of the mudskipper was carried out by observing and measuring 23 morphometric characters. The detailed representation of these morphometric characters is presented in **Fig 2**.

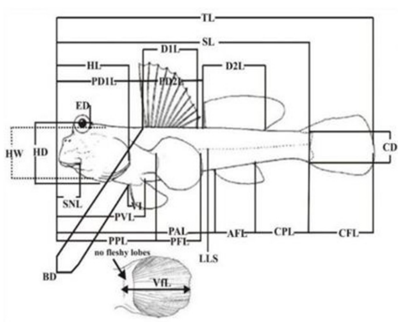


Fig. 2. Morphometric characters measured [20].

2.6.3 Morphometric analysis with water quality

The results of twenty-three morphometric character factors per sex were correlated with water quality (temperature, pH, and salinity) using the Principal Component Analysis (PCA) correlation, a modification of the method [15]. The use of PCA uses software, namely SPSS 20.

2.6.4 Growth pattern of mudskipper

a. Length-weight relationship of mudskipper

Analysis of the relationship between length (L) and weight (W) of the mudskipper fish using the following formula:

$$W = aL^b \qquad (2)$$

Description:

W = Fish body weight (grams)

L = Fish length (mm)

a and b = constants, to determine the closeness of the relationship between growth parameters (b value), a t-test with a 95% confidence interval is used.

If the b value = 3, then the growth pattern is isometric where the growth of fish length and fish weight growth are balanced. If the b value >3, then the growth pattern is positive allometric where the growth of fish weight is faster than the growth of fish length. If the b value <3, then the growth pattern is negative allometric where the growth of fish length is faster than the weight of fish.

b. Growth Parameters (L∞, K and t0)

Estimation of growth parameters is carried out following the von Bertalanffy equation as follows:

$$L_t = L\infty(1 - e^{[-K(t-t0)]}) \quad (3)$$

Description:

L_t	= length of fish at age t (time unit)
L∞	= theoretical asymptotic length of fish
K	= growth coefficient (per time unit)
t0	= theoretical age when fish length is equal to zero

The estimation of growth parameters of the von Bertalanffy method with ELEFAN can be done using the statistical software Rstudio [21]. The estimation of theoretical age (t0) is done using the empirical equation [22] as follows:

$$\text{Log}(-to) = -0{,}3922 - 0{,}2752\ \text{Log}(L\infty) - 1{,}038\ \text{Log}(K) \quad (4)$$

3 Result and discussion

3.1 Abundance of fish

The results of the study conducted at two stations in the Karangantu Mangrove Area obtained 111 mudskippers. Based on the identification results, 3 species were obtained, namely *Periophthalmus chrysospilos*, *Periophthalmodon schlosseri* and *Boleopthalmus pectinirostris* (**Fig 3**). The largest number was from the *B. pectinirostris* species of 100, then from the *P. chrysospilos* species of 7 and the fewest species was *P. schlosseri* of 4.

a b c

Fig. 3. Types of mudskipper fish found in the Pancer Karangantu Mangrove area: (a) *P. chrysospilos,* (b) *P. schlosseri* and (c) *B. pectinirostris*.

Based on the observation results, it is known that the highest abundance value was found at station 2 of the *B. pectinirostris* species, namely 72 ind/100m^2 and the second highest abundance value was found at station 1 of the *B. pectinirostris* species 26 ind/100m^2. Meanwhile, the lowest abundance value was found at station 1 of the *P. schlosseri* species 1 ind/100m^2 (**Fig 4**). Stations one and two have slightly different water parameter characteristics because station 2 has more mangroves and less garbage, and the distance between stations is only 20 meters. However, at station one, the cause of the low abundance value is thought to be because the area is closest to the fishing port of Karangantu pier, as well as the location of the entrance to the Pancer Karangantu Mangrove area. According to

[13], fishing activities that can cause noise and vibrations can disturb and affect fish activity so that fish will experience stress which can inhibit fish growth in general, including mudskipper. Habitat conditions greatly influence the value of fish species abundance [23].

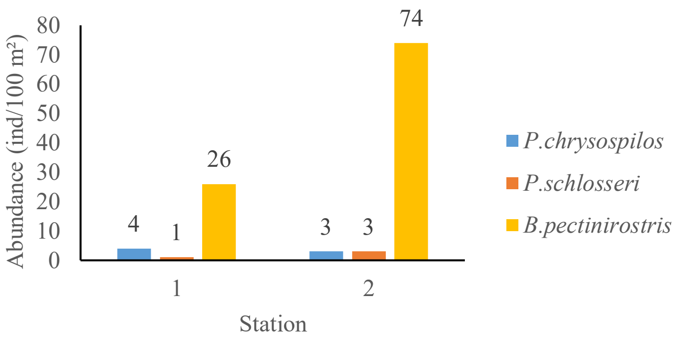


Fig. 4. Abundance of fish.

The proximity of the station one area to the pier makes this area vulnerable to pollution from port activities such as waste disposal and ship fuel spills that can reduce air quality and damage the basic aquatic habitat. In addition, as the entrance to the area, this area is also a place for stretches of garbage that carry coastal currents or garbage that is carelessly thrown away by visitors, which ultimately disrupts the balance of the ecosystem and reduces the carrying capacity of the habitat for fish. The low fish display value at station one is affected by the slightly emphasized environmental conditions and the availability of food sources. Environmental factors greatly influence the distribution and reporting of fish, in supporting the life of an organism [24].

The *B. pectinirostris* species is the most dominant in the Pancer Karangantu Mangrove area. This may be attributed to the substrate (mud) and environmental conditions that are suitable for the lifestyle of *B. pectinirostris* fish. The quality of temperature in the pancer mangrove area supports the habitat of *B. pectinirostris* fish. The temperatures measured in this study were 34.3°C at station 1 and 31.3°C at station 2. The average temperature recorded in this study, when compared with the study of [25] Juveniles *B. pectinirostris* showed a preference (preferred) for temperatures between 27-34°C, with a preferred temperature of 31.2 ± 0.5°C. In terms of ecological preference for high temperatures, this is considered reasonable, because *B. pectinirostris* lives in intertidal mudflat habitats which have higher temperature characteristics compared to deeper subtidal zones [25]. At low tide, shallow waters are often exposed to direct sunlight, so that the temperature increases faster than deeper waters. In addition to temperature factors, the condition of the substrate or mud in the Pancer Karangantu mangrove area which has a hollow nest shape, supports the behavior of *B. pectinirostris* fish. This species spends a lot of time soaking in the mud and likes to jump when doing activities such as looking for food and breeding. According to research by [12] also stated that the genus *Boleopthalmus* lives in nests in the form of channels in the substrate (mud) with a depth of between 40-100 cm. In this study, the capture of mudskipper was also widely caught using gill nets, which are effective in catching *B. pectinirostris* when swimming on the surface of the mud. Therefore, it is possible that *B. pectinirostris* is the most dominant and is found in this study. Meanwhile, *Periophthalmus* fish were not found much because the behavior of these fish is rarely active in the mud, more active by attaching themselves to the mangrove roots and wood. The genus *Periophthalmus* always appears on mangrove roots [12].

3.2 Morphometric characteristics

B. pectinirostris as a species mudskipper with the highest abundance value in the Pancer Karangantu Mangrove area, was further analyzed for its morphometric characteristics. **Table 1** shows considerable variation in the body size of individual fish in the sample. The total length (TL) has an average value of 151.33 ± 21.77 mm, indicating that the body size of the fish is generally quite large and varied. The standard length (SL) also reflects this variation, with an average value of 121.55 ± 16.46 mm. Other characters such as head length (HL), length before the first dorsal fin (PD1L), length before the second dorsal fin (PD2L), length of the first dorsal fin (D1L), length of the second dorsal fin (D2L), length of the anal fin (AFL), length of the lateral line (LLS), length of the posterior pelvic fin (PPL), length of the pre-anal (PAL), length of the pre-ventral (PVL) and length of the ventral fin (VFL) also showed fairly consistent size diversity, indicating that the growth of fish body parts took place proportionally to the increase in body length.

Table 1. Morphometric characteristics of *B. pectinirostris*.

Morphometric Characteristics	*B. pectinirostris*
	Mean Value (mm)
TL	151.33±21.77
SL	121.55±16.46
HL	32.29±4.78
PD1L	43.31±5.93
PD2L	22.03±3.99
D1L	18.18±3.45
D2L	52.13±8.51
CD	9.87±1.60
CFL	29.31±4.02
CPL	5.63±1.15
AFL	47.60±8.06
LLS	58.32±13.59
PAL	69.08±10.15
PFL	23.82±5.47
PPL	32.02±4.90
ED	5.17±0.91
HD	20.08±3.33
SNL	13.32±2.39
HW	16.15±2.46
VL	5.90±2.02
PVL	34.05±5.10
BD	29.08±5.31
VFL	17.13±4.33

Meanwhile, several other body parts such as eye diameter (Eye Diameter/ED), head width (Head Width/HW), and length of the ventral fin (Ventral Fin Length/VFL) also experienced variation, but in a smaller range compared to other main body characters. Eye diameter (ED) had an average of 5.17±0.91 mm. Head width (HW) had an average of 16.15±2.46 mm. The smaller standard deviation values for ED and HW indicate that the size of these body parts is relatively uniform between individuals, although they still show differences.

Overall, these morphometric data illustrate the fairly high morphological diversity in the *B. pectinirostris* population in the Pancer Karangantu Mangrove area. This reflects the existence of natural variation between individuals in one population and shows the ability of this fish to grow and adapt to diverse environmental conditions in the mangrove habitat.

The total length (TL) in this study had a greater value compared to [26] study related to *Boleopthalmus boddart*i in Mekong Delta, Vietnam. In [26] study, the average total length of female *B. boddarti* was 12.07±0.08 cm and the total length of males was 11.95±0.08 cm. In [27] study, related to *Boleopthalmus dussumieri* in Indian waters, the SL was 9.90±2.05 cm, PD1L was 3.44±0.65 cm, PD2L was 5.27±1.10 cm, D1L was 1.36±0.53 cm, D2L was 4.20±0.99 cm, AFL was 3.76±0.80 cm, PAL was 5.68±1.24 cm, PFL was 0.57±0.13 cm and PPL was 2.19±0.42 cm. SL, PD1L, PD2L, D1L, D2L, AFL, PAL, PFL and PPL in this study have higher values compared to [27] study related to *B.dussumieri*. So overall, the morphometric characters of *B. pectinirostris* in the study have a larger size compared to other *Boleopthalmus* fish.

3.3 Water quality

The environmental quality conditions of the waters in the Pancer Karangantu mangrove area were carried out by measuring temperature, pH, and salinity parameters at two different stations. The measurement results showed that the water temperature at station 1 was recorded at an average of 34.3°C, while at Station 2 it was lower, namely 31.3°C (**Table 2**). This difference in temperature is caused by variations in vegetation cover, sunlight intensity, or differences in depth and water circulation at each station. Where at station 2 it is more covered by mangrove vegetation, than station 1. Based on the measurements obtained, the temperature at both locations is still in the range of temperatures that are suitable for organisms to survive. The mudskipper can still survive at temperatures between 28–38°C [13].

Table 2. Average results of water quality parameter measurements.

Water Quality Parameters	Water Quality Parameters	
	Station 1	Station 2
Temperature (°C)	34.3±2.9	31.3±2.2
pH	7.5±0.2	6.9±0.1
Salinity (PPT)	22.0±5.4	29.3±1.0

The pH value obtained from the measurements shows a difference in the acidity of the waters between station. At Station 1, the pH reached 7.5 which is slightly alkaline, while at Station 2 the pH was lower at 6.9, neutral which leads to weak acidic conditions (Table 2). Although the range of pH differences between the stations is small, Station 1 is more alkaline and Station 2 is less acidic. According [28], Waters with a pH value = 7 mean that the water conditions are neutral, pH <7 means that the water conditions are acidic, while pH> 7 means that the water conditions are alkaline. However, this pH range still meets the appropriate range to support the life of marine organisms. According to [15], the pH of the waters of the mudskipper habitat is 5.8-8.2. The conditions of Station 2 which are more vegetated allow the water pH to be less acidic. The difference in pH values at the research stations is caused by the presence of leaves, tree roots, and stems around the water flow that fall to the ground and decompose to form organic soil material [29]

The salinity of the waters also showed quite a striking difference between the two stations. At station 1, the salinity was recorded at 22.0 ppt which is included in the medium salinity category, while station 2 had a higher salinity value, which was 29.3 ppt (Table 2). This value indicates that station 1 is more affected by freshwater flow, such as from rivers or land runoff, because station 1 is also closer to the river or estuary area. According to [30], the salinity range that can be tolerated by marine biota is 18-32 ppt. Therefore, the salinity of both stations is still within the salinity that can be tolerated by marine biota.

3.4 Differences in male and female sex

In the analysis of morphometric characteristics of fish, not only environmental parameters such as water quality are considered, but also biological factors such as sex. Differences between male and female individuals can affect the results of morphometric measurements, so it is important to identify sex before conducting a Principal Component Analysis (PCA) correlation analysis. Gender differences in mudskippers can be recognized by the shape of their urogenital papillae. Male mudskippers generally have longer and tapered papillae, accompanied by small protruding bumps. Meanwhile, female fish have papillae that tend to be rounded and do not show tapered protrusions as illustrated in **Fig 5**.

Literature image [31] Research image

Fig. 5. Differences between male (A) and female (B) mudskippers.

3.5 Relationship between fish morphometrics and water quality

The relationship with water quality parameters such as pH, temperature, and salinity was tested using Principal Component Analysis (PCA) with SPSS 20 software. The component plot of the PCA test results illustrates the relationship between the morphometric characteristics of *B. pectinirostris* mudskippers and water quality parameters including temperature, pH, and salinity. The PCA results for male *B. pectinirostris* (**Fig 6**) showed that component 1 was dominated by the majority of morphometric characters, indicating strong correlation among body size parameters. Component 2 was mainly influenced by temperature and pH, while component 3 was driven by salinity and pelvic fin length (VL). Overall, the three principal components explained 82.16% of the total variation, with 69.79% from the first component, 6.92% from the second, and 5.45% from the third.

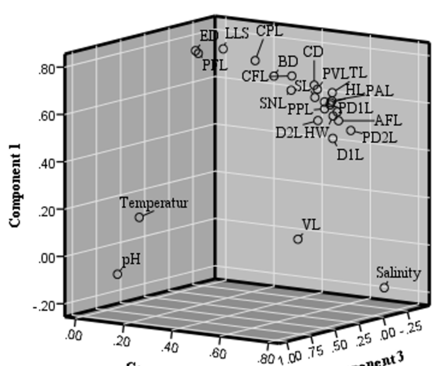


Fig. 6. Component plot of PCA test analysis results between morphometric characters of male *B. pectinirostris* fish with environmental quality parameters.

Morphometric characters and environmental quality parameters that are combined in one main component will be located close together [15]. Based on the component plot of the PCA test analysis results between morphometric characters of male *B. pectinirostris* fish with environmental quality parameters, most morphometric characters of male B. pectinirostris clustered together, while pelvic fin length (VL) was separated and closely associated with salinity, suggesting its potential influence on pelvic fin size growth. In contrast, temperature and pH were correlated with each other but have no relationship to the size of the morphometric characters of male *B. pectinirostris*.

In the results of the PCA test analysis between morphometric characters of female *B. pectinirostris* fish (**Fig 7**), component 1 is dominated by the main morphometric characters that are close to each other, TL, SL, HL, D1L, D2L, PD1L, PD2L, CD, AFL, CFL, PFL, PAL, PPL, PVL, LLS, VFL, ED, SNL, HW, HD, and BD. Component 2 was mainly represented by CPL, while Component 3 was associated with salinity, temperature, pH, VL, and ED. Overall, the three components explained 70.41% of the total variation, with 57.30% from the first, 7.83% from the second, and 5.28% from the third. Component 2 is dominated by the length of the caudal peduncle (CPL). Component 3 is dominated by the parameters of salinity, temperature, pH, pelvic fin length (VL) and eye diameter (ED). Overall, the three principal components explained 70.41% of the total variation, with 57.30% from the first component, 7.83% from the second, and 5.28% from the third.

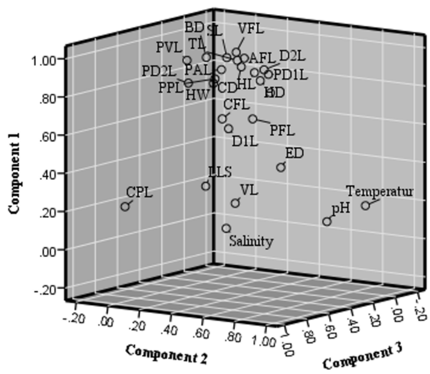


Fig. 7. Component plot of PCA test analysis results between morphometric characters of female *B. pectinirostris* fish with environmental quality parameters.

Based on the results of the PCA analysis of the morphometric characters of female *B. pectinirostris* fish and environmental quality parameters (Fig 7), most morphometric characters are closely grouped in the first component, indicating a strong relationship among these characters. The characters are TL, SL, HL, D1L, D2L, PD1L, PD2L, CD, AFL, CFL, PFL, PAL, PPL, PVL, LLS, VFL, ED, SNL, HW, HD and BD. These characters influence each other, meaning that the growth of one body part tends to be followed by the growth of other body parts. On the other hand, the CPL (caudal fin length) character was separated, showing weak correlation with other characters or water quality. Salinity and VL were positioned close together, suggesting salinity may influence pelvic fin growth, while temperature and pH showed no strong relationship with morphometric traits. ED was also isolated, indicating low correlation with both morphometric traits and environmental parameters.

A significant finding of this study is the consistent correlation between salinity and pelvic fin length (VL) in both male and female *B. pectinirostris*. This indicates that salinity may play a direct role in influencing the growth of the pelvic fin, an organ that contributes to stability and locomotion on muddy substrates in mangrove ecosystems. According to [32], the pelvic fins of *B. boddarti* have a large, fused bone structure, thus acting as a 'strong sitting pad' on a muddy semi-terrestrial substrate, which supports the fish's mobility in the mangrove ecosystem. The association suggests that variations in salinity levels could affect the allocation of energy resources towards the development of specific fins, reflecting a morphological adaptation to fluctuating estuarine environments. Unlike temperature and pH, which showed weak or no correlation with morphometric traits, salinity emerges as a dominant environmental factor shaping the morphometric variation of *B. pectinirostris*.

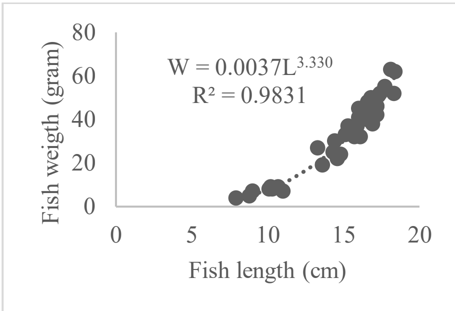
The relationship between fish morphometrics and water quality in this study has different results when compared to the study of [15] regarding mudskipper in the waters of Wonorejo Mangrove Surabaya. In the study by [15], temperature affects the growth of pelvic fin length, snout length, and pectoral fin length, and salinity affects the growth of standard length of mudskipper, lateral line length, and length before pelvic fin. This means that water quality parameters have different roles in the morphometric characteristics of fish depending on the species and environmental conditions of the waters where the fish live. This difference can be caused by specific morphological adaptations in each species to its habitat, as well as interactions between genetic factors and local ecological conditions. Therefore, the results of this study indicate that although water quality is an important factor in fish growth, its effect on morphometric characteristics can vary.

3.6 Growth pattern of mudskipper fish

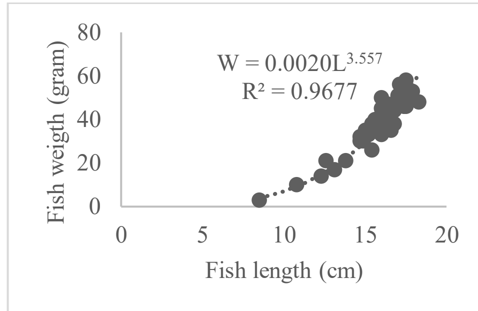
3.6.1 Relationship of length and weight of mudskipper fish

The calculation results of the relationship between length and weight of mudskipper fish can be seen in **Fig 8**. From the calculation results, the relationship between the length and weight equation of male *B. pectinirostris* $W = 0.0037L^{3.330}$ was obtained, while the female *B. pectinirostris* equation was obtained $W = 0.0020L^{3.557}$, and the combined male and female *B. pectinirostris* equation was obtained $W = 0.0031L^{3.395}$. The b value obtained is more than 3 for the relationship between the length and weight of male, female and combined male and female *B. pectinirostris*. This value shows that b is more than 3, which means that the growth pattern of mudskipper fish *B. pectinirostris* is positive allometric. According to [33], a positive allometric growth pattern is a growth pattern where the increase in weight is more dominant than the increase in length. So the result of the b value is more than 3, which is 3.395, which means that the increase in weight of *B. pectinirostris* is faster than the increase in length.

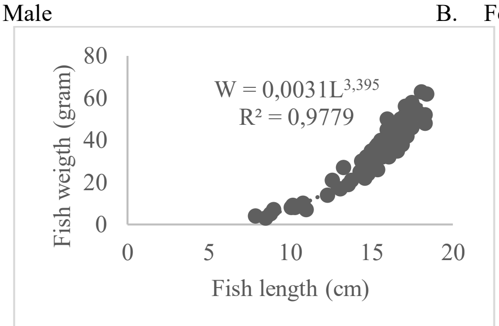
The results of the relationship between the length and weight of males in this study, has a greater value compared to the study of [34] in the Merauke estuary, Merauke Regency, Papua Province, Indonesia. In the study of [33] the results showed that the relationship between the length and weight of male *B. Pectinirostris* achieved was $W = 0.0112L^{2.856}$ and $W = 0.0099L^{2.888}$, while female *B. Pectinirostris* was $W = 0.0062L^{3.090}$ and $W = 0.0052L^{3.121}$. According to [34] *B. Pectinirostris* which is positively allometric shows a tendency for fish to be more still, so that there is an accumulation of energy which is then used for the formation of new cells, which has an impact on increasing fish body weight. This shows that *B. Pectinirostris* in this study has this tendency.



A. Male



B. Female



C. Combination of male and female

Fig. 8. Relationship between length and weight of *B. pectinirostris* mudskipper.

The coefficient of determination (R^2) value obtained was 0.9779. The R^2 value approaching 1 indicates that the relationship between length and weight of the fish is very strong, which is 97.79%. This means that variations in fish weight can largely be explained by variations in fish length. If the R^2 value approaches 1, the total length of the fish will increase along with the increase in fish body weight [35].

3.6.2 Growth parameters (L∞, K and t0)

The estimation of the parameters of the *B. pectinirostris* mudskipper caught in the Pancer Karangantu Mangrove Area obtained from the Rstudio statistical software, is modeled using the Von Bertalanffy equation as follows:

$$L_t=17.63(1-e^{[(-1.02(t+0.18)]}) \quad (5)$$

Based on this equation, a growth curve of the *B. pectinirostris* mudskipper can be made (Fig 9). The value of $L\infty$ = 17.63 cm indicates that the theoretical maximum length that can be achieved by the fish is around 17.63 cm. The growth rate K = 1.02 per year, meaning that the fish grows relatively quickly approaching its maximum length, because its value is quite high. The value of t0 = -0.18 years, t0 is the theoretical age when the length of the fish is equal to 0. Negative t0 values are common in the Von Bertalanffy model and do not always mean that the fish are actually at a negative age, this is just a mathematical adjustment value so that the curve fits the initial data. According to [36] Lt is the length of the fish at age t (time unit), $L\infty$ is the average length that fish can reach if they grow to a very old age / without limits (asymptotic length), K is the growth coefficient (time unit) and t0 is the age of the fish at zero length if they always grow according to the equation (t0 generally has a negative value). Statistically significant parameters $L\infty$ and K are very significant ($p < 0.001$), and t0 is not yet significant ($p > 0.05$).

Table 3. Results of parameter estimation of Von Bertalanffy growth model from Rstudio.

Parameter	Estimate	Standar Error	t-value	p-value
Linf	17.6259	0.3591	49.0894	0.0000***
K	1.0217	0.2174	4.6997	0.0000***
t0	-0.1822	0.2291	-0.7953	0.4284

Note: *** = very significant (p < 0.001), No sign (*, **, ***) = not significant (p > 0.05).

As a mention in **Table 3**, the asymptotic length (*L*∞) in this study has a greater value compared to the study by [37] in the coastal mudflats area of southwest Korea, namely female *B. pectinirostris L*∞ = 16.5 cm and male *B. pectinirostris L*∞ = 15.5 cm. The results of the study by [37] obtained a value of K = 1.07 per year and t0 = -0.23 in females and K = 1.39 per year and t0 = -0.35 in males. So, the K and t0 values in this study have smaller values than the results of the study by [37]. Differences in growth parameters in various water locations are caused by differences in aquatic environmental conditions [38].

The fish growth curve (Von Bertallanvy) can be seen in Fig 9. The black dots are fish length data grouped based on estimated age from 1 to 4 years. The curved line shows the estimated length of fish at a certain age from the von bertallanffy model. In the actual value of the length data at the age of 4 years, there is data that is higher than *L*∞. The longest length data in the study was 18.4 cm. Some fish can exceed the *L*∞ value, although it is not common. This discrepancy indicates a limitation of the model in fully representing the growth of the population. Biologically, L∞ does not represent the absolute maximum length of the fish, but rather the asymptotic mean size that the population tends to reach in the long term. Therefore, it is still possible for certain individuals to attain sizes larger than the estimated L∞, either due to genetic factors, longer lifespan, or favorable environmental conditions. Such exceptionally large individuals may be considered outliers that influence the model's estimation results. In the study of [36] related to *B. pectinirostris*, a *L*∞ value was also found to be lower than the longest actual data, namely females 19.5 cm and males 16.9 cm.

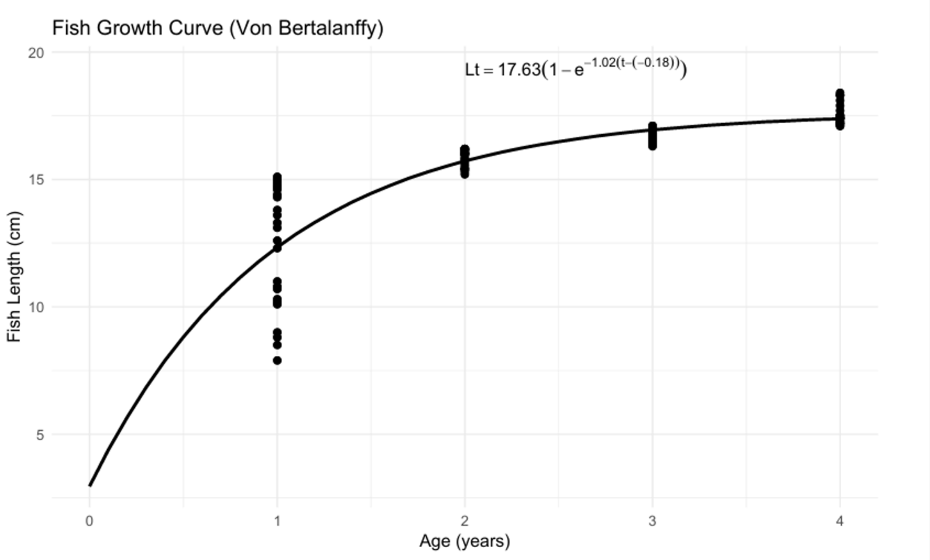


Fig. 9. Fish growth curve (Von Bertallanffy) of B. pectinirostris mudskipper from the Rstudio statistical software.

4 Conclusion

The mudskipper fish found in the Karangantu Mangrove Area are 3 species, namely *P. chrysospilos, P. schlosseri* and *B. pectinirostris*, the most dominant being the *B. pectinirostris* species. The *B. pectinirostris* species has a special morphometric characteristic, namely a longer second dorsal fin, compared to the other two species. The length of the second dorsal fin of *B. pectinirostris* is 52.13 ± 8.51 mm. The water quality is still in the range that is suitable for mudskipper fish. In the relationship between morphometric characters per sex of B. pectinirostris mudskipper fish, salinity has the potential to affect the length of the pelvic fins, especially in female fish.

The growth pattern of male, female and combined male and female mudskipper fish is positive allometric, meaning that the increase in fish weight is faster than the increase in length. The observed positive allometric growth suggests that, at present, the environmental conditions have not resulted in the negative growth patterns associated with severe habitat degradation. The growth parameters of the mudskipper *B. pectinirostris* were obtained $L\infty$ = 17.63 cm, K = 1.02 per year and t0 value = -0.18 years. From the Von Bertalanffy equation, it can be concluded that the mudskipper *B. pectinirostris* experiences quite rapid growth in length at the beginning of its age and slows down when approaching $L\infty$.

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