Gill net selectivity, length at first capture and length at first gonad maturity on *Hampala macrolepidota* (Kuhl & Van Hasselt, 1823) in Ranau Lake, Indonesia

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**Abstract.** *Hampala macrolepidota* is one of the dominant species caught in Ranau Lake, (name of city/province). This species has an economic value because its highly demand in the community around the lake. The objective of this study was to know the gill net selectivity, length at first capture (Lc) and length at first gonad maturity (Lm) of *Hampala macrolepidota*, in Ranau Lake. This study was carried out in March to November 2013. Samples of fish were obtained using an experimental fishing in two stations, Banding Agung and Talang Teluk. Fishing gear used two different mesh sizes, 1.5 and 1.75 inches, respectively. For length at first capture and size at first gonad maturity, 1 ½, 1 ¾, and 2 ½ inch-mesh sizes were employed. Results showed that optimum length of fish caught was 16.154 cm and 18.846 cm in 1 ½ and 1 ¾ inch mesh size, respectively. The selective size ranged from 9.5-19.6 cm and 12.5-22.1 cm, respectively. Lc/L50% was 15.2 cm, 18.3 cm and 26.8 cm for 1 ½ 1 ¾ and 2 ½ inch mesh size, respectively. Lm was 15.38 cm for males and 19.21 cm for females, respectively. Among fishing gear selectivities, Lc/L50% and Lm had very strong relationship, in which compared with Lm value, female hampala population is very alarming since 1 ½ and 1 ¾ inch mesh sizes caught immature gonad females. Good mesh size used was 2 ½ inch, due to catching post-spawning-sized hampala. Fishing immature fish could cause fish resources extinction.

1. **Introduction**

*Hampala*, *Hampala macrolepidota* (Kuhl & Van Hasselt, 1823) is consumption fish with economic and ecological values, since as carnivorous fish and even the only predator, plays important role in maintaining the ecological equilibrium in term of keeping the food chain equilibrium in Ranau lake waters. In order to prevent biodiversity loss, species playing important role in ecological process should receive higher priority to be conserved [1].

Ranau Lake is the second widest in Sumatera Island, South Sumatera and Lampung Provinces, with a total area of 12,398 Ha or 123.98 km² and mean depth of 78 m [2]. Hampala is one of the most dominant fish in Ranau Lake waters. High demand of hampala, *Hampala macrolepidota*, makes increased fishing activity and fish exploitation. Hampala fishing is done using various fishing gears depending upon desired size, and the most dominant fishing gears is gill nets of various mesh size [3]. Gill net is a passive fishing gear possessing a lot of limitations [4]. Beside the mesh size, the gill net-caught fish is also affected by the stiffness of net body, the strech tension of the net body, the hanging ratio, the net height and the net color [5].
Selectivity is a quantitative expression of size selection. Fishing gear selectivity is the ability of fishing gear to catch fish of certain species and size of a fish population. Gear selectivity is the ability of fishing gear to pass the fish [6]. Size at first capture ($L_c$) is the length in which 50% fish is retained on the net and the other 50% passes through the mesh [7]. Size at gonad first maturity ($L_m$) is part of reproductive aspects useful for estimating the fish spawning potential [8]. The fishing gear selectivity information, $L_c$ and $L_m$, are highly benefit for fisheries resources management.

High use of gill nets for hampala exploitation is feared to cause hampala population reduction if the mesh size setting is not managed. One of the extinction causes of freshwater fish stock is over-exploitation [9]. Selective gill net utilization can give an opportunity of unmatured hampala to reproduce so that the recruitment could be continuously maintained. The objective of this study was to know gill net selectivity, size at first capture ($L_c$) and size at gonad first maturity ($L_m$) of *Hampala macrolepidota* in Ranau Lake.

2. Material and Methods

This study was carried out in March to November 2013 in Ranau Lake waters, Indonesia. Fish samples were collected using an experimental fishing of gill net. To test the fishing gear selectivity, two different mesh sizes were employed, 1½ and 1¾ inches, respectively. To know the size at first capture ($L_c$) and size at gonad first maturity ($L_m$), 1½, 1¾ and 2½ inch-mesh sizes were used. Fishing operation was conducted in Ranau Lake, Muara Silabung or Banding Agung (04°48.920’S, 103°55.193’E) and Talang Teluk (04°49.318’S, 103°54.769’E).

![Figure 1](image).

**Figure 1.** Map of study site in Ranau Lake, South Sumatera, Indonesia. A=Talang Teluk, B=Banding Agung.

The gill net selectivity study applied Holt model with two mesh sizes [7]:

$$SL = \exp \left[ - \frac{(L - L_m)^2}{2 \times s^2} \right]$$

where: $L_m$ = optimum fish length caught
$s$ = standard deviation of normal distribution
Lma, Lmb and s are optimum length of small mesh size, optimum length of large mesh size, and standard deviation of both mesh sizes. The analytical steps of two mesh-sized fishing gear are as follows:

Step 1: Calculate y=ln (Cb/Ca) for each length group. Only lengths, whose frequencies are overlapping, are used.

Step 2: Apply the regression analysis of (y=ln(Cb/Ca)) against median of fish length (x=L) intervals and determine a and b.

\[ \ln \left( \frac{C_b}{C_a} \right) = a + bL \]

Step 3: Final output can be obtained by putting in a, b, ma and mb values in the following equations:

Selection factor is estimated from:

\[ SF = \frac{-2a}{b*(ma+mb)} \]

Optimum lengths of small size and large mesh size are:

Lma = SF*ma and Lmb=SF*mb

Standard deviation for both is determined by variance:

\[ s^2 = \frac{mb-ma}{b} - \frac{a}{b} \]

Step 4: Points for the selection curves are obtained by putting in L values into equations:

\[ S_a(L) = \exp \left[ - \frac{(L-Lma)^2}{2s^2} \right] \]

\[ S_b(L) = \exp \left[ - \frac{(L-Lmb)^2}{2s^2} \right] \]

Step 5: From step 1 to 4 and Ca(L) and Cb(L) catches, an index of number in population is estimated for each mesh size:

\[ N_a(L) = \frac{Cb(L)}{S_b(L)} \]

\[ N_b(L) = \frac{Ca(L)}{S_a(L)} \]

Hampala size at first capture estimation was done by creating the relationship graph between length class distribution (x-axis) and number of fish expressed in cumulative percent (y-axis). An "S"-like curve was formed. To obtain Length at first capture (Lc), the relationship line at X-axis and 50% value at Y-axis was taken or using a standard logistic curve method [7, 10, 11].

Size at gonad first maturity (M) was calculated using Spearman-Karber [12], with the following formula:

\[ M = (X_k + X/2) - (X, \Sigma pi), \]

where the length range was estimated using the equation:

\[ \text{antilog} \left[ m \pm 1.96 \sqrt{\text{var} (m)} \right] \]

\[ \text{var} (m) = (X)^2 \times \Sigma \left[ (pixqi) / (ni-1) \right], \]

where:

M = size at first maturity (antilog of m),

m = logarithm of fish length at first maturity,

Xk= logarithm of length class median at 100% matured fish,

X= increment of logarithm of length class median,

pi= ri/ni = number of matured fish and each length class ratio

ri = number of matured fish at class i

ni = number of fish samples at class i

qi = 1-pi

3. Results and Discussion

3.1 Fishing gear selectivity

In Talang Teluk, number of catches gained using 1½ inch mesh-gill net was 174 individuals with total length range of 9.7 to 19.6 cm and mean length of 15.69±1.66 cm, while that of 1¾ inch mesh size was 253 individuals with total length range of 12.5 to 21.7 cm, with mean length of 18.07±1.43 cm. Whereas in Banding Agung, number of catches gained using 1½ inch mesh-gill net was 199 individuals with total length range of 9.5-18.7 cm and mean length of 14.8±1.78 cm, while that of 1¾ inch mesh size was 242 individuals with total length range of 15.6-22.1 cm with mean length of 18.49±1.22 cm. The fish size obtained by 1½ and 1¾ inch mesh size was not significantly different between Talang Teluk and Banding Agung.
The 1¾ inch mesh-sized gill net caught more fish than that of 1½ inches, 496 individuals or 57.03% of total 868 individuals caught by both mesh sizes. The fish total length ranged from 9.5-19.6 cm with an average of 15.22±1.78 cm for 1½ inch mesh size and 12.5-22.1 cm with an average of 18.3±1.35 cm for 1¾ inch mesh size, respectively. The optimum fish length caught in each sampling station and both station combination is given in Fig. 2,3 and 4 and Table 1. It was 16.154 cm for 1½ inch-mesh size and 18.846 cm for 1¾ inch-mesh size, respectively, with standard deviation (s) of 1.962 (Fig. 2 and Table 1). The selection size of both meshes ranged from 9.5 to 19.6 cm and 12.5 to 22.1 cm, respectively, with selection factor value (SF for both station combination) of 10.769 (Table 1).

![Figure 2](image)

**Figure 2.** (A) Length frequency curve between 1½ inch (a) and 1¾ inch (b) mesh gill nets from Banding Agung station. (B) Length frequency curve between 1½ inch (a) and 1¾ inch (b) mesh gill nets from Talang Teluk station. (C) Length frequency curve between 1½ inch (a) and 1¾ inch (b) mesh gill nets from combination of Banding Agung and Talang Teluk stations.

**Table 1.** Optimum length of fish catches and selection factor (SF) at each station and combination of both sampling station.

| Station          | Lma (cm) | Lmb (cm) | SF     |
|------------------|----------|----------|--------|
| Banding Agung    | 15,753   | 18,379   | 10,502 |
| Talang Teluk     | 15,608   | 18,210   | 10,406 |
| Combination      | 16,154   | 18,846   | 10,769 |

3.2 Length at first capture

Size at first capture ($L_c/L_{50%}$) was 15.2 cm long for 1½ inch-mesh size, 18.3 cm long for 1¾ inch-mesh size, and 26.8 cm long for 2½ inch-mesh size (Fig. 3). Size at first capture caught the size class range of 14.5 to 15.5 cm long for 1½ inch-mesh size and the size class range of 17.5 to 18.5 cm long for 1¾ inch-mesh size and the size class range of 26.5 to 27.5 cm long for 2½ inch-mesh size, respectively.

![Figure 3](image)

**Figure 3.** Graph of size at first capture ($L_c/L_{50%}$) with gill net mesh size of a=1½ inches, b=1¾ inches, and c=2½ inches.
3.3 Length at first maturity

Gonad Maturity Level of hampala catches in Ranau Lake were mostly level 1, i.e 78.12% males and 90.07% females of the total samples observed. Whereas the mature gonad hampala (GML III, IV and V) covered 10.5% males and only 6.62% females (Table 2).

Table 2. Gonad maturity level frequency distribution of male and female *Hampala macrolepidota* catches in Ranau Lake.

| Maturity Level | Male N | %  | Female N | %  |
|---------------|--------|----|----------|----|
| I             | 357    | 78.12 | 517     | 90.07 |
| II            | 52     | 11.38 | 19      | 3.31  |
| III           | 18     | 3.94  | 6       | 1.04  |
| IV            | 30     | 6.56  | 25      | 4.36  |
| V             | 0      | 0     | 7       | 1.22  |
| **Total**     | 457    | 100   | 574     | 100   |

The length range of male gonad maturity level IV ranged from 23.5-48.2 cm long or an average of 29.15±5.59 cm, while that of female gonad maturity level IV ranged from 26.2-44.3 cm long with an average of 30.9±4.71 cm (Table 3). Based on Spearman-Karber method, size at first gonad maturity (Lm) was 15.38 cm or in the range of 14.80 to 15.97 cm for males and 19.21 cm or in the range of 18.27 to 20.18 cm for females, respectively. It reflects that male hampala has smaller size and is mature faster than female.

Based on selection factor (SF=10.769), the optimum length size of hampala caught (two station combination) in 1½ and 1¾ inch mesh-zed gill net was 16.154 cm and 18.846 cm long, respectively. The larger the mesh size used the larger the optimum fish length caught [13]. The selectivity curve was obtained from the calculation of selectivity curve empirical equation [14]. The curve could be used to see the fishing opportunity at the desired size in line with operational objective and target, and the caught fish size will possess the maximum value at several optimum fish sizes so that the fish catches are with the desired need [15]. Uttered that gill net selectivity could be estimated by looking at the fish catch size distribution or the frequency proportion of the fish caught [16].

Table 3. Gonad Maturity Level-Based Length Range of mature male and female *Hampala macrolepidota* catches in Ranau Lake.

| Maturity Level | Total length (cm) of male | Total length (cm) of female |
|---------------|---------------------------|-----------------------------|
|               | range mean±sd             | range mean±sd               |
| III           | 24.0-45.8 29.61±6.41      | 26.2-48.4 37.3±9.84         |
| IV            | 23.5-48.2 29.15±5.59      | 26.2-44.3 30.9±4.71         |
| V             | 26.6-44.5 33.6±5.99        |                             |

Among gill net selectivities, size at first capture and size at gonad first maturity have very strong relationship. In the present study, the gill net selectivity of 1½ inch-mesh size caught the optimum size of 16.15 cm long and that of 1¾ inch-mesh size did 18.84 cm or Lc/L50% of 1½ inch-mesh sized gill net was 15.2 cm long and that of 1¾ inch-mesh size was 18.3 cm, respectively. Lc/L50% is the fish length possessing 50% opportunity to be caught and often used as a guide to determine the mesh size utilization [17].

Furthermore, size at gonad first maturity (Lm) is 15.38 cm length and 19.21 cm length for hampala males and females, respectively. This these were higher than recorded in depik Rasbora tawarenis in Lake Laut Tawar, Aceh Province [18]. According to Setyohadi et al. [13] that gill net selectivity measurement will be closely related with size at first gonad maturity. It reflects that the population of female hampala is highly alarming since both gill net mesh sizes used have caught unmature (juvenile)
females despite good enough for the male population. Fishing the unmature fish could danger the sustainability of the fish resources.

Looking at the size firstly caught by 2½ inch-mesh sized gill net, the optimum size of 26.8 cm long, it would be the best mesh size to use because both males (Lm=15.38 cm) and females (Lm=19.21 cm) are spawning more than once, or the gill net of 2½ inch-mesh size is biologically and technically the best mesh size. The use of fishing gear, particularly gill net, and the estimation of size at first capture could be taken as fisheries management information, especially in relation with size at gonad first maturity (Lm). The use of gill net needs to consider the mesh size since gill net has high selectivity, and gill net would maintain fish length range less than 20% of the optimum size [19-21]. One of the responsible fisheries implementation characteristics is to guarantee that the resources could be sustainably exploited, and it could be achieved by fishing the mature fish or letting the fish opportunity to spawn [22].

4. Conclusion

The optimum fish length caught in 1½ inch mesh size was 16.154 cm while that in 1¾ inch mesh size was 18.846 cm. Lc/L50% was 15.2 cm for 1½ inch mesh, 18.3 cm for 1¾ inch and 26.8 cm for 2½ inch mesh size, respectively. Lm was 15.38 cm for males and 19.21 cm for females, respectively. Among fishing gear selectivities, Lc/L50% and Lm had very strong relationship. If compared with Lm value, female population is very alarming since both mesh sizes (1½ and 1¾ inches) used also catch unmature (juvenile) females but good enough for male fish population. Therefore, the best mesh size used is 2½ inches, because it will catch the post-spawning hampala. Fishing unmature size could cause the fish resources extinct.

Acknowledgments

All authors appreciate and wish to thank to Research Institute for Inland Fisheries and Extension for support. Also, we wish to thank to: Dr. Dina Muthmainnah, Sevi Sawestri, Makri, Dwi Atminarso, Agus Sudrajat, Budi Irawan, Ranau Lake team.

References

[1] Gustiano R. 2006 Technical and Socio-Economic Report on Fish Genetic Resources Sustainable Management. Paper presented in National Workshop on Genetic Resources Management and protection in Indonesia: Economic Benefit To Realize National Endurance 6 p
[2] Pusat Penelitian Pengelolaan Perikanan dan Konservasi Sumberdaya Ikan (P4KSI) 2012 Lake Bathymetric and Hydroacoustic Survey batimetri dan hidroakustik Danau in Sumatera. Research Survey Report Unpublished 10 p
[3] Makmur S 2009 Fishing activity and major fishing gears in Ranau lake waters. Proceedings on the 6th National Seminar of Indonesia Freshwater, 2009 Fishing Fisheries Research Centre
[4] Prchalová M., Kubečka J, Riha M., Mrkvička T, Vašek M., Jůza T, Kratochvíl M, Peterka J, Draštík V, Křížek J 2009 Fisheries Research 96 51-57
[5] Karlson I, Bjarnason B 1987 Small scale fishing with driftnet fisheries Technical Paper FAO 64p
[6] Gulland J.A 1983 Fish Stock Assessment-A Manual of Basic Methods John Wiley and Sons New York 223p
[7] Sparre P, Venema S C 1999 Introduction to Tropical Fish Stock Assessment Translated in Indonesia FAO Fish Tech. Paper 306(1) 376 p
[8] Heriati, Subani W 1993 Journal of Marine Fisheries Research 78 46-58.
[9] Nasution S H 2008 Ecobiology and stock dynamics as basis of endemic fish, Bonti bonti (Paratherina striata Aurich), management in Towuti Lake, South Sulawesi. Dissertation Bogor Agriculture Institute, Bogor, Unpublished 173 p.
[10] Widodo A A, Mahiswara, Mahulette R T 2010 Journal of Fisheries Research of Indonesia 16(4) 259-266
[11] Triharyuni S, Sulaiman P S, Rianto J 2012 *Journal of Fisheries Research of Indonesia* 18 (1) 35-41
[12] Udupa K S 1986 *Fishbyte* 4(2) 8-10
[13] Setyohadi D S, Muhammad, Marsoedi, Risjani Y, Bintoro G 2013 *Journal of Applied Environmental and Biological Science* 3(2)1-5
[14] Sparre, P.E., Ursine, and Venema, S.C. 1989. Introduction to Tropical Fish Stock Assesment. Part I Manual. FAO. Fisheries Technical 306/1. Rome. 337 p.
[15] Aziz K A 1989 Tropical Fish Population Stock Assessment. Life Science Inter-university Center Bogor Agriculture Institute 89p
[16] Jude D, Neethiselvan N, Gopalakhrisman P, Sugumar G 2002 *Indian Journal of Marine Sciences* 31(4) 329-333
[17] Pope J A 1966 Manual of Methods for Fish Stock Assessment Part III, Selectivity of Fishing Gear FAO Technical Paper 41 FAO Rome 36p
[18] Muchlisin Z A, Musman M, Siti-Azizah M N 2010 *Reproductive Biology and Endocrinology* 8: 49
[19] Vazquez J A R, Sanchez F A, Dominguez E G 2001 *Revista de Biologia Marina and Oceanografia* 36(1) 9-14
[20] Faife J R. 2003 Effect of mesh size and twine type on gillnet selectivity of cod (*Gadus morhua*) in Icelandic Coastal Waters. Fisheries Training Programme. The United Nations University, Reykjavik, Iceland 23p
[21] Walker R, Donkers A 2011 An Examination of The Selectivity of Fishing Equipment in Relation to Controlling The Common Carp (*Cyprinus carpio*) in Lakes Cresnant and Sorell Technical Report No.2 Inland Fisheries Service Tasmania Australia.23p
[22] FAO 2011 Code of Conduct For Responsible Fisheries, Food and Agriculture Organization of the United Nations, Rome 108p