DETERMINING MONOFILAMENT GILLNET OPTIMUM MESH SIZE TO MITIGATE *Amphilophus citrinellus* POPULATION OUTBREAKS IN IR.H.DJUANDA RESERVOIR

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ABSTRACT

Gillnet is the most common fishing gear used by fishers in Ir. H. Djuanda Reservoir. Currently, gillnet catches are dominated by midas cichlid (*Amphilophus citrinellus*) which is not the main target catch. To some extent, their presence is even considered intrusive by the fishers. The aim of this study is to reveal the optimum gillnet mesh size in catching this alien species, which in turn can be useful to control the fish population in Ir. H. Djuanda Reservoir. The study was conducted from August 2011 to January 2012. The mesh size of the gillnets were 1, 1.5, 2, 2.5, 3, and 3.5 inches. The total midas cichlid caught were 628 fish which were mostly caught in 1.5 inches sized gillnet. Length first mature fish is 13.31 cm. The optimum size of fish caught in the mesh of 1.5, 2, 2.5, 3, and 3.5 inches are 9.7, 12.9, 16.2, 19.4, and 22.6 cm, respectively.

KEYWORDS: Selectivity, gillnet, midas cichlid, Ir. H. Djuanda Reservoir

INTRODUCTION

Human created an increase in transport capacity and fastly leading to worldwide biotic homogenization through the establishment of alien species (Garcia-Berthou, 2007), a species that is not native to the area. While there are numbers of alien species which are beneficial to people, increasing number of cases where the alien species is becoming as one of the main threats to biodiversity can not be overlooked. Any alien species that is considered harmful and detrimental to the surrounding environment and also human health is now commonly known as invasive alien species (ISAC, 2006; GISP, 2007).

Reservoirs Ir. H. Djuanda is one of Indonesia's several tiered that plays a significant role in supplying the water and electricity to cities in West Java (Tjahjo & Purnamaningtyas, 2010). At the start of the construction, about 31 species of fish were present in the reservoir, mostly native to Citarum River (Kartamihardja, 2008). However, it gradually decreased overtime. In the span of 2006-2009, there were only 24 species left (Tjahjo & Purnamaningtyas, 2011). Peculiarly, while the number of native fish keeps decreasing, there was an increase in the number of alien species, one of the most dominant being midas cichlid (*Amphilophus citrinellus*) (Putri & Purnamaningtyas, 2011).

Midas cichlid is a fish native to Central America region, brightly colored and often being traded to many countries due to their attractive coloration (Baensch & Fischer, 2007). This fish has the potential to alter their feeding habit as their body size changes overtime (Nurnaningsih *et al.*, 2004) and eventually becomes a fierce competitor to other fish. Unfortunately, midas cichlid does not possess high economical value in Ir. H. Djuanda Reservoir (Hedianto & Purnamaningtyas, 2012). Their presence in Ir. H. Djuanda is now considered as detrimental to the local fishermen and needs to be controlled. Other inland water bodies in Indonesia such as Cirata, Darma and Kedung Ombo Reservoir are also negatively affected by this species (Purnamaningtyas & Tjahjo, 2010). Controlling invasive alien species is one of many challenges that conservation biologists have to face (Allendorf & Lundquist, 2003) and information regarding the issue such as the gillnet selectivity is needed in managing fish resources (Carol & Garcia-Berthou, 2007). Gillnet is the most used fishing gear by fishermen at Ir. H. Djuanda Reservoir. Although similar research was done by Warsa & Purnomo (2013) on gillnet selectivity towards midas cichlid in Situ Panjalu, up to this date there has not been any studies being conducted regarding adequate mesh size to control midas cichlid population in Ir. H. Djuanda Reservoir. Therefore this study is intended to determine the monofilament gillnet optimum mesh size towards midas cichlid catch and first maturity size of the fish in the Reservoir. The result of the study will be useful to determine the gillnet mesh size used to control midas cichlid in Ir. H. Djuanda reservoir.

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MATERIALS AND METHODS

Time and Location

This research was carried out for six months from August 2011 to January 2012 locating in Ir. H. Djuanda Reservoir, Jatiluhur, Purwakarta, West Java Province (Figure 1). Sampling was done in six stations which represent the whole body of water of Ir. H. Djuanda Reservoir.

Materials and Tools

The object observed in this study is the midas cichlid caught by the gillnet (Figure 2), the most commonly used fishing gear by the local fishermen in Ir. H. Djuanda Reservoir. Similar method has also been used as a way to control invasive alien fish population in Mizoro Ga Ike, Japan (Abekura *et al.*, 2004). The gill net was made from mono-filament nylon thread with a diameter of 0.15 mm. One set of gill net consists of 6 pieces of nets with different mesh sizes of 1.0; 1.5; 2.0; 2.5; 3.0; and 3.5, respectively. Each piece of net was connected with one another gradually from the smallest mesh size to the largest. The length for each gill net was 36 m and the depth was various according to the mesh size. There were 70 meshes for each gill net. Selection of the mesh sized relating to its compatibility that is within the range of the target fish size, and measurement ruler with 1 mm accuration.

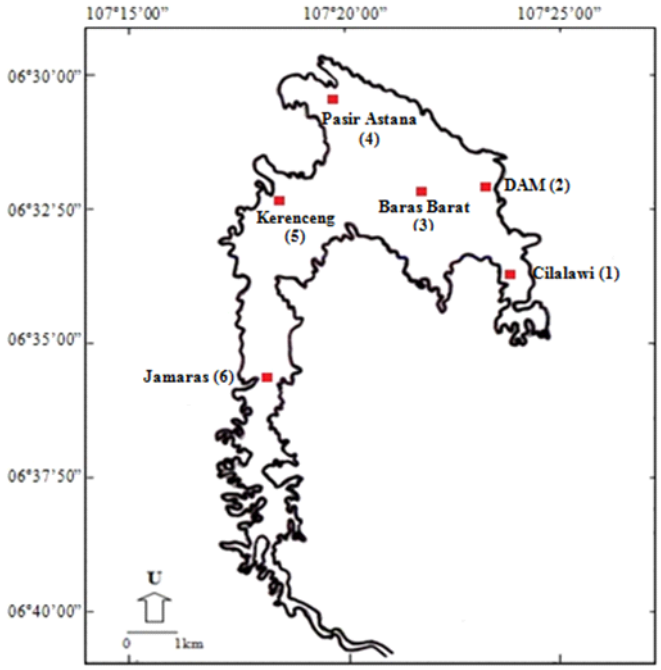


Figure 1. Sampling stations in Ir. H. Djuanda Reservoir.

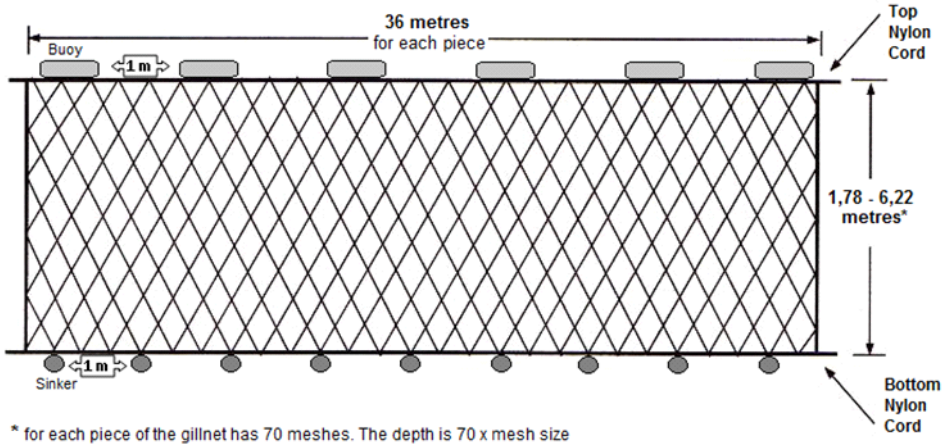


Figure 2. The illustration of the gillnet used in sampling.

Sampling Method

Gillnets were set up parallel to the shoreline at 4 pm in the late afternoon to avoid the boat traffic which will possibly entangle the net and hauled at 6 am in the following morning. One set of gill nets, consist of 6 pieces with different mesh size, was set up on each of the sampling site. Samples are then sorted out according to the mesh size and brought to biological laboratory of Research Institute for Fisheries Enhancement and Conservation for further identification such as fish weight and length measurement. The samples are then dissected in order to determine the stage of gonadal maturation according to morphology characteristics (Effendie, 1979). In this study, fish at the stage of III, IV and V are regarded as mature.

Data Analysis

Gillnet selectivity

Gillnet selectivity was estimated by using indirect method. This method compares catch from two different mesh sizes (m_a dan m_b) for the same length class (Sparre & Venema, 1999). The length of the fish was divided into 15 classes with an interval of 10 mm. For each mesh size, the normality of the data was tested using Kolmogorov-smirnov (Supardi, 2013).

Natural Logarithm (Ln) from each of length class (C_a dan C_b) on different mesh sizes is linear towards fish length, as is seen from the formula:

$$\text{Ln } (C_b/C_a) = x + yL \quad \text{.....(1)}$$

where: L = Length class of fish caught; x = intercept; and y= slope

The intercept (x) and slope (y) are then used to calculate fishing gear selection factor (SF) and its standard deviation (SD). The equation used to calculate SF and SD are shown below:

$$SF = -2\sum\left[\left(\frac{x}{y}\right)\left(m_a + m_b\right)\right] / \sum\left[\left(m_a + m_b\right)^2\right] \quad \text{.....(2)}$$

$$SD = \left\{1/n-1\right)\sum\left[2x\left(m_b - m_a\right)\right] / y^2\left(m_a + m_b\right)\ ]\ \}^{1/2} \quad \text{....(3)}$$

Catch probability (P) of the fish with length (L) on mesh size (m) is calculated with formula below:

$$P = \exp[-(L-Lm)^2/(2SD)^2] \quad \text{.....(4)}$$

Optimum length of fish caught (L_{opt}) for every mesh size is calculated with formula below:

$$L_{opt} = SF \text{ x } m \quad \text{.....(5)}$$

The first maturity size of midas cichlid in Ir. H. Djuanda Reservoir is determined by Spearman Karber method (Udupa, 1986). The length of fish first reached maturity size (L_{mg}) is predicted from the antilog m with formula:

$$m = x_k + \frac{x}{2} - \left(x \text{ x } \sum p_i\right) \quad \text{.....(6)}$$

With deviation of :

$$anti\log m = m \pm 1.96 * \sqrt{X * 2\left(pi * qi / ni - 1\right)} \quad \text{.....(7)}$$

Where: m = Mean length of first time maturity size of fish logarithm; x_k = Last logarithm where all fish reached maturity; x = Median logarithmic difference value; p_i = proportion of mature fish on -i length class**.**

RESULTS AND DISCUSSION

Results

There were 628 individuals of midas cichlid caught during the research. The number and the length of midas cichlid caught by each mesh sizes varies accordingly by number (Figure 3). Most of them were caught from 1.5 inches mesh size (353 fish; 88-137 mm), 2 inches (136 fish; 94-170 mm), 2.5 inches (88 fish; 101-200 mm), 1 inch (21 fish; 62-90 mm), 3 inches (17 fish; 107-206 mm) and last 3.5 inches (13 fish; 110-210 mm) respectively. Based on the Kolmogorov-smirnov test, the data were found to be normally distributed.

Gillnet selectivity was analyzed according to the fish length distribution on combined mesh sizes. The combinations used in this study are 1.5 & 2 inches; 2 & 2.5 inches; 2.5 & 3 inches; and 3 & 3.5 inches. Combination of 1 & 1.5 inches could not be performed due to lack of data from the length class.

Figure 4 shows the regression of comparison between catches of different mesh in the same length class. Results of this regression (regression constants and coefficients) and length distribution for certain mesh size and length class were used to calculate the gillnet selectivity factor and standard deviations simultaneously. Selectivity factor and standard deviation for joint combination are 2.5452 and 1.5430.

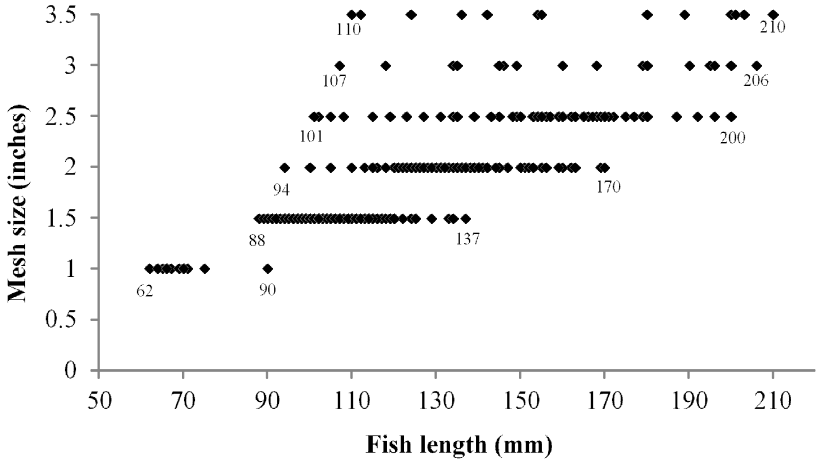
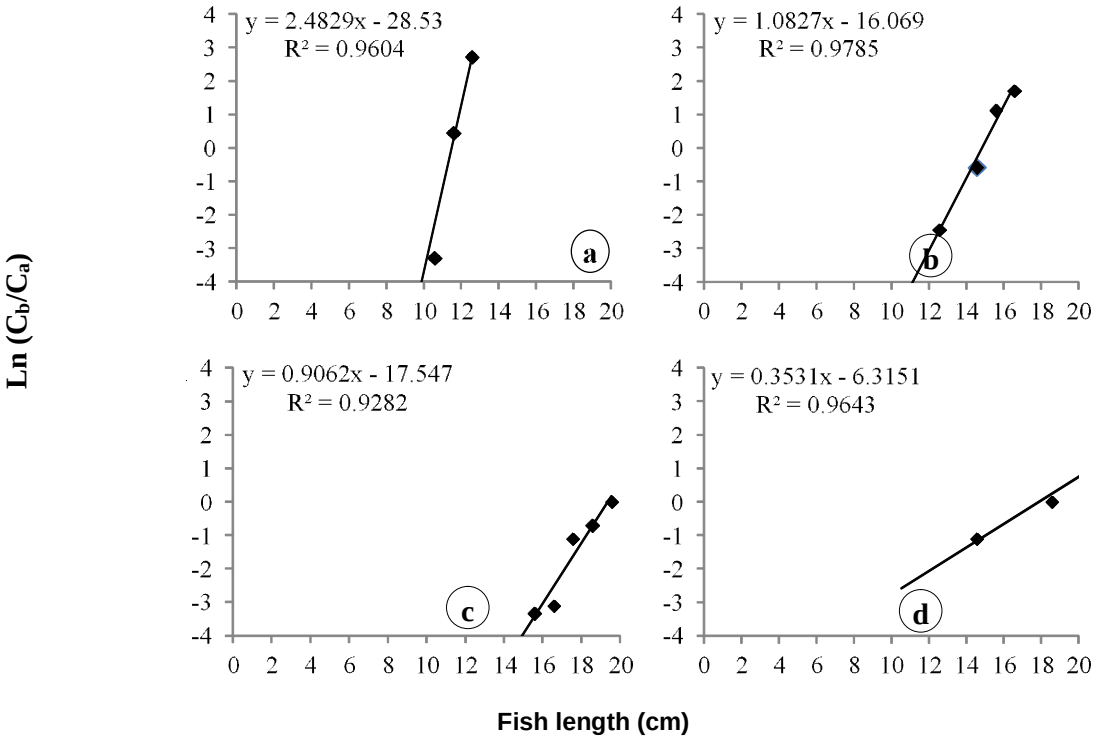


Figure 3. Length distribution of midas cichlid caught using different mesh size.



Where: a= 1.5 and 2 inches; b= 2 and 2.5 inches; c= 2.5 and 3 inches; and d= 3 and 3.5 inches

Figure 4. Natural logarithm plot of each length class for different mesh sizes.

The counted joint combination selectivity factor and standard deviation then used to estimate the optimum length for each mesh size of the gillnet. The optimum total length of fish that are able to be caught in gillnet with mesh sizes of 3.81 5.08; 6.35; 7.62 and 8.89 cm are 9.7; 12.9; 16.2; 19.4 and 22.6 cm respectively (Figure 5).

Based on the Spearman-Karber analysis, it could be determined that the mean length of the first maturity for midas cichlid is 133.18 mm (13.3 cm) with length in the range of 125.04 – 141.85 mm (Table 1). All fish caught in gillnet with mesh size of 1 inches are not mature yet, similar condition happened to most of the fish caught using gillnet with mesh sizes of 1.5 and 2 inches, while only a small portion of fish caught using 2.5; 3; and 3.5 inches mesh size are immature (refer to Figure 3).

Table 1. Midas Cichlid first time maturity length Calculation Based on Spearman-Karber Method

Midlength (mm)	Log Midlength (x_i)	Number of fish (n_i)	Mature (r_i)	Proportion of mature fish (p_i)	$X = X_{i+1}-X_i$	$q_i=1-p_i$	$(p_i x q_i)/(n_i-1)$
85	1.9294	4	0	0	0.0483	1	0
95	1.9777	142	0	0	0.0435	1	0
105	2.0212	155	0	0	0.0395	1	0
115	2.0607	64	4	0.0625	0.0362	0.9375	0.0009
125	2.0969	51	25	0.4902	0.0334	0.5098	0.0050
135	2.1303	59	24	0.4068	0.0310	0.5932	0.0042
145	2.1614	29	11	0.3793	0.0290	0.6207	0.0084
155	2.1903	40	23	0.5750	0.0272	0.4250	0.0063
165	2.2175	27	15	0.5556	0.0256	0.4444	0.0095
175	2.2430	13	11	0.8462	0.0241	0.1538	0.0108
185	2.2672	4	2	0.5000	0.0229	0.5000	0.0833
195	2.2900	7	6	0.8571	0.0217	0.1429	0.0204
205	**2.3118**	4	4	**1**		0	0
Total		**599**	**125**	**5.6726**			**0.1488**

m = 2.3118 + (0.0362/2) – (0.0362 x 5.6726) = 2.1244
Length at first maturity = antilog (m) = **133.18 mm**
Range limit = antilog $\left(2.1244 \pm 1.96 \times \sqrt{0.0362^2 \times 0.1488}\right)$ = 141.85 mm - 125.04 mm

Discussion

There were a total of 19 species of fish caught during the experiment in Ir. H. Djuanda Reservoir totalling in 1.035 fishes. Most of them were midas cichlid. Based on similar study done by Tampubolon *et al.* (2014) at the same location, native fish species population is very low, such as *Puntius binotatus* and *Hemibagrus nemurus* totalling just 1 individual during the whole experiment, others being *Hampala macrolepidota*, *Mystus nigriceps*, *Barbonymus balleroides*, *Ompok bimaculatus*, and with 12, 2, 25, and 2 individuals respectively.

The presence of midas cichlid in Ir. H. Djuanda Reservoir is widely deemed as one of species to pressurize the fish community in the reservoir (Hedianto & Purnamaningtyas, 2011). Their aggressive nature, through time, resulted in their dominance in the reservoir, and considered as a threat to the local fish species as they would provide fierce food competition (Tampubolon *et al.*, 2014) and are known to be highly territorial (Oldfield, 2011). Hedianto & Purnamaningtyas (2011) stated that the fish population in 2010 reached 307 individuals out of 1,081 fish that were collected in Ir. H. Djuanda Reservoir. Although already listed as an invasive species in several nations such as Australia (Kennard *et al.*, 2005; Ng *et al.*, 2010) and Singapore (Yeo, 2010; Elmer *et al.*, 2010), further studies regarding efforts to control midas cichlid population remains lacking. Many studies on midas cichlid usually circulate on their phylogenetic traits and biological evolution (Hulsey *et al.*, 2010; Barlow, 1976).

Gillnet is recognized as a selective type of fishing gear (Spare & Venema, 1999). What makes it selective is that smaller mesh size does not always necessarily means more fish can be caught. The reason behind this is because the catch depends strictly on the fish size. Based on the result of catch by gillnet of different mesh sizes, it could be inferred that most midas cichlid were able to be caught by gillnet with 1,5 inches mesh size. It was suspected due to a large population of fish from that particular range of size (<134 mm) were considered as juvenile from the length at first maturity (Table 1). Whereas the usual sustainable fishery is an effort to manage the fish with using selective gears with the purpose of giving young fishes to mature and spawn at least once (Palo, 2009; Acarli *et al.*, 2013; Yuksel *et al.*, 2014). Controlling invasive species is more of an effort to eradicate them, with using highly selective gears with the purpose of halting the reproduction cycle, therefore curbing the

population down. Suggested size used for this effort is, therefore, using 1.5 inches mesh size gillnet in a timely manner. Other mesh sizes cannot be considered since they were not able to catch the juvenile fish of midas cichlid and this mesh size was considered the most effective as they were able to catch the most number of fish.

The first length when midas cichlid first reached maturity is also studied to further effectively control the population. Controlling effort could be made more efficient if the fish can be caught before being mature. It will completely hinder the probability of recruitment of this alien species. Based on the result of the research, midas cichlid in Ir. H. Djuanda Reservoir could be caught before they reach 13.3 cm in order to control their population. According to Tampubolon *et al.* (2015), the fish tend to reach maturity every month. However, the peak (when mature fish was found most abundant) occurred between December-January. Based on this finding, suggested effort could be conducted before and during that time of the year. A further study then need to be carried out to see the outcome of the controlling effort.

Due to the reservoir condition which does not only consist of midas cichlid alone, it is feared that the controlling effort could also has an impact to the other local fishes. Therefore it is important to conduct the effort with considering other fishes ecobiological traits, by this it means that the place and time of setting the net is suggested not to take place when other fishes are on their spawning period. The other factor that has to be taken into consideration is the mesh size used, which is considerably below the standard permitted size (2 inches) issued by the local government. The action can only be conducted under the strict watch of the authority. In the worst case, to keep the other fishes community intact, small fishes other than midas cichlid will be released again into the wild, giving them the chance to grow and reproduce.

CONCLUSION

The optimum mesh size of monofilament gillnet for controlling midas cichlid population in Ir. H. Djuanda Reservoir is 1.5 inches. This size is deemed fit to be used to mitigate the increasing number of midas cichlid population in the reservoir through its capability to catch juvenile stage which hopefully will prevent them from reproducing,

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