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## Morphometric characteristics of Fur Cockles (*Anadara spp.*) in Wonokromo and Juanda Estuary, Surabaya

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# Morphometric characteristics of Fur Cockles (*Anadara* spp.) in Wonokromo and Juanda Estuary, Surabaya

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**Abstract.** One of the invertebrate seawater animals that are considered to be a pollution existence parameter is fur cockles (*Anadara* spp). Further study is necessary to determine the environmental conditions that support the fur cockles' survival in the estuaries by observing the morphometric characteristics and analyzing the correlation factors between the fur cockle's growth and the environmental condition. This research was conducted in January and February 2017 in the river estuary area of Wonokromo and Juanda. Fur cockles (*Anadara* spp.) found in the estuarine area of Wonokromo and Juanda River were 18 - 57.59 mm in length with a rounded and thick shell. The shell color of the fur cockles in Wonokromo and Juanda are a blackish brown, while the flesh color in Wonokromo was observed to be darker than that in Juanda.

## 1. Introduction

Estuaries are an area that intake a lot of organic materials and there is a vast expanse of mud with benthic biota, such as shellfish [1]. The estuary region in Wonokromo and Juanda rivers has different water qualities. Wonokromo estuary contains many pollutants, because the river flow passes by industry areas and settlements that utilize the watershed for a living [2]. Juanda produces water which is able to be processed into drinking water by repeated filtering, as the river flow rarely passes by industries and settlements, making the pollutants in the water body of the river below the maximum content limit.

One of the invertebrate seawater animals that is able to be used as a pollution existence parameter is fur cockles (*Anadara* spp). Fur cockles are a great detritus eater through filter feeding, which allows them to filter any kind of food in the surrounding area. This feeding ability causes the pollutants to accumulate in their digestive tracts without poisoning themselves [3]. Polluted ecosystems in the water will result in the fur cockles being exposed to more pollutants, interfering with their growth.

The decline in fur cockle productivity on the Eastern coast of Surabaya was caused by a high level of shellfish-catching activity. Shellfish catching in the Sidoarjo region from 2013 - 2014 resulted in a decreased catch of shellfish by 534 tons [4].

The appeal of consuming fur cockles is triggered by their high nutritional value. Fur cockles contain minerals (calcium, phosphorus, iron, iodine), thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin and B12 vitamins [5]



Further study is necessary to determine the environmental conditions that support fur cockles in the estuaries by observing their morphometric characteristics and analyzing the correlation factors between the fur cockles' growth and the environmental condition.

## **2. Materials and methods**

### *2.1 Time and place*

This research was conducted in January and February 2017 in the river mouth estuary area of Wonokromo and Juanda. The fur cockle sample analysis was conducted in the Faculty of Fisheries and Marine laboratory of Universitas Airlangga, while the seawater and sediments sample were analyzed in Badan Riset and Standarisasi Industri (Baristand) laboratory in Surabaya.

### *2.2 Materials and equipments*

The materials used in this study were seawater, fur cockles and sediments taken from Wonokromo and Juanda estuaries. The equipments used in this study consisted of two boats, shellfish nets, a cool box, 0.01 mm callipera, a 0.0001 g precision digital scale, a dropper, a digital camera, paper labels, a cart, plastic clips, a permanent marker, a stopwatch, PVC pipes, a Global Positioning System (GPS) and water quality measurement devices such as a thermometer, refractometer and pH meter.

### *2.3 Study methods*

This study used the purposive sampling method to get a good description of the particular issue in the particular location of focus by conducting population random sampling, as well as obtaining the information considered to be important by the scientist [6].

### *2.4 Procedures*

#### *2.4.1 Sampling point*

The sampling location in Juanda River estuary was divided into three points: (1) 2000 m from the shore (S 07° 22.943' E 112° 51.173'), (2) 1750 m from the shore (S 07° 22.924' E 112° 51.019') and (3) 1500 m from the shore (S 07° 22.940' E 112° 50.868').

The sampling location in Wonokromo River estuary was divided into three points: (1) 2000 m from the shore (S 07° 22.943' E 112° 51.173'), (2) 1750 m from the shore (S 07° 18.050' E 112° 51.678') and (3) 1500 m from the shore (S 07° 17.978' E 112° 51.543').

### *2.5 Sampling*

The cockle sampling was done once a month from January to February 2017, with three replications at each sampling points for both locations. The cockles were caught using shellfish nets from a boat, and the cockles were put in a labeled plastic bag. The samples were stored in the cool box and their length, height and thickness was measured using a caliper. They were weighed using digital scales.

The sediment sampling was done using a capture tool at a depth of 1-5 meters [7]. The amount of sediment taken at each station was approximately 200 g. The sediment samples were put in labeled plastic bags and stored in the cool box.

Seawater sampling was done at each station taken 30 cm below the water surface, and as much as  $\pm 100$  ml. The water samples were inserted into a bottle for quality analysis [8]. The samples were added to  $\text{HNO}_3$  until the pH was  $< 2$ , allowing for sample preservation for up to 6 months [9]. The bottle or jerry can containing the water samples were labeled and put in the cool box for further observation.

#### *2.5.1 Parameters*

This study observed the main and supporting parameters. The main parameter was the cockle's morphometric characteristics, while the supporting parameters were the sediment condition and water quality (temperature, dissolved oxygen, salinity, pH and transparency).

#### *2.5.2 Morphometric characteristics*

The calculation method using frequency distribution followed the theory of Battacharya, as follows:

- a. Counted the number of size classes with the formula:

$$K = 1 + (3.32 \log n) \quad (1)$$

Note:

K : the number of class size.

n : number of observation data.

- b. Calculated the range data/regions with:

$$\text{Area} = \text{largest data} - \text{smallest data} \quad (2)$$

- c. Calculated the width of the class with:

$$\text{Class Width} = \frac{\text{Area}}{\text{Class}} \quad (3)$$

- d. Determined the limit under the first class and the upper limit. The upper limit of the class was obtained by adding the width of the class and the lower limit.

- e. Listed all of the limit classes for each class interval.

- f. Determined the value of the middle for each hose with a spread limit class.

- g. Specified the frequency for each class.

- h. Summarized the frequencies and checked the results was the total number of observation.

The frequency distribution morphology was determined to be in the same class interval and this was plotted on a graph used for determining the shift in the length distribution for each month in order to describe the number of age groups.

The weight and length correlation could be determined by determining the growth pattern of the observed objects [11]. The length and weight correlation of the fur cockles was analyzed using the following equation:

$$W = a L^b \quad (4)$$

Note:

W = Total weight (g);

L = Total length (cm);

a, b = Variable.

The isometric growth pattern as shown in the correlation resulted in a value of  $b=3$  (the growth of the weight and length was balanced), while the allometric growth resulted in a value of  $b \neq 3$  (unbalanced growth in terms of length and weight). Determining the growth pattern from the allometric patterns, such as  $b>3$  (length grew faster than weight) and  $b<3$  (length grew slower than weights) [12], was done through the sample t-test statistical analysis.

The condition factors related to the growth of the cockles were determined through different methods based on the growth patterns. The isometric growth condition factor formula has been presented [13].

$K_n$  = Whether the allometric growth condition factor formula is presented as [13] (5)

Note:  $K_n$  = Relative condition factor

$W_b$  = Object weight (g)

L = Shell length (cm)

a, b = Variable

The ratio of the weight total and flesh and shells was determined based on the class length size. The magnitude of the flesh weight percentage meat against the total weight was stated by [13]:

$$\text{Percentage} = Bd \left( \frac{Bd}{Bt} \right) \times 100\% \quad (6)$$

Description:

Bd = weight of meat (g)

Bt = total weight (g)

The shell and flesh color observation of the fur cockles was done by determining the color differences in the shell and flesh samples of the cockles from each station.

The soil texture on the water base was observed using a relative comparison between the sand samples, dust and clay soil particles with  $< 2$  mm being the standard diameter. There are several classification systems used to determine soil fractions that shown a triangle texture [14].

### 3. Results and discussion

#### 3.1 Fur cockle size

Shell size was one factor used to determine the shell's age, in which an increased size shows how growth occurred on the cockles' body. The young cockles that had early ripe gonads increased in length, while mature cockles do increase their length until death. *Anadara* sp. reaches maturity at a length of (anterior to posterior shell) approximately 17-38 by the time that it is six months old [15]. This study showed that young cockles had a length of 18 to 37.79 mm, while adult cockles reached 37.80 to 57.59 mm in length (Table 1).

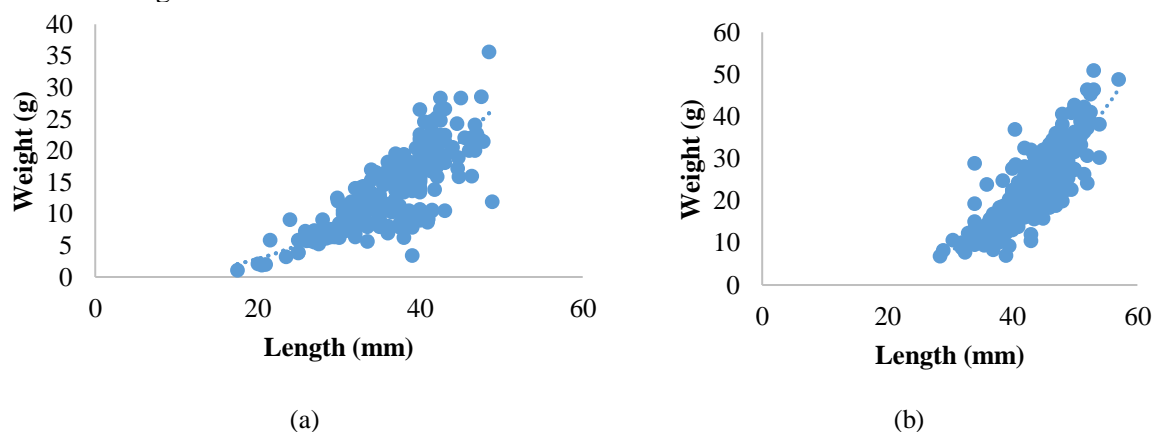
**Table 1.** Fur cockle shell size based on age

Age Based on Length	Fur Cockle Size							
	Juanda Zone Frequency				Wonokromo Zone Frequency			
	Jan	%	Feb	%	Jan	%	Feb	%
Young Cockles (18-37.79 mm)	57	46.72	74	54.41	33	12.50	7	13.73
Adult Cockles (37.80-57.59 mm)	65	53.28	62	45.59	231	87.50	44	86.27

The percentage of young cockles at Juanda showed a 7.69% increase, while the adult cockles showed a decreased value. The young and adult cockles at Juanda showed no significant differences. Wonokromo showed that young cockles also experienced an increase, but the difference between with the percentage of young cockles in Juanda and the adult cockles in Wonokromo showed very significant differences. The increased percentage of young cockle size showed that growth has occurred in both populations.

#### 3.2 Fur cockle growth

The analysis of the weight and length correlation of Fur Cockles in January and February 2017 has been presented in Figure 1.



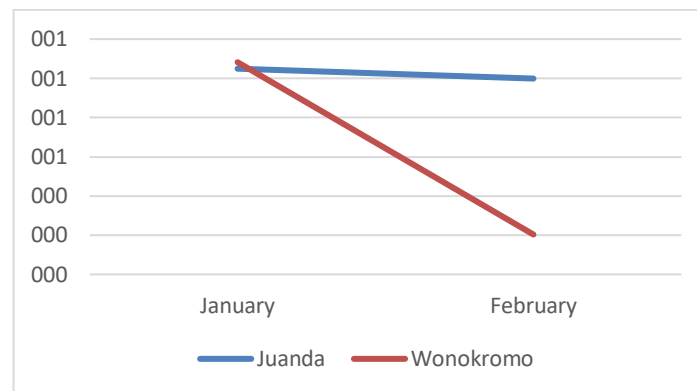
**Figure 1.** Length and weight correlation of fur cockles in (a) Juanda and (b) Wonokromo

The statistical calculation (one sample t-test) on the length and weight correlation obtained growth patterns for both zones, Wonokromo and Juanda River, with an allometric negative as the value of  $b < 3$ . The length and weight correlation in both zones showed there to be a significant difference as both parameters had a closed correlation, as the  $(r)$  value was greater than 0.61 [16].

#### 3.3 Condition factor

The condition factor of the Fur Cockles from both zones was calculated on a monthly basis from January to February 2017 (Figure 2). The condition factor of the Fur Cockles in Juanda declined, which also happened in the ones found in Wonokromo. The range value of the condition factor in Juanda in January

was 0.8-1.3 and in February, it was 1.26-0.72. Wonokromo gained a decreased range of 0.94 – 1.22 in January and 0.17 – 0.57 in February.



**Figure 2.** Condition factor of the fur cockles

### 3.4 Fur cockle shape

Fur cockles generally have a rounded body shape with a furry shell [9]. The body shape of the shell is affected by the metabolic processes in the shell in juvenile phase of food processing [5] Cockles which have a good metabolism will possess a normal body shape (rounded). The calculation of the flesh and total weight ratio percentage observed in Fur Cockles has been presented in Table 2. The percentage of flesh and the total weight ratio decreased during the study period in both zones.




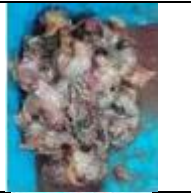


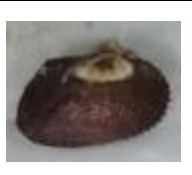

**Table 2.** Fur cockles' weight percentage

	Weight (%)	
	January	February
Juanda	24.24	23.60
Wonokromo	23.40	22.96

### 3.5 Flesh and shell color

The observation of the shell and flesh color in Fur Cockles on January and February 2017 showed no significant differences. The color of the shell and flesh of the cockles found in Juanda showed similarities with those found in Wonokromo, which tended to be a brown-blackish shell. The flesh color of the cockles found in Juanda was a bright reddish color while in Wonokromo, the flesh was a darker reddish color (Table 3).

**Table 3.** Shell and flesh color of the fur cockles

	Juanda		Wonokromo	
	Shell	Flesh	Shell	Flesh
January				
February				

There was also found to be a white cloudy umbo on cockles found in both zones, which is a sign of the periostracum layer covering the limestone layer formed on the shell. According to [17], the limestone layers are composed of prism-shaped calcite and aragonite, lath or pearl sheets, and they are a distinct sign of every shellfish commodity known.

### 3.6 Water base soil texture

Based on the analysis results, the soil texture in both zones showed a higher muddy sediment than sandy as presented in Table 4.

**Table 4.** Sediment types in Wonokromo and Juanda Rivers

	Sediments	
	Sand (%)	Mud (%)
Juanda	4.34	67.33
Wonokromo	12.36	47.26

### 3.7 Water quality

The measurement of the water quality parameters indicated suitable life support for Fur Cockles observed in both zones. The measurement of the water quality parameters in January and February 2017 in the Juanda and Wonokromo River estuary areas can be seen in Table 5.

**Table 5.** Water quality in Juanda and Wonokromo Rivers

	Juanda		Wonokromo	
	January	February	January	February
Temperature (°C)	30	29	29	27
Salinity (ppt)	31	31	29	29
pH	7.9	7.8	8.1	8.1
Transparency (cm)	80	100	40	45
Dissolved Oxygen (mg/l)	6	6	5	5
Total Suspended Solid (TSS) (mg/l)	17	5.5	29	37

Based on the fur cockle size data (Table 1), the percentage of young cockles at Juanda and Wonokromo in January and February 2017 was more than the percentage of adult cockles, due to the growth of the fur cockles from the juvenile phase into young cockles. The growth of the juvenile phase happened due to the abundant food availability along with the suitable environment. The growth rate of cockles involves three affected factors; water temperature, food presence, and reproductive activity [18]. Adult cockles experienced natural death and were more often captured by fishermen.

The cockle's life supporting factors were a decent substrate, good water quality and decent food availability. Based on the results of the soil texture analysis in the Wonokromo and Juanda estuarine area, muddy soil dominated the sediment type compared to sandy soil (Table 4). This meant that the structure of the sediment had a tendency to support fur cockles, as this soil had a widespread distribution of organic matter contained within it. The relationship between the muddy soil and organic material was justified by the opinion of [19], who stated that muddy soil had a better crystal structure and mineral contents.

The potential of muddy soil to bond with organic matter also became a reserved ecosystem nutrient around the river. The basic conditions of water with a high percentage of mud supports shellfish life as justified by [20], who mentioned that although cockles can live on sandy substrates, the highest abundance of them was found in the substrates with mud or muddy sand.

The results of the water quality showed that the water brightness in Juanda and Wonokromo River was suitable enough for the cockles to survive, based on [21] who stated that this should not exceed 100 cm. The water brightness influences the TSS content, consisting of sand and mud as well as the remaining molecules. The obstruction of sunlight was caused by the large number of suspended particles floating on the water's surface, such as sediment material which came with the river flow [22].

The optimum temperature for shellfish varied between 26-37.5°C in tropical areas, where there was no temperature variations throughout the year [23]. This opinion was added by [24], who stated that the normal temperature range for shellfish located in the tropics is 25-35°C with no exceptions within a 5°C fluctuation. These opinions supported the good state of the water temperature found in Juanda and Wonokromo with an average range of  $\pm 26^\circ\text{C}$ .

The pH content of Juanda and Wonokromo River, near to the estuarine area, was also suitable for cockles to live, as the optimum pH needed to support the growth of shellfish is between 7-8.5 [25]. The salinity range between both zones was also observed to be in the optimum range, based on [23], who mentioned that shellfish are only able to live in an area with more than 23 ppt salinity, though younger shellfish may perform the feeding activity in a lower salinity down to 18 ppt. [26] claimed that shellfish are tolerant to both high and low salinity.

The environmental state also affected the growth pattern of cockles. The growth pattern of the fur cockles observed was determined based on the correlation of length and weight. Fur cockles found in both zones had a negative allometric growth pattern from where the cockles experienced stunting, where their length grew faster than their weight. This happened allegedly because of the dry season during the study period when there was no rain. This situation made the food available limited. The growth pattern was affected by the availability of food [9].

The negative allometric growth pattern in cockles could also be caused by environmental adaptations [27]. The length and weight correlation affected the shell's condition; if filled with meat, then the cockles would appear buxom. Otherwise, when not fully filled, the cockles reveal stunting [28].

The condition factor values of the fur cockles in Juanda and Wonokromo has been shown in Figure 2. The decreased condition factor during the study period was due to the cockles caught for the samples mostly being the matured adult cockles which had passed the reproduction stage and consequently aged. The condition factor value was also allegedly caused by the shells experiencing a recovery, by trying to return to their original condition after spawning. According to [9], the condition factor was closely related to the spawning period and the whole process took place over a relatively short amount of time.

Based on the ratio of the total and the flesh weight (Table 2), the results showed there to be a decreased content during the study. According to [9], the weight of the cockles was supported by the state of the weather and season, as well as the environmental conditions providing natural food for the cockles. This opinion supported the condition of the weather during the study period, which was less supportive of the food availability for the cockles.

Food availability and the reproductive cycle also affected the cockle's weight. Nutrition stocks obtained from the environment were being channeled to fuel their metabolism, reproduction and growth [29]. Food availability in the estuarine area itself is affected by the tidal movements, as high tide makes shellfish to feed actively by filtering the drifted food, whereas low tide prompts the shellfish to decrease their feeding activity.



An observation of the shell and flesh color of the fur cockles found in Juanda and Wonokromo showed similar results during the study period (Table 3). The fur cockles had a blackish-brown shell color with a white murky umbo color and the typical soft fur surrounding the shell. This was justified by [9] who characterized *A. antiquata* as having overgrown blackish brown fur coating the murky colored shell.

The flesh color of the fur cockles in the Juanda zone were observed to be brighter than in the Wonokromo zone. Most of the cockles observed in Juanda were a bright reddish color, while the flesh color found in Wonokromo were a murky reddish color. This is allegedly because the pollutant particles present in Wonokromo river were higher than in Juanda River. The pollutant particles in Wonokromo river came from the community activities throughout the river basin, causing pollutants to occur in the body of the water, which made the cockles ingest contaminants, regarding the filter feeding method.

#### 4. Conclusion

Fur Cockles (*Anadara* spp.) found in the estuarine area of Wonokromo and Juanda rivers were of an 18 - 57.59 mm length with a rounded and thick shell. The shell color of the fur cockles in Wonokromo and Juanda were both a blackish brown, while the flesh color in Wonokromo was observed to be darker than the color in Juanda.

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