Monofilament Gillnet Selectivity for *Hampala Barb* (*Hampala macrolepidota*) Management at Ir. H. Djuanda Reservoir-West Java

Andri Warsa¹*, Didik Wahju Hendro Tjahjo¹, lismining Pujiyani Astuti¹

¹ Research Institute for Fisheries Resources Conservation, Jl. Cilalawi No 1, Jatiluhur, Purwakarta, Jawa Barat 41152, Indonesia

*Corresponding authors: andriwarsa@yahoo.co.id

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ABSTRACT

Native species from Citarum River and introduce new species caused high fish biodiversity in this reservoir and one of them is Hampala barb (*Hampala macrolepidota*) and it’s economical species. Hampala barb is one of dominant species was captured at Ir. H. Djuanda Reservoir but was experience decreasing of population by overfishing. The objective of this research were to known gillnet selectivity and length at first mature for hampala barb (*Hampala macrolepidota*) at Ir. H. Djuanda Reservoir. The information will be used as base determination of gillnet mesh size and legal size for sustainability fisheries management (Silvano et al., 2009). The research was done at February-September 2017 with experimental fishing used gillnet with mesh size between 1.0 - 3.0 inch with intervals 0.5 inch. Total length hampala barb with highest captured probability for gillnet with mesh size 1.0; 1.5; 2.0; 2.5 and 3.0 inch were 11.0; 17.0; 22.5; 28.0 and 33.5cm respectively. Length at first mature of hampala barb for female and male were 14.2 and 13.8 cm respectively. Based on the information, the minimum total length for exploitation was 19 cm using gillnet with mesh size > 2.0 inch.

Keywords: gillnet, selectivity, total length, hampala barb

1. Introduction

Ir. H. Djuanda Reservoir located at Purwakarta Regency, West Java Province is a multifunction reservoir and was used for captured fisheries activity. The Jatiluhur Reservoir was built with the damming Citarum River and native fish from this river was entry and inhabits the reservoir. Introduction new species like milk fish caused increasing of fish species in this reservoir (Hedianto and Purnamaningtyas, 2011). Its caused this reservoir have high fish biodiversity. Result of the result from Putri and Purnamaningtyas (2011) shown 15 species were captured by experimental fishing using gillnet and one the species is hampala barb. Hampala barb (*Hampal macrolepidota*) is economical value of native species. Its one of dominant species was captured but now experience population decreasing is caused overfishing (Kartamihardja, 2008). The overfishing has caused significant changes in of fish population. Therefore, to achieve sustainable fisheries, management should conserve the age and spatial structure in addition to spawning biomass (Hsieh et al., 2010). Effective management of fisheries resources depends on the fishing gear selectivity, fishing effort control and biology aspect of target species (Kindsvater et al., 2017).

The fishing gear was used at Jatiluhur Reservoir by fisherman including hook, lift net, cast net, trap and gillnet as dominant fishing gear. Gillnets was used for the commercial harvest and the assessment tool of fish population with highly selective for certain size of fish. The size selectivity for fish exploitation therefore needs to be known to effectively regulate its commercial use (Svedang and Hornborg, 2014; Vainikka and Hyvarinen, 2012). Information on the fish reproductive is required in order to advise on management measures to protect the reproductively active part of the population. Such measures could involve the introduction of a minimum mesh size and closed

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season and/or area (Kuparinen et al., 2016). Proper fisheries management requires that fishing gear harvest large mature fish while allowing the small juveniles to escape. This property of fishing gear is called gear selectivity (Dincer and Bahar, 2008).

Fisheries management based on biology parameters and fishing gear selectivity prevent recruitment over fishing (Jarvis et al., 2014). If length at first harvest is correctly determined, a stock is more likely to be sustained and yield optimized (Ratz et al., 2015). The regulation of minimum gillnet mesh size for nile tilapia exploitation was enforcement in El-Bahr El Faroumy Canal, Egypt (El-Kasheif et al., 2015). Determine of reference point for fish exploitation have some objective include to ensure the long sustainability and risk minimize of fish resources exploitation (Olin et al., 2017). The objective of this research were to known gillnet selectivity and length at first mature for hampala barb (*H. macrolepidota*) at Ir. H. Djuanda Reservoir. The information will be used for based of determination of gillnet mesh size and legal size for sustainability fisheries management.

2. Material and Methods

2.1. Study sites

The hampala barb were collected from February-September 2017 at Ir. H. Djuanda Reservoir, West Java using monofilament gill nets mesh size 1,0-4,0 inch with intervals 0,5 inch. Experimental fishing was done at six stations include Cihonje-Cibadak, Cikayanyan, Cirirp, Cihonje, Pasirkole and Cilalawi (Figure 1). The nets were made from white monofilament polyester twine with diameter size 0.25 mm. The length of each gill nets was 40 m with the number meshes in depth was 100.

The experimental gillnets with seven mesh size were used simultaneously at the same area with the depth from 6,0-18 m. The gillnets were set at 04:00 am and hauled at 07:00 pm. After hauling, the catch was remove and separated according the mesh size and the total length of each fish was measured to the nearest 0.1 cm using measure board. Secondary data of hampala barb total length was used got from Research Institute for Fisheries Conservation (Balai Riset Pemulihan Sumber Daya Ikan) Jatiluhur.

![Figure 1. Sampling stations using experimental gillnet](image)
The data was collected at 1985 and 1986. Measurement of opercular or Head (G_H) and maximum girth (G_max) for hampala barb according Ozekinci (2005).

The maturity scale used for determination of sexual stages according Legendere and Ecoutin (1989). That scale includes seven stages: Stage 1: immature; Stage 2: beginning mature; stage 3: maturation; Stage 4: advanced maturation; Stage 5: ripe. The mature of females and males if they had reached gonad stage 3 or higher.

2.2. Data analysis

Optimum mesh size for hampala barb exploitation decided by optimum length (Lc) with length at first mature (Lm) (Makmur et al., 2014). The Lm defined as the mean length at which gonadal development advanced to at least stage 3 of individual. The determination of Lm was estimated using logistic curve (King, 2007). The logistic equation used is as follows:

\[
P = \frac{1}{1 + \exp(-r(L - Lm))}
\]

Where:
- P = The proportion of mature fish gonad (%)
- Lm = Length at first maturity (cm)
- L = Total length (cm)
- R = Slope

Curve linear constant of a relationship between the proportion of fish mature with a number of examples of the same length class can be used to determine the value of r and Lm where \( r = -\frac{1}{b} \) and \( Lm = \frac{a}{r} \).

In calculating the selectivity parameters and selection curve of nets using indirect method (Holt, 1963), in which selectivity parameters are estimated form catches taken by slightly difference mesh size. The natural logarithms of caught number per length class, \( C_1 \) and \( C_2 \), by two slightly difference mesh size, \( m_1 \) and \( m_2 \) are linearly related to fish lengths:

\[
\ln \left( \frac{C_2}{C_1} \right) = a + bL
\]

where:
- L = length class of caught fish (cm)
- a = intercept
- b = Slope

The optimum length (Lc\textsubscript{a} and Lc\textsubscript{b}) for mesh sizes c\textsubscript{a} and c\textsubscript{b}

\[
L_{c_a} = -2\left[am_a/b(m_a + m_b)\right]
\]

\[
L_{c_b} = -2\left[am_b/b(m_a + m_b)\right]
\]

Selection factor (SF) and standard deviation (SD) of the gillnet were then estimated using the following equation:

\[
SF = -2a/b(c_a+c_b)
\]

\[
SD = \left(\frac{1}{n-1}\sum\left[2\alpha(m_{i+1} - m_i)/b\right]^2(m_i + m_{i+1})\right)^{1/2}
\]

The probability of capture (P) for a given a length (L) in a gill nets with mesh sizes (m) was determined from the following equation:

\[
P = \exp\left[-\frac{(L-Lc)^2}{2SD}\right]
\]

The optimum length (corresponding to a 100% of probability of retention) for each mesh size was obtained:

\[
Lc = SF \times m
\]

Relationships between fish total length and \( G_H \) and \( G_{\text{max}} \) were estimated by linear regression analysis (Kurkiilahuti et al., 2002):

\[
y = a + bL
\]

where:
- a = intercept
- b = slope
3. Result and Discussion

3.1. Length distributions and length at first mature

A total of 823 individuals of hampala barb (H. macrolepidota) specimens were captured during the sampling period. The total length distribution of hampala barb caught using experimental gillnets with five mesh size in Ir. H. Djuanda Reservoir are shown at Fig 2. The total length of fish of caught ranged around 5.0-34.0 cm and increases according increasing of gillnet mesh size. The length frequency distribution of hampala barb each mesh size followed normal distribution with specific mesh size. The modal of total length of hampala barb captured with experimental gillnets increased namely 10.5; 15.5; 20.5; 26.5 and 29.5 cm for mesh size 1.0; 1.5; 2.0; 2.5 and 3.0 inch respectively. Hampal barb was not captured at gillnet with 3.5 and 4.0 inch mesh size.

![Histograms showing length frequency distributions of hampala barb caught for each mesh size](image)

**Figure 2.** Length frequency distributions of hampala barb caught for each mesh size

The total length of hampala barb was captured at Jatiluhur Reservoir smaller than Lake Ranau around 9.7-33.3 cm (Makmur et al., 2014). Percentage of total length bigger than length at first mature (Lm) for 1.0; 1.5; 2.0; 2.5 and 3.0 inch were 0.0; 16.0; 91.7; 98.2 and 100% respectively. The mesh size > 2.0 inch would captured the hampala barb longer than Lm with proportion > 90%. Use of this mesh size ensures that at least 85% of the barbs harvested by the commercial gillnet fishery are large adults as their size at maturity is much smaller than their size at capture (de Graaf et al., 2003).

Fishes resources management can be done with determination the fishing season and location, the number of catches and the minimum fish size that can be captured (Andersen et al., 2018) which its was greater than the value of Lm (Tesfaye et al., 2016; Teame et al., 2018). There is a potential for immature individuals being caught at mesh size < 2.0 inch.
Length at first mature (Lm) for female and male of hampala barb at Ir. H. Djuanda Reservoir were 14.2 and 13.8 cm respectively and its smaller than another research result. The length at first mature (Lm) for female and male of hampala barb in Lake Zoo Nagara, Kuala Lumpur were 15.0 and 18.0 cm respectively (Abidin, 1986) and 16.0 cm for female in Lake Kenyir (Zakaria et al., 2000). Lm can be considered as minimum permissible size for first capture (Amarasinghe and Pushpalatha, 1997) and reduce the risk of overexploitation of specific spawning component (Van Overzee and Rijnsdorp, 2015). Restriction of size for exploitations is a fisheries resources management efforts before there are restrictions on efforts or the number of fish biomass that can be exploited (Davies et al., 2009) and its also a sustainable fisheries management (Garcia et al., 2016).

3.2. Gillnet Selectivity

The calculations of selectivity parameters based on the net pairs 2.54-3.81; 3.81-5.08; 5.08-6.35; 6.35-7.62 cm. The regression constant (slope and intercept) coefficient for optimum lengths and selectivity parameters were assessed from length frequency distribution for each mesh size combination (Table 1). That's values were used to estimate the common selectivity factor, standard deviation and optimum selection length for mesh size respectively. The generally of selectivity factor and standard deviation were 4.3805 and 3.467, respectively.

The selection curve of monofilament gillnets for hampala barb obtained with the probability of capture (P) equation and shown in Figure. 2. The optimum selectivity length were 11.0; 17.0; 22.5; 28.0 and 33.5 cm for gillnet 2.54; 3.81; 5.08; 6.35 and 7.62 cm mesh size respectively. Fishing gear selectivity as importance instrument for fisheries management (Zhenlin et al., 2014; Jorgensen et al., 2009) cause diminished non target catches (Kalayci and Yesilcicek, 2014).

Table 1. The selectivity parameters of monofilament gillnet with different mesh size

<table>
<thead>
<tr>
<th>m₁</th>
<th>m₂</th>
<th>a</th>
<th>b</th>
<th>n</th>
<th>R²</th>
<th>L₁</th>
<th>L₂</th>
<th>SF</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.54</td>
<td>3.81</td>
<td>-28.8900</td>
<td>2.400</td>
<td>3</td>
<td>0.9250</td>
<td>9.6</td>
<td>14.5</td>
<td>3.79</td>
<td>1.41</td>
</tr>
<tr>
<td>3.81</td>
<td>5.08</td>
<td>-16.7890</td>
<td>0.9010</td>
<td>4</td>
<td>0.9984</td>
<td>16.0</td>
<td>21.3</td>
<td>4.19</td>
<td>2.43</td>
</tr>
<tr>
<td>5.08</td>
<td>6.35</td>
<td>-17.9690</td>
<td>0.7390</td>
<td>6</td>
<td>0.9655</td>
<td>21.6</td>
<td>27.0</td>
<td>4.25</td>
<td>2.70</td>
</tr>
<tr>
<td>6.35</td>
<td>7.62</td>
<td>-4.2686</td>
<td>0.1316</td>
<td>3</td>
<td>0.9494</td>
<td>30.0</td>
<td>35.5</td>
<td>4.66</td>
<td>6.72</td>
</tr>
</tbody>
</table>

n=Number of point used in the regressions, L₁ and L₂=estimated catch lengths (cm) for nets of mesh size m₁ and m₂ respectively, SF= selection factor, SD= Standard deviation.
The selectivity can serve for fisheries management with minimizing bycatch and fishing impact for fish structure (Laurence and Marie-Joelle, 2016). Determination of mesh size for fishing activity is more efficient because it is minimize catches of unwanted species and minimize capture of certain size (Breen et al., 2016; Laurence and Marie-Joelle, 2016; Dineshbabu et al., 2012). Gillnet with mesh size > 2.0 inch could be safely, as they allow the target resources to attain Lm before vulnerable to fishing. The increasing size-selectivity could increase yield and juveniles captured avoiding and its provide an opportunity to reproduce at least once before they are harvested (Garcia et al., 2012). The increased management for protecting juvenile and megaspawners of target species (Tesfaye et al., 2016). Appropriate mesh size is thus one way of establishing an appropriate Lc for target species and as the basis of regulation for specify the minimum mesh size (Emmanuel and Chukwu, 2010; Saberin et al., 2013). The effect of exploitation pattern for fisheries resources depend on selectivity of the gear relative to the available fish size (Rochet et al., 2011). Nile tilapia (Oreochromis niloticus) fisheries resources management at Amerti Reservoir, Ethiopia was done with determination of gillnet mesh size for fish captured bigger than Lm (Hailu, 2014).

Total length estimation of fish captured was estimated based on mesh size selectivity value for a gillnet because its have high selectivity (Oginni et al., 2006). Relationship between optimal length (Lopt, cm) and mesh size (MS, inch) can be shown with linear regression (Jawad et al., 2009) as follows:

\[ Y = 3.622MS + 1.5 \]

\[ R^2 = 0.9925 \]

The formula shown that fish with total length smaller than length at the first mature would be dominant caught at gillnet with mesh size 1.5 inch while the gillnet with mesh size > 2 inch would be dominant caught fish ≥ 19 cm (L>Lm).

The relationship between head girth (Gh) and maximum girth (Gmax) versus total length (L) of hampala barb shown the equations as follows:

\[ L = 1.6456G_{H} + 4.2627 \quad R^2 = 0.8311 \]

\[ L = 1.3757G_{\text{max}} + 3.2109 \quad R^2 = 0.8753 \]

Head girth and maximum girth for hampala barb with 19 cm total length were 9.0 and 11.5 cm, respectively. Its dominant captured on gillnet with mesh size ≥ 2.0 inch with ratio of head girth and maximum girth were 0.9 and 1.1. Its same with experimental gillnet where is hampala barb with 19 cm of total length dominant caught at gillnet with mesh size ≥ 2.0 inch. Significant variation in the selectivity parameters was explained by simple shape descriptors such as percent girth, suggesting that these descriptors might be used as a preliminary tool to describe gillnet selectivity for fish species (Carol and Garcia-Berthou, 2007).
4. Conclusions

Legal size for hampala barb exploitations was ≥ 19 cm by used gillnet with mesh size > 2.0 inch. Its bigger than length at first mature of female and male were 14.2 and 13.8 cm respectively. These information could be used for sustainability management for hampala barb resource at Ir. H. Djunda Reservoir

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