Some population parameters of Longhorn Cowfish *Lactoria cornuta* (Linnaeus, 1758) in Laikang Bay, Takalar District, South Sulawesi, Indonesia (preliminary study)

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Abstract. Longhorn cowfish *Lactoria cornuta* is a boxfish species from the Ostraciidae family which inhabit in Indo-Pacific waters. This fish can reach lengths up to 50 cm. This fish has high economic value and traded as ornamental and fresh fish. Longhorn cowfish is a favorite fish at the seafood restaurants. It is caught by many fishermen in the waters of the Gulf of Laikang. Although of high economic value, Longhorn cowfish has not been studied in many aspects of its bioecology. This study aims to analyze some population parameters, such as sex ratio, length-weight relationship, growth, and ponderal index of longhorn cowfish in Laikang Bay Waters. The results of this study indicate that there was more male than female. The total length range of male was between 65 - 155 mm, and female was 83 - 250 mm. The range of body weight of the male was 11.84 - 56.85 gr and female was 16.56 - 155.82 gr. Male and female growth curve were hypalometric. The female ponderal index was greater than male.

1. Introduction
Longhorn cowfish *Lactoria cornuta* inhabit in the coral reefs of the Indo-Pacific tropics [1] and the Pacific, namely in the Red Sea [2], East African sea [3] the islands of Marquesas, Tuamoto, Japan, and Lord Howe [4]. Longhorn cowfish was also found off the coast of Gopalpur (Odisha), Northwestern Bay of Bengal, India [5] and in the inshore waters of the Bay of Bengal, Bangladesh [6]. Longhorn cowfish inhabit in coral reefs in bays, harbors and estuaries [7]. Juvenile longhorn cowfish live solitary, but as adults form small groups and move near river mouths and brackish waters. Longhorn cowfish generally inhabit at depths of one to 45 m, but can live at depths of up to 100 m [6].

Longhorn cowfish are a group of reef fishes of the genus *Lactoria* which have a square, gray and green body, have strong and sharp horns that protrude at the front of the head, have large eyes, white and blue spots on the back. The base of the tail is rather short but has a long tail fin, the length of the caught ranges between 12.8 and 50 cm [8] commonly. Longhorn cowfish have a somewhat transparent tail fin color. Pectoral fins are brownish, subterminal mouth, and protruding lips, have 9 to 10 cm soft fins on the dorsal fin with brownish spots. Scales form hexagonal bone plates that fuse into solids, have two pairs of long parallel horns, one located dorso-anterior, and the other ventral-posterior, a small round dorsal fin, having 18 vertebrae [6] (Figure 1).
Longhorn cowfish has high economic value because it is a favorite fish in restaurants [9] and is an ornamental fish in the seawater aquarium [10]. This fish has not been studied enough about the biological aspects of its fisheries. Therefore it is necessary to study the fisheries biology, namely sex ratio, length-weight relation, growth, and ponderal index. Longhorn cowfish are caught in Laikang Bay, Takalar Regency, South Sulawesi Province, Indonesia.

![Image of live longhorn cowfish](image1)

![Image of longhorn cowfish measuring parameters](image2)

**Figure 1.** Live longhorn cowfish *Lactoria cornuta* (a) [10], and longhorn cowfish when measuring parameters (b).

Takalar Regency, which lies along the Makassar Strait, has coastal and bays areas that are rich in reef fish, pelagic fish, shrimp, crab, and seaweed. Laikang bay is the fishing and seaweed cultivation areas in Takalar Regency. The Laikang bay is fishing areas of the fishermen who inhabit in Puntondo Hamlet, Laikang Village, Mangarabombang District, Takalar Regency. One species caught by Puntondo fishermen is longhorn cowfish.

Laikang bay is an artisanal fishing area. Laikang bay is an ecotone or a region of transition between biological communities of Makassar Strait and the Flores sea, which is crossed by the Wallace line. As a trajectory of the Wallace Line which is rich in reef fish [11-14] and other marine biological resources [15-17], the resources inhabit therein need to be managed with the principles of sustainability, especially at present, there were indications that this areas crossed by the Wallace line suffer from overexploitation [18]. Sustainable management of fisheries resources requires fisheries biological data, such as sex ratios, length-weight relations, growth, and ponderal index. This study aims to analyze the sex ratio, length-weight relation, growth, and ponderal index of longhorn cowfish caught in the waters of Laikang Bay, Takalar Regency. This study was a preliminary study of longhorn cowfish in the Makassar Strait and the Flores sea. Further studies of longhorn cowfish and other reef fishes in Makassar strait and Flores sea are underway.
2. Materials and methods
The study was done from May to July 2018 in the waters of Laikang bay, Takalar Regency. Samplings were done every month for three months. Samples were collected from the fishermen catches in Puntondo Hamlet (Figure 2).

The measured parameter was the total length, which starts from the front edge of the mouth to the tip of the tail fin by using the bar with a precision of 1 mm. The total weight was weighed using an electrical scale with a precision of 0.01 g. Sex determination was carried out by observing the morphology of the gonads by referring to the gonad structure of reef fish, where male gonads were usually milky white, and female gonads were usually light yellow to dark yellow [19-21].

Sex ratio was calculated by using equations:

\[ SR = \frac{\Sigma J}{\Sigma B} \]  

Where, SR = sex ratio, \( \Sigma J \) = the number of males, \( \Sigma B \) = the number of females. Chi-square test [22] was used to analyze the significance of sex ratio related to sampling periods and length classes. The interval length classes are calculated based on the smallest and largest sample sizes [23].

The length-weight relation of longhorn cowfish was calculated using the equation [24]:

\[ W = aL^b \]  

Which was then transformed in the form of a logarithm, thus forming a linear equation, i.e.:

\[ \log W = \log a + b \log L \]
Where, \( W \) was the weight of the fish (g), \( L \) was the total length of the fish (mm), \( a \) and \( b \) were constants. If \( b=3 \), the growth of fish shows an isometric pattern, which means the increase in length and weight was balanced. If the value of \( b<3 \), then the pattern of hypoalometric growth, which means growth in body length, was faster than body weight gain. Conversely, \( b>3 \) shows a hypsometric growth pattern, which means that body weight gain was faster than body length [25]. t-test was used to find out if the \( b \) is equal or not equal to three [22] by the equation:

\[
 t = \frac{3-b}{se} 
\]  

Where the was the standard error of \( b \). t-test was used to find out whether male and female regression is different or not. If it is not different, then the data are combined, and joint regression analysis is carried out by using the equation:

\[
x = \sqrt{(sb1)^2 + (sb2)^2} 
\]

\[
t = \frac{b1-b2}{SE(b1-b2)},
\]

Where \( b1 \) was the female regression coefficient, \( b2 \) was the male regression coefficient, and \( SE(b1-b2) \) was the standard error.

Ponderal index fish was analyzed using the relative ponderal index equation \((Kn)\), that is [24, 26]:

\[
Kn = \frac{W}{al^b} 
\]

Where \( W \) was the weight of the fish, \( L \) was the length of the fish, and \( a \) and \( b \) were the growth constants.

3. Results

3.1. Sex ratio

The longhorn cowfish sample was dominated by males (Figure 3), which is 104 males and 38 females. The sex ratio between males and females was 1.74:1. The sex ratio related to the sampling period was significantly different (\( P<0.05 \)). The longhorn cowfish sample was divided into eight classes (Table 1). The small length classes were dominated by males, while the big length classes were dominated by females (Figure 4). The sex ratio related to length classes was significantly different (\( P<0.05 \)).

![Figure 3. Sex ratio related to the sampling periods of longhorn cowfish *Lactoria cornuta.*](image-url)
Table 1. Number of male and female longhorn cowfish *Lactoria cornuta* related to the length classes.

| Length Classes (cm) | Σ Male | Σ Female |
|---------------------|--------|----------|
| 6.50-8.80           | 12     | 0        |
| 8.81-11.11          | 27     | 13       |
| 11.12-13.42         | 20     | 20       |
| 13.43-15.73         | 5      | 6        |
| 15.74-18.04         | 0      | 0        |
| 18.05-20.35         | 0      | 0        |
| 20.36-22.66         | 0      | 0        |
| 22.67-25.00         | 0      | 1        |

Figure 4. Sex ratio related to the length classes of longhorn cowfish *Lactoria cornuta*.

3.2. Length-weight relation and growth parameters

Male Longhorn cowfish has a total length range of 65-155 mm with an average length of 103.0 ± 21.1 mm and body weight 11.84-115.85 g with an average body weight of 26.09 ± 9.85 g. Longhorn cowfish females have a body length range of 83-250 mm with a mean length of 120.8 ± 26.7 mm and a bodyweight range of 16.56-155.82 g with an average body weight of 33.10 ± 15.36 g, based on that sex, it appears that females have a longer range and weights bigger than males (Table 1).

Table 1. Length-weight relation and growth of longhorn cowfish *Lactoria cornuta* male and female.

| Parameters                  | Male     | Female   |
|-----------------------------|----------|----------|
| Number of samples           | 66       | 38       |
| Total length range (mm)     | 65–155   | 83-250   |
| Total length average (mm)   | 103.0±21.1| 120.8±26.7|
| Total weight range (g)      | 11.84-56.85 | 16.56-115.82 |
| Total weight average ± SD (g)| 26.09±9.85 | 33.10±15.36 |
| log a                       | -2.1078  | -1.7944  |
| Coefficient regression (b)  | 1.7431   | 1.5852   |
| Coefficient correlation (r) | 0.9303   | 0.9165   |
| Regression equation         | *W* = 0.0078 *L*^{1.7431} | *W* = 0.0166 *L*^{1.5795} |
| *T* test                    | *t*_{calculation} > *t*_{table} | *t*_{calculation} > *t*_{table} |
| Growth type                 | Hypoalometric | Hypoalometric |
| *t* test for the similarity of the regression coefficient (b) | *t*_{calculation} < *t*_{table} |
The correlation coefficient of the regression equation in males \( W = 0.0078 L^{1.7431} \) was very strong \( (r = 0.9303) \) (Figure 4a), as well as the regression equation in females \( W = 0.0166 L^{1.5795} \) was very strong \( (r = 0.9165) \) (Figure 4b).

The growth coefficient of males and females was less than 3 \( (b<3) \), so the growth coefficient of males and females were hypoalometric, meaning that body length increases faster than body weight gain.

![Figure 5](image.png)

**Figure 5.** Length-weight relation at the male (a) and the female (b) of longhorn cowfish *Lactoria cornuta*.

3.3. *Ponderal index*

The range of male ponderal index was 0.6896-1.3135, with an average value of 1.0080±0.1447. Whereas in female longhorn, cowfish was 0.6759-1.4160 with an average value of 1.0169±0.1322 (Table 2).

Ponderal index related to sampling period was quite varied. The highest variation of the ponderal index value was found in female fish in May, which was 0.9392-1.1292. While the smallest ponderal index variation was found in male fish in June, which was 0.7253-1.2545 (Table 3). The t-test showed that the ponderal index of male and female were significantly different. This shows that in May, the plumpness was higher than in June and July.

| Parameter               | Sex          |
|-------------------------|--------------|
|                         | Male         | Female       |
| Total length range (mm) | 65 - 155     | 83 - 250     |
| Total weight range (g)  | 11.84 - 56.85| 16.56 - 155.82|
| Ponderal index rage     | 0.6896 - 1.3135| 0.6759 - 1.4160|
| Average and SD          | 1.0080 ± 0.1447| 1.0169 ± 0.1322|
The hypoalometric. The cause of _hypoalometric_ growth also found in other Tetraodontiformes, such as those that happen in longhorn cowfish _Lactoria cornuta_.

Longhorn cowfish is unknown studied, 199 reef fishes or 32.1% were hypoalometric [39]. Of the 288 species of reef fish, 180 or 62.5% were hypoalometric [40]. Studies of longhorn cowfish in Makassar Strait waters are underway further studies of longhorn cowfish in Makassar Strait waters are underway.

### Table 3. Ponderal index of longhorn cowfish _Lactoria cornuta_ related to the sampling periods.

| Sampling date | Male                  |          |          | Female                |          |          |
|---------------|-----------------------|----------|----------|-----------------------|----------|----------|
|               | Range value           | Average ± SD | Σ        | Range value           | Average ± SD | Σ        |
| May 16th, 2018| 0.8552-1.2849         | 1.0388 ± 0.1016 | 28       | 0.9391-1.1292         | 1.0138 ± 0.0621 | 8        |
| June 15th, 2018| 0.7253-1.2545         | 1.0096 ± 0.1225 | 24       | 0.8965-1.2957         | 1.0141 ± 0.0900 | 20       |
| July 17th, 2018| 0.7984-1.3386         | 1.0115 ± 0.1542 | 14       | 0.8451-1.1244         | 1.0051 ± 0.1005 | 10       |

### 4. Discussion

#### 4.1. Sex ratio

Biologically, the ideal sex ratio is 1:1, but this rarely happens. Variations in sex ratio can be caused by many factors, including growth patterns, size at first maturity [27, 28], geographic variation [29], waters pH [30], and fishing mortality [31]. Unequal sex ratio in reef fish was often found [32]. The sex ratio of reef fish was generally dominated by females [20, 21]. Sex ratios dominated by males, such as those that happen in longhorn cowfish, are rarely found. The distribution of sex ratio related to sampling periods, where male fish were more dominant in the small size, can lead to the suspicion that longhorn cowfish was a hermaphrodite protandry, but this suspicion is still too early, more detailed studies are needed to prove it.

#### 4.2. Length-weight relation and growth

Length-weight relations describe the relative the fish plumpness [25]. Ecologically, length-weight relation can describe several ecological phenomena. Ecologically, length-weight relation can describe several ecological phenomena that an organism faced by an organism in its life cycle [33], like the abundance of prey species [25]. Whereas economically, length-weight relations are needed to statistically convert catches in weights to fish numbers, to estimate population size, and to estimate mortality [34]. In fisheries resource management, length-weight relations are also needed because they can describe the selectivity of fishing gear [35] and fishing gear pressure [36].

Fish growth can be influenced by two factors, that is, internal factors and external factors. Internal factors include heredity, sex, age, and disease. While external factors are parasites, food, and water temperature [25]. Hypoalometric fishes indicated that the weight growth was not as fast as its length. Weight differences between males and females can be caused by differences in maturity stages because at the sampling periods, the size was very varied, and all samples were mature. If referring to reef fish in the Makassar Strait, then May to July was the period where reef fishes were generally mature [20, 21].

Allometric growth is a continuous change in which the length-weight relationship almost follows the cubic law, which is weight is a cube of its length. The practical value of a length-weight correlation is able to estimate the weight from the length or vice versa [37], growth, plumpness, and environmental change [25]. The fish weight is considered ideal if it is equal to the cube of its length for small and large fish [25]. The ponderal index value of fish changes if there are changes in water conditions and biological aspects of fish. Not all fish have an ideal or allometric growth form. Longhorn cowfish has hypoalometric growth, which means that the weight growth is slower than the length growth. Hypoalometric growth also found in other Tetraodontiformes, which is _Tetraodon lunaris_ [38]. Length-weight relations can differ from one water to another. Coral fish that inhabit coral reefs and lagoons of New Caledonia, out of 288 species of reef fish, 180 or 62.5% were hypoalometric [39]. Coral reef fish that inhabit in the waters of Reunion island, out of 28 species of reef fish, only 9 or 32.1% were hypoalometric [40]. While reef fish that inhabit in Kenyan coastal, out of 39, only 6 or 15.4% were hypoalometric [41]. Three previous studies showed that of the 355 reef fishes that were studied, 199 reef fishes, or 54.9% were hypoalometric. The cause of hypoalometric in longhorn cowfish is unknown. Further studies of longhorn cowfish in Makassar Strait waters are underway.
4.3. Ponderal Index

Ponderal index is a condition that states fish plumpness with numbers and values that are influenced by age, sex, food, and level of gonad maturity. In bio-ecological terms, the ponderal index indicated the state of fish, both in terms of physical capacity, as well as in terms of survival and reproduction [25]. Economically, a fish ponderal index is useful in determining the quality and quantity of fish stocks [25, 42].

The ponderal index of a fish species is not permanent. If there is a change, for example, population density increases, then the ponderal index will decrease due to increased interspecific competition. Ponderal index variations can also be caused by differences in sex. The female ponderal index is generally bigger because it has a greater gonad weight than male fish. Ponderal index increases with the development of the gonad, and will reach the highest value before spawning occurs [25]. Ponderal index longhorn cowfish are in the range of ponderal index finfish seawater, such as rainbow trout [43], but much smaller than the ponderal index of freshwater finfish, such as Tilapia zilli, Oreochromis niloticus, Hemichromis bimaculatus and Clarias gariepinus [44]. The difference in ponderal index between fish that inhabit in the freshwater and seawater can be caused by higher physiological challenges on seawater fish, especially in terms of the regulation of salt ions in their bodies fluids [45, 46]. Fish that live in the sea are thought to need more energy to regulate salt ions in their bodies fluids so that the energy allocation for growth is smaller than fish that live in freshwater.

5. Conclusion

The results of this study indicate that there was more male than female. The total length range of male was between males 65-155 mm, and the female was 83-250 mm. The range of body weight of the male was 11.84-56.85 gr, and the female was 16.56-155.82 gr. Male and female growth curves were hypsometric. The female ponderal Index was greater than the male.

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