Reproductive biology of hampala barb 
(*Hampala macrolepidota* Kuhl & Van Hasselt 1823) in Ranau Lake, Indonesia

S Makmur1,2,*, D Muthmainnah1,2, Subagdja4, D Arfiati3, G Bintoro 3 and A W Ekawati3

1 Research Institute for Inland Fisheries and Extension, Ministry of Marine Affairs and Fisheries
2 Inland Fishery Resources Development and Management Department – Southeast Asian Fisheries Development Center
3 Fishery and Marine Science Faculty, Brawijaya University

*Corresponding author: frans_makmur@yahoo.com

Abstract. One of the economically valuable consumption fish in Ranau Lake is the hampala barb (*Hampala macrolepidota*). Hampala barb is the top predator in Ranau Lake. The fish population is still quite a lot, but it is starting to decline. This study aimed to determine the reproductive biology of hampala barb in Ranau Lake. Ranau Lake is located in South Sumatra Province and Lampung Province, Indonesia. The research was conducted by the inventory survey method and laboratory analysis. Fish samples were obtained from fisher’s catch, where the fish were caught using gill nets with varying mesh sizes and harpoon. The fish were measured for length body and total weight. Then surgery was performed to determine their reproductive biological characteristics (sex, size of first gonad maturity, gonad maturity stage, Gonad Somatic Index, fecundity, and egg diameter). The results showed that the hampala barb in Ranau Lake laid the eggs throughout the year with a sex ratio of 1: 1, the size of the first stage of gonad maturity of male and female were 15.38 cm and 19.21 cm, fecundity between 17,406-63,793 eggs, and egg diameter between 0.8-1.9 mm. This reproductive biology information can be used for the management of hampala barb in Ranau Lake.

Keywords: hampala barb; reproductive biology; Ranau Lake

1. Introduction
Ranau Lake is located in two provinces in Indonesia, namely Ogan Komering Ulu Selatan Regency belongs to South Sumatra Province, and West Lampung Regency belongs to Lampung Province. The water surface area of Ranau Lake is approximately 12,398 hectares (123.98 km²). Based on the previous studies, 19 fish species have been identified, and the hampala barb (*Hampala macrolepidota*) (figure 1) is one of them. Hampala barb is known as a consumed fish and has economic value for the people who live surrounding the lake.

The hampala barb is a top predator among the food chain [1]. The local name of hampala barb is different depending on the size. Kemencut is for a small size, arongan is for the medium size, while sebarau is for the big size. The hampala barb is a migration fish from the lake to the upstream of the
This fish migrates in the group when they are in a small size (about 24 cm), but the large fish (> 24 cm) migrates in solitary.

To identify sex morphologically, it looks at secondary sexual characteristics as external signs in fish. Meanwhile, to find out more about sex, it can be seen from fish's primary sexual features, namely testes and ovaries. Gonad maturity and reproduction rate depend on the growth rate. Therefore, juveniles from eggs that hatch at the same time will reach gonad maturity at different times [2]. The fish size to reach the first gonad maturity is not always the same [3]. The difference size occurs due to differences in the waters' ecological conditions [4].

This paper describes the reproductive biology of hampala barbs, such as sex ratio, gonad maturity stage, the length at first maturity, Gonad Somatic Index, fecundity, and egg diameter.

![Figure 1. Hampala barb (H. macrolepidota Kuhl & Van Hasselt 1823).](image1)

2. Materials and methods
The study was conducted in Ranau Lake, Indonesia (figure 2), by direct observations followed by laboratory works in a year of activity. The number of fish samples was 1,031 individuals. Fish samples were collected by two kinds of fishing gears are gillnets with a mesh size of 1½ inch, 1¾ inch, and 2½ inch, and a harpoon. The fish was preserved for laboratory examination. The fish biology was analyzed
by measuring the length (cm), weight (g), and observing the reproduction to identify the sex, gonad maturity stage, Gonad Somatic Index, fecundity, and egg diameter.

2.1. Data analysis

Sex ratio is analyzed by the comparison between male and female, using the formula:

$$X = \frac{J}{B}$$

(1)

where:
- $X$ = Sex ratio (%)
- $J$ = Total number of male fish (individuals)
- $B$ = Total number of female fish (individuals)

The size of the first mature is estimated by using the Spearman-Karber [5] as follows:

$$M = \left( \frac{X_k + \frac{X}{2}}{2} \right) - (X, \sum p_i)$$

(2)

The range of fish length is estimated with formula:

$$\text{antilog} \left[ \frac{m \pm 1.96 \sqrt{\text{var}(n)}}{2} \right]$$

(3)

$$\text{var}(m) = (X)^2 \times \sum \left[ (p_i \times q_i) / (n_i - 1) \right]$$

(4)

where:
- $M$ = log size of fish at first mature;
- $M_0$ = log of fish length at first stage mature;
- $X_k$ = last log size at which 100% of fish are mature;
- $X$ = log size increment;
- $p_i = r_i / n_i$ = proportion of mature fish in its size group;
- $R_i$ = number of fish at mature in class $i$
- $N_i$ = number of fish samples in class $i$
- $Q_i = 1 - p_i$

To calculate the percentage of first-stage mature, it is using the formula [6]:

$$MS_{i} \% = \frac{MS_i}{\sum_{i=1} MS_i} \times 100$$

(5)

where:
- $MS_{i}$ = percentage of fish which reach the gonad mature in stage-$i$
- $MS_i$ = number of fish which reach gonad mature in stage-$i$
- $\Sigma MS_i$ = all of the stages of gonad mature

To know the Gonad Somatic Index and the percentage proportion of the fish sample in each gonad maturity stage, it was estimated using the formula of [6, 7]:

$$\text{GSI (IKG)} \% = \left( \frac{B_g}{B_t - B_g} \right) \times 100$$

(6)

where:
- $\text{GSI}$ = Gonado Somatic Index (%)
- $B_g$ = Weight of gonad (g)
- $B_t$ = Weight of fish (g)

Total fecundity (biotic potency) was measured by the fish in gonad mature by the gravimetric method. The fecundity was estimated using [3], with the formula:
\[
\frac{X}{x} = \frac{G}{g}
\]

(7)

Where:
- \(X\) = The egg number in the gonads (fecundity)
- \(x\) = The egg number from the egg number known (eggs)
- \(G\) = Weight of total gonads (g)
- \(g\) = Weight of half of the gonads (g)

The 100 eggs were taken to measure of egg diameter of fish in the mature stage (4th stage). Using the microscope (Olympus S2 x 16) with magnification 10 times, the egg diameter was measured by the Whipple Grid. The distribution pattern of egg diameter was analyzed using Microsoft Excel by making size classes and the percentage distribution of diameter sizes.

3. Results and discussion

3.1. Sex ratio

Sex ratio is needed to know the ratio between the number of males and females; therefore, it can be explained by the proportion of the fish population in waters between males and females. The total of fish collected was 1,031 individuals, whereas 457 (44.33% of the total) and 574 (55.67%) were males and females, respectively. The sex ratio of hampala barb is 1:1.26 (figure 3), which means that there were 1 male and 1 female in the hampala barb population [8] stated that in the waters is estimated the ratio of male fish and female fish is 1:1.

![Figure 3. Sex ratio of hampala barb in Ranau Lake.](image)

Based on the total length of hampala barb, the sex ratio shows the distribution pattern of males and females is almost the same. Most of the samples were in a class measuring 18.5 cm or a total length between the range of 18.00-19.00 cm, which was indicated by males 16.85% and females 19.69%. While based on the first gonad mature, the male was in 15.38 cm, and the female was in 19.21 cm. The length distribution of males in gonad mature was different from the females.

The sex ratio could be different even though in each individual. Sex ratio could be impacted by individual distribution in a room and time [9]. Unusual ecology conditions could also give an impact or can change the sex ratio [10]. The sex ratio is a reproduction parameter that is needed to manage the fish. The information of sex ratio is needed to know the estimation of reproduction potency, especially the females [11].
3.2. Gonad maturity stage

The gonad maturity stage of fish was determined morphologically based on the criterion of fish gonad maturity index, i.e., quiescent/undeveloped (stage 1), develop (stage 2), early mature (stage 3), ripe (stage 4), and spend (stage 5). Gonad maturity is divided into two categories, immature (1st and 2nd stage) and mature (3rd and 4th stage). The gonad maturity stage of hampala barb was dominated by the first stage with a percentage of 78.12% males and 90.07% females (table 1).

![Table 1. The distribution of gonad mature stage of *H. Macrolepidota*.](image)

| Gonad Maturity Stage | Male | Female |
|----------------------|------|--------|
|                      | N (ind) | % | N (ind) | % |
| 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 |
| Σ Total (Ind)        | 457 | 100 | 574 | 100 |

The fish was caught by an experimental fishing method using the gillnet with 3 mesh sizes, i.e., 1½, 1¾, and 2½ inches. The mesh size of 1½ inch and 1¾ inch dominantly caught the hampala barb in the first stage of gonad mature and a small percentage of the 2nd stage. While the mesh size of 2½ inch caught all the stage of gonad mature.

The 3rd, 4th, and 5th stages of gonad mature could only get from the samples caught by gillnets with a mesh size of 2½ inch and harpoon fishing gear. The gillnet with a mesh size of 1½ inch and 1¾ inch captured the hampala barb that not spawn yet, i.e., 1st and 2nd stages. This study is not recommended to use the gillnet with a mesh size of 2½ inch since it will be dangerous to the hampala barb population in Ranau Lake.

Hampala barb inhabited in Ranau Lake, spawn every month with length range between 23.5-48.2 cm or average 29.15±5.59 cm for male in the gonad mature 4th stage, while 26.4-44.3 cm or average 30.9±4.71 cm for female in the similar stage (table 2). In the gonad mature 5th stage, there were two peaks of spawn for hampala barb in Ranau Lake, which is March and April for the first peak and November for the second peak.

The study got the fish data in the 4th stage of gonad mature; it indicated that the fish spawn every month; moreover, it indicated that the fish spawn in the whole year. This result was similar in Kenyir Lake, Malaysia, that *H. macrolepidota* did three periods to spawn [12], the first period was in the rainy season (February), the second period was in May, and the last period was in September [13].

![Table 2. Range of fish length based on gonad mature stage of *H. Macrolepidota* male and female.](image)

| Gonad Maturity Stage | Total Length (cm) of Male | Total Length (cm) of Female |
|----------------------|---------------------------|----------------------------|
|                      | range | r ± SD | range | r ± 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 |

3.3. Length of the first maturity

Based on the Spearmen-Karber method, the size of the male hampala barb in the 1st gonad stage was 15.38 cm in length size between 14.80-15.97 cm. While the size of the first gonad mature female was 19.21 cm with ranged 18.27-20.18 cm. A male of hampala barb has a smaller size and mature faster than females. The first stage of gonad mature for each fish was different, although it was from the same species. The female and male of *H. macrolepidota* in Cangkuang Lake reached the first gonad mature...
in the length of 23.0-36 cm and 13.5-24 cm, respectively [14]. Whereas in Saguling Reservoir, Lahor Reservoir (East Java), and Karangkates Reservoir, the female of hampala barb reach the first gonad mature in 25.5-30 cm, 19.7-34.9 cm, and 39-52 cm, respectively [15]. The size of the first gonad mature is relatively different from each other. The differences occurred due to the water’s ecological conditions and the fishing pressure.

3.4. Gonad Somatic Index (GSI)

The qualitative analysis was to know the gonad somatic index of hampala barb inhabited in Ranau Lake. The GSI will increase concomitantly with the gonad mature. The increase of 3rd stage to 4th stage was from 2.12% to 8.34%. Nevertheless, the GSI will decrease to 2.35% after reaching the 5th stage of gonad mature for females (table 3, table 4, and figure 4).

Gonad Somatic Index will increase along with the development of the gonad and reach the maximum when fish are spawning. For example, for the female hampala barb, the GSI increased from only 0.27% (1st stage), 1.28% (2nd stage), 2.12% (3rd stage), and 8.34% (4th stage), then drops to 2.35% when the fish are spawned. The average gonad weight of females will increase by 10-25% of body weight [16].

Table 3. Range and average of Gonad Somatic Index based on gonad mature stage of male hampala barb in Ranau Lake.

| Gonad Mature Stage | N  | Fish weight (g) | Gonad Weight | Gonad Somatic Index (%) |
|--------------------|----|-----------------|--------------|-------------------------|
|                    | Male | Range  | Average ± SD | Range | Average ± SD | Range | Average ± SD |
| I                  | 377  | 79.12-207.43   | 112.79±26.88 | 0.01-1.26 | 0.12±1.13 | 0.01-1.06 | 0.19±0.13 |
| II                 | 32   | 24.86-268.41   | 296.94±65.84 | 0.01-1.53 | 1.26±0.46 | 0.01-1.11 | 0.77±0.25 |
| III                | 18   | 150.0-886.0    | 574.63±24.58 | 1.99-13.9 | 7.92±2.69 | 0.35-2.78 | 1.63±0.57 |
| IV                 | 30   | 155.15-820.0   | 559.67±180.45 | 3.62-26.3 | 7.36±4.27 | 1.70-4.22 | 2.78±0.66 |
| V                  | 0    |                |              |         |            |         |             |

Table 4. Range and average of Gonad Somatic Index based on gonad mature stage of female hampala barb in Ranau Lake.

| Gonad Mature Stage | N | Fish Weight (g) | Gonad Weight | Gonad Somatic Index (%) |
|--------------------|---|-----------------|--------------|-------------------------|
|                    | Female | Range | Average ± SD | Range | Average ± SD | Range | Average ± SD |
| I                  | 518  | 10.05-17.00    | 208.20±84.92 | 0.01-5.71 | 0.57±0.3  | 0.01-1.64 | 0.27±0.15 |
| II                 | 18   | 69.56-1,025    | 522.89±243.09 | 0.38-9.43 | 3.56±2.18 | 0.25-1.61 | 1.28±0.42 |
| III                | 7    | 171.54-1,100   | 938.92±407.85 | 4.29-24.51 | 20.3±7.96 | 1.84-2.83 | 2.12±0.22 |
| IV                 | 25   | 181.23-1,000   | 646.89±197.51 | 7.38-40.16 | 23.03±7.11 | 4.05-15.51 | 8.34±3.44 |
| V                  | 6    | 226.44-895     | 790.89±264.06 | 2.54-20.82 | 10.61±6.61 | 1.13-3.67 | 2.35±0.85 |

Figure 4. Gonad Somatic Index (GSI) of male and female of hampala barb in every stage.
3.5. Fecundity
The number of eggs or fecundity of hampala barb in Ranau Lake with a total length ranged between 26.2-44.3 cm (average 30.9 ± 4.71), the weight ranged between 159.04-1000 g (average 336.38 ± 197.5), and the gonad weight ranged between 7.38 - 40.16 g (average 23.02 ± 7.11), as well as the number of eggs or fecundity, was between 17.406 - 63,793 (average of 34,977.64) eggs. Fecundity is related to the body weight and gonad weight of females. The more fecundity granules, the heavier the fish gonads will be (figure 5 and figure 6).

Gonad weight will affect the fish weight and egg number or fecundity. The weight gain tends to increase, causing fecundity linearly. Statistics show a significant relationship between fecundity with body weight and gonad weight [17]. The correlation of the relationship shows the amount of fecundity, where the small correlation showed low fecundity.

Fecundity is the number of mature eggs in the ovaries released during spawning [18]. The fecundity of the hampala barb in Ranau Lake ranged from 17,406-63,793 with a total length ranging from 26.2 to 44.3 cm and a weight of 159.04-1000 g. Compared with the results of previous research in Saguling Reservoir, West Java, the total fecundity of hampala fish ranged from 12,006-74,355 eggs with a total length range between 25.5-35 cm and weight between 140-500 g [19]. The hampala fish in the Jatiluhur reservoir has a size of 20.6-50.7 cm. The fecundity ranged from 5,398-56,109 eggs [20]. The difference in fecundity of the hampala barb is due to differences in habitat or environment. Besides that, fecundity is also influenced by genetic differences and the abundance of food available in each habitat.

Figure 5. The relationship between fecundity with fish weight (W=fish weight).

Figure 6. The relationship between fecundity and gonad weight of hampala barb (Wg is gonad weight).
3.6. Egg diameter

Egg diameter of hampala barb was measured from 24 individuals with egg total was 2,400 egg, or 100 eggs were randomly taken for female fish with 4th stage gonad mature. The egg diameter ranged between 0.8-1.9 mm (average 1.39 ± 0.17). The egg diameter size dominated by 1.3 mm (19.46%), followed by 1.4 mm (25.5%), and the biggest size was 1.5 mm (21.17%) (figure 7).

The size of the egg diameter will increase along with the development of the gonad mature stage. The observation was conducted to female gonad in 4th gonad mature stage with the range of total length was between 26.2-44.3 cm with average 30.9 ± 4.71, weight range between 159.04-1,000 g with average 336.38 ± 197.5, gonad weight range between 7.38-40.16 g with average 23.02 ± 7.11, and the egg diameter was ranged in 0.8-1.9 mm with average 1.39±0.17.

![Figure 7. The distribution of egg diameter size (4th stage of gonad mature) of hampala barb in Ranau Lake.](image)

The egg diameter of the 4th stage of gonad mature fish in Ranau Lake was different from Saguling Reservoir of West Java [19]. In Saguling Reservoir, the hampala barb had a length size range between 25.5-35 cm with a weight between 140-500 g, egg diameter between 0.28-1.03 mm. The differences showed that the longer and heavier the hampala fish, the larger the egg diameter. The differences in egg diameter size were influenced by genetic factors, environmental conditions, fish size, fish age [21].

4. Conclusion

This research found the sex ratio relatively 1:1 and could spawn a whole year. Hampala barb in Ranau Lake has the potential to exploit for supporting the fishers’ livelihood.

Acknowledgment

This study was funded by the Ministry of Marine Affairs and the Fisheries Republic of Indonesia through Research Institute for Inland Fisheries and Extension. We gratefully acknowledge the research assistants for invaluable help during the field survey and laboratory activity.

References

[1] Makmur S 2009 Fish Diversity in Ranau Lake Proceeding National Seminar of Biology Jenderal Soedirman University Purwokerto 10 p [in Indonesian]
[2] Nikolsky G V 1963 The Ecology of Fishes (New York: Academic Press) 352 p
[3] Effendie M I 1979 Methode of Fish Biology (Bogor: Yayasan Dewi Sri First Edition) 112 p [in Indonesian]
[4] Blay J and Eyeson K N 1982 Observation on the reproductive biology in the coastal water Ghan Journal Fish Biology (21): 485-496
[5] Udupa K S 1986 Statistical methods of estimating the size at first maturity in fishes ICLARM Metro Manila Fishbyte 4(2): 8-10

[6] Wudneh T 1998 Biology and Management of Fish Stocks in Bahir Dar Gulf, Lake Tana Ethiopia PhD [Thesis] Fish culture and fisheries group Wageningen Institute of Animal Science Wageningen Agricultural University Netherlands 144 p

[7] Bandpe A, Aghhor M A M M, Abdolmaleki S H, Najafpour H and Janbaz A A 2011 The environmental effect on spawning time length at maturity and fecundity of Kutum (Rutilus frisii kutum, Kamensky, 1901) in Southern Part of Caspian Sea Iran Iranica Journal of Energy and Environment 2(4): 374-381

[8] Ball D V and Rao K V 1984 Marine Fisheries Tata Mc Graw Hill (New Delhi: Company Limited) pp 5-24

[9] Khalifalla M M, Hammouda Y A, Tahoun A M and Abu-Stute A M 2000 Effect of broodstock sex ratio on growth and reproductive performance of blue Tilapia Oreochromis aureus (Steidachner) reared in hapas 8th International Symposium on Tilapia in Aquaculture 2008 Egyptr: 115-125

[10] Bohlen J, Freyhof J and Nolte A 2008 Sex ratio and body size in Cobitis elongatoides and Sabanejewia baicanica (Cypriniformes, Cobitidae) from a thermal spring Folia Zoology 57(1-2): 191-7

[11] Arocha F, Marcano L and Silvy J 2010 Sex ratio at size of salfish (Istiophorus albicans) from the Venezuelan fishery off the Carribbean Sea and Adjacent Areas Collect Volume Science Paper ICCAT 65(5): 1633-40.

[12] Zakaria M Z, Jalal K C A and Ambak M A 2000 Length weight relationship and relative condition factor of sebarau Hampala macrolepidota (Van Hasselt) in Kenyir Lake, Malaysia Pakistan Journal of Biological Sciences 3(5): 721-4

[13] Tamsil A 2000 Study of Some Pre-spawning Reproductive Characteristics and the Possibility of Artificial Spawning of Glossogobius aureus in Tempe Lake and Sidenreng Lake, South Sulawesi [Dissertation] IPB University Bogor unpublished [in Indonesian]

[14] Rahardjo M F 1977 Food Habits, Spawning, Long-weight Relationship and Condition Factors for Hampala Fish, Hampala macrolepidota (CV) in Jatiluhur Reservoir, West Java [Thesis] IPB University Bogor 39 p unpublished [in Indonesian]

[15] Jubaedah I 2004 Distribution and Feeding of Hampala Barb (Hampala macrolepidota C.V) in Cirata Reservoir, West Java [Thesis] IPB University Bogor 82 p unpublished [in Indonesian]

[16] Effendie M I 2002 Fish Biology Revision Edition (Yogyakarta: Yayasan Pustaka Nusantara) 163 p [in Indonesian]

[17] Sabe H M, Kamali A., Soltani M, Bani A and Rostami H 2012 Age, sex ratio, spawning season gonadosomatic index, and fecundity of Cobitis faridpaki (Actinopterygii, Cobitidae) from the Siahrud River in the Southern Caspian Sea Basin Caspian Journal Environment Science 10(1): 15-23

[18] Hunter J R, Maciewicz B J, Chyanhuilo N and Kimbrill C A 1992 Fecundity, spawning and maturity of female dover sole, Microstomus pacificus and evaluations of asumptions and precisions Fishery Bulletin 90:101-128

[19] Satria H 1991 The reproductive potential of hampala barb (Hampala macrolepidota) in Saguling Reservoir, West Java Bulletin of Inland Fishery 10(1): 10-16 [in Indonesian]

[20] Admadja H, Setiadi K E and Rabegnatar N S 1989 Some biological aspect of the predominant fish species in the Jatiluhur Reservoir, West Java Indonesia Proceedings of A Workshop Held in Kathmandu, Nepal, 23-28 November 1987 IDRC Canada 98-104

[21] Putra K K 2010 Growth and Reproduction of snakehead fish (Channa striata) Related to the Hydrodynamics of Flood Swamp in Musi River Basin (DAS), South Sumatra [Thesis] IPB University Bogor 89 p unpublished [in Indonesian]