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GILLNET SELECTIVITY TO HAMPALA BARB FISH *HAMPALA MACROLEPIDOTA* KUHL AND VAN HASSELT, 1823 IN LAKE KERINCI, JAMBI

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ABSTRACT

The use of suitable mesh size in the gill net fishery is important as it creates a possibility of protecting the fish, which has not reached the minimum legal or commercial length. For this reason, study on the gill net selectivity of mesh size of Hampala barb catch in Lake Kerinci was carried out from April to October 2013. The length data of fish samples were obtained from fishermen using various mesh sizes gill nets of 1.0 to 4.5 inches. Gillnet selectivity was analysed based on estimation of optimum length (Lm) and selection factor (SF) conducted by using two gillnets with different mesh size (Mi and Mi+1). The results reveal that selection factor value (SF) was 10.75 and a standard deviation value (S) was 3.29. The optimum length of fish in each mesh size of 1.0 inches, 1.5 inches, 1.75 inches, 2.0 inches, 2.5 inches, 3.0 inches, 3.5 inches, 4.0 inches and 4.5 inches were: 10.75 cm, 16.13 cm, 18.81 cm, 21.5 cm, 26.88 cm, 32.25 cm, 37.63 cm, 43.0 cm and 48.38 cm respectively. Based on the selection factor value, it was found that gill nets with a mesh size of 2.0-2.5 inches was efficient gill nets to fish the Hampala barb in Lake Kerinci. For fisheries management of Hampala barb (Hampala macrolepidota) in Lake Kerinci, the utilization of gill nets with mesh sizes less than 2.0 inches should be limited.

INTRODUCTION

Gill net is fishing gear that belong environmentally friendly (Tamarol *et al*., 2012; Tawari, 2013). This fishing gear is generally rectangular in shape where the top edge rope has a float, while the bottom edge rope has a ballast. Nets are installed in the form of a set of nets with different mesh sizes (Sparre *et al*., 1989). Nets are included the type of passive fishing gear (Anonymous, 1986). The nets are operated vertically by means of blocking the course of the fish in accordance with the size of fish schools in the depth of the swimming layer of the fish that swim into the targets (Nomura, 1985). Theoretically, fast-moving fish, have a greater chance of getting caught than slow moving fish. Big fish move faster than small fish of the same species. Regier and Robson (1996) and Helser *et al*. (1991) state that the chances of a particular species of fish to be caught and the number who were caught when dealing with the construction of certain fishing gear determine the selectivity of fishing gear to the species. Selectivity is an important tool for effective management of fisheries. It is defined as the ability to target and capture fish by species, size or sex or a combination of these during harvesting operation, allowing all incidental by-catch to be released unharmed. By regulating the minimum mesh size of a fishing fleet, the minimum landing size of the target species can be determined. Gill net selectivity is influenced by several factors; mesh size, visibility of net material, stretchability of meshes, net construction, method of fishing, shape of the fish and pattern of behaviour of the fish are other factors determining gill net selectivity (Naesje *et al*., 2004). Out of six factors, mesh size is the important factor from the standpoint of conservation of population (Naesje *et al*., 2004). Studies on the selectivity of gill nets is usually described by the curve, any mesh size of one another shows how the possibilities of each mesh to catch fish in accordance with the size of the fish caught (Hansen *et al*., 1997). Gulland (1976) states that the proportion of fish retained is a maximum at the optimum size, and will decrease for larger fish or smaller than before and after the optimum value. Assuming each net has same power at capturing optimum, so that the data of the catches of each net can be used to obtain the value of the relative efficiency of the two different mesh that is to the size of certain fish, the relative efficiency of the different sizes of the fish caught is called the the selectivity of fishing gear. Selectivity curves for all the nets that are used have the same shape and amplitude (Pauly, 1984). Hampala barb (*Hampala macrolepidota*) is an economically important fish and contribute significantly to the

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income of fishermen of Lake Kerinci (Samuel and Suryati , 2014). The body length of Hampala barb caught by gill nets in Lake Kerinci are dominated by small-size fish that has not been suitable for consumption. Therefore, it needs to be a study of the gill net selectivity so that these fish population in Lake Kerinci be sustainable (Samuel *et al*., 2013).

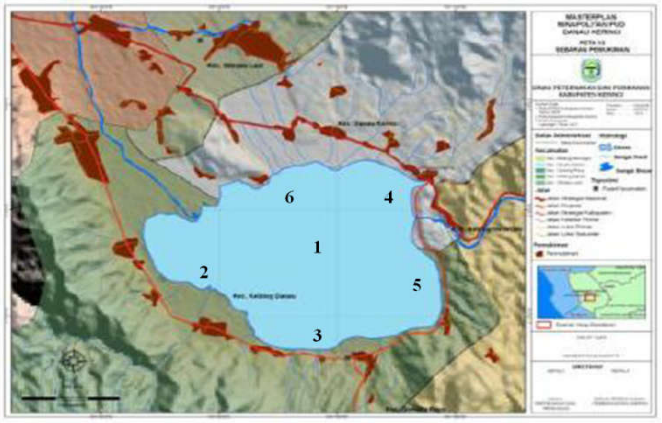
MATERIALS AND METHODS

In the general theory for the selectivity of gill nets, Jones, (1984) illustrates that the method of determining the net selectivity curve based on the assumption that the same curve shape of each net. According to Garrod (1991), theory of the gillnet fishing gear selectivity is based on the assumption that fish growth is isometric length so that the selection of fish caught with mesh sizes given are expected to be normally distributed. When two units of gill nets are installed simultaneously then the logarithm of the ratio of catches by groups of fish are caught of two units of the net will have a linear relationship, namely: 1). two gill nets differ only very slightly in mesh size that has a wide selective range overlapping. 2). standard deviation of the curve selection is the same for both units nets (Sparre and Venema, 1992). Both of selection curve will intersect and if the series of units of gill nets are operated simultaneously, the graph of the length of fish caught against mesh size will be linear. This problem will be the same as using more than two mesh sizes. Theory of gill net selectivity of two mesh sizes is used as an intermediate stage in calculating the selection factor (SF) and standard deviation (S). In this case, the shape of the normal distribution is highly dependent on the above two parameters (SF and S).

Catch data of Hampala barbs were collected from local fishermen using various mesh sizes gillnet and from gill nets experimental fishing in Lake Kerinci from April to October 2013. For gill nets experimental fishing, they were made of monofilament nylon materials with length of 100 meters and depth of 2 meters. Various mesh sizes of nets used were; 1.0 ; 1.5 ; 1.75 ; 2.0 ; 2.5 ; 3.0 ; 3.5 ; 4.0 and 4.5 inches respectively. The gillnets were set in several places such as 1) the middle part of the lake, 2) the inlet areas, 3) near the rice field areas, 4) the outlet areas, 5) near the protected forest, and 6) near the human settlement (Figure 1). Total length of the fish collected varied from 10 cm for the smaller to 43 cm for the bigger one, with 17 classes with the class interval of 2 cm. (Table 1). Gillnet selectivity was analysed based on Holt's formula (Sparre *et al*., 1989). Estimation on optimum length (Lm) and selection factor (SF) were conducted by using two gillnets with different mesh size (M_i and M_{i+1}). The two mesh sizes must be such that their selection gives overlap (Pauly, 1984; Poulsen *et al*., 2000). This method assume that the optimum length (the top of the bell-shaped selection curve) is proportional to the mesh size, and the two selection curves have the same standard deviation. From nine gillnets mesh sizes applied, there are eight consecutive pairs of nets. The steps to calculate the parameters of gillnet selectivity follow the way proposed by Sparre and Venema (1992) as follows:

- Determine for each consecutive pair of mesh size M_{i+1}/M_i, here: M_B/M_A, M_C/M_B, M_D/M_C, M_E/M_D, M_F/M_E, M_G/M_F, M_H/M_G and M_I/M_H.
- Every pair of mesh size can be made the linear regression of the form of Y= a + bX, where Y= Ln (C_{i+1}/C_i) and X= midpoint of length class (L). The ratio (C_{i+1}/C_i) is called the catch ratio of mesh size (i+1) and mesh size (i). The ways of calculation refers to Steel and Torrie (1981).
- Estimate the overall selection factor by making a regression analysis through the origin of linear regression with Yi= b.Xi, where Yi= -2ai/bi for i from 1 to 8, b= the overall selection factor (SF) and Xi= M_i+M_{i+1}.

$$SF= [-2*\sum((ai/bi)*(M_i+M_{i+1}))] / \sum(M_i+M_{i+1})^2 \quad \text{..... (1)}$$



Legends

Name of Station	Coordinate Position	
1= Middle of the lake	S= 02.08.937	E= 101.29.858
2= Inlet areas	S= 02.08.073	E= 101.27.714
3= Rice field areas	S= 02.09.911	E= 101.28.308
4= Outlet areas	S= 02.07.490	E= 101.31.398
5= protected forest areas	S= 02.10.167	E= 101.31.593
6= Human settlement areas	S= 02.07.057	E= 101.30.457

Figure 1. Research locations of setting the gillnets in Lake Kerinci, Jambi

The common standard deviation (s) is estimated as the mean value of the individual estimates for each consecutive pair of mesh sizes, i.e.:

$$S= \sqrt{[\ (1/n-1)*\sum\{SF*(M_{i+1} - M_i) / b_i\}]} \quad \text{..... (2)}$$

- Determine the optimum length for each mesh size i by using equation of Lmi = SF*M_i , where Lmi=the optimum length at M_i, SF=the overall selection factor and M_i =mesh size i.
- Describe the normal distribution (selection curve) by the way of estimate the probability of capture (SL) at a given length (L) is given for each mesh i.

$$Pmi = \exp.[-(L-Lmi)^2 / 2s^2] \quad \text{……..…….. (3)}$$

RESULTS

Based on the parameters a and b in linear regression of each pair mesh size , the value of the selection factor (SF) and standard deviation (S) varied between 9.86 to 12.39 and from 2.00 to 3.84 respectively (Table 2). From 2125 Hampala barb collected, the greatest frequency number of fish caught was in the mesh size of 1.5 and 1.75 inches which are more than 18.0% (389 fish), while the smallest frequency of 4.8% (101 fish) in a 4.5 inch mesh size (Figure 2). There is a tendency that the greater mesh size gill nets applied the less Hampala barb was caught. From the overal mesh size calculation (Figure 3), the greatest frequency number of Hampala barb caught was at 19 cm mean length (9.76%), while the smallest frequency was at 11 cm mid length (1.18%). Value of the overall selection factor (SF) was 10.75 and common standard deviation (S) was 3.29.

Table 1. Length frequency data of Hampala barb (*Hampala macrolepidota*) caught by gillnets with various mesh sizes in Lake Kerinci, Jambi

No	fish length interval (cm)	ML (cm)	1	2	3	4	5	6	7	8	9	(%)
			M_A	M_B	M_C	M_D	M_E	M_F	M_G	M_H	M_I	
			1.0	1.5	1.75	2.0	2.5	3.0	3.5	4.0	4.5	
1	[10 - 12]	11	25									1.18
2	[12 - 14]	13	65	90								7.32
3	[14 - 16]	15	35	108								6.75
4	[16 - 18]	17	14	114	55							8.64
5	[18 - 20]	19	8	61	138							9.76
6	[20 - 22]	21		15	115	53						8.64
7	[22 - 24]	23			62	64						5.95
8	[24 - 26]	25			19	32	42					4.38
9	[26 - 28]	27				18	93	21				6.23
10	[28 - 30]	29				6	76	78				7.55
11	[30 - 32]	31					53	91	12			7.36
12	[32 - 34]	33					12	27	56			4.48
13	[34 - 36]	35						13	83	78		8.21
14	[36 - 38]	37							42	96		6.51
15	[38 - 40]	39							15	19	7	1.94
16	[40 - 42]	41								9	62	3.35
17	[42 - 44]	43								5	32	1.75
#	(%)		6.9	18.1	18.3	8.2	13	10.9	9.8	9.8	4.8	100

Table 2. The estimation of intercept (a) and slope (b) based on linear regression of each consecutive pair of mesh size M_{i+1}/M_i

No	Pair of Mesh Size	n	a	b	R	SF	S
1	M_B/M_A	3	-5.4608	0.4429	0.9985	9.86	3.34
2	M_C/M_B	3	-12.429	0.6914	0.9977	11.06	2.00
3	M_D/M_C	3	-7.5255	0.3240	0.9902	12.39	3.09
4	M_E/M_D	3	-13.818	0.5668	0.9928	10.84	3.09
5	M_F/M_E	4	-11.145	0.3706	0.9320	10.94	3.84
6	M_G/M_F	3	-31.823	0.9700	0.9718	10.09	2.28

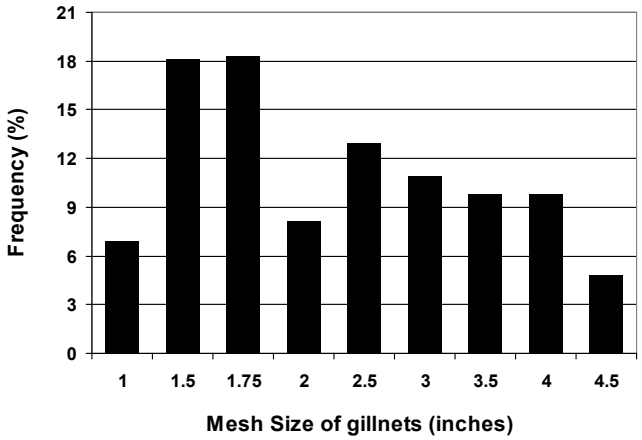


Figure 2. Number distribution of Hampala barb caught by various mesh size gill net in Lake Kerinci

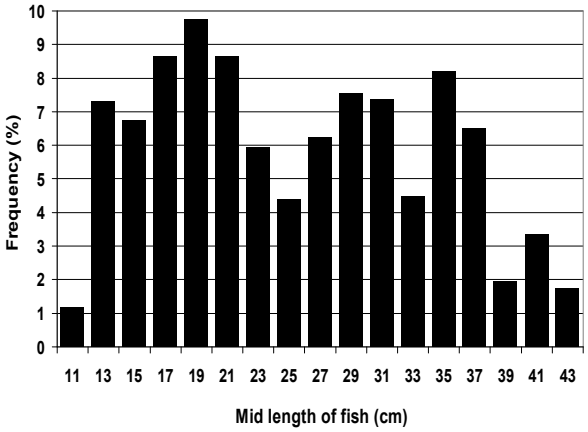


Figure 3. Length distribution of Hampala barb caught by overall mesh size of gillnets

The results of estimation by using the overall selection factor (SF) and common standard deviation (S) values, were obtained the optimum length of each mesh sizes as shown in Figure 4, were as follows: 1.0-inch mesh size of fish obtained optimum length of 10.75 cm or (1.0 inches, 10.75 cm) , the next row was (1.5 inches, 16.13 cm), (1.75 inches, 18.81 cm), (2.0 inches, 21.50 cm), (2.5 inches, 26.88 cm), (3.0 inches, 32.25 cm), (3.5 inches, 37.63 cm), (4.0 inches, 43.00 cm), and (4.5 inches, 48.38 cm). Each mesh size has the optimum size of the fish caught and it give an idea that every mesh size nets used by fishermen will be known to the highest frequency of the optimum length of the fish. In the management of Hampala barb fish resources caught by gill nets, the optimum size of the length of the fish caught can be taken into consideration in setting the use of mesh size used by fishermen.

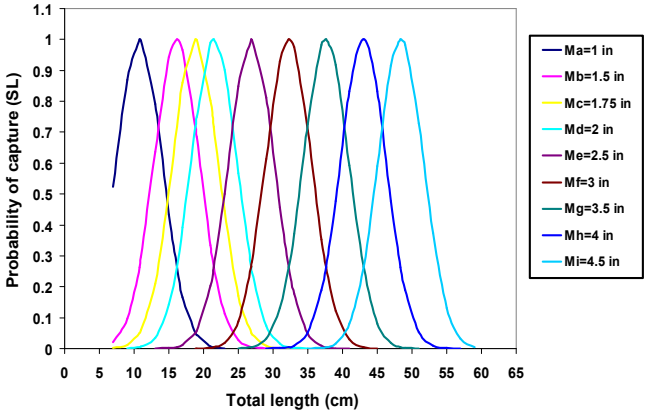


Figure 4. Probability of capture / the selection curve of gillnet on Hampala barb (*Hampala macrolepidota*) in Lake Kerinci, Jambi

DISCUSSION

A tendecy of less number of fish caugh with increasing gill net net mesh size is that relate to the population of large fish is less than the population of small fish, so the chance of the large fish caught is too small (Tamarol *et al*., 2012 and Johannes *et al*., 2011). Similar tendency is also recorded by Polo (2000) studying gill net selectivity on flying fish (*Exocoetidae*) in the Majene Waters of the Makassar Strait. The length size of Hampala barb with a median value of 19 cm of the class interval 18-20 cm up to median value of 35 cm of class interval 34-36 cm had a frequency of 62.56%. Thus it can be assumed that during the study period, the distribution of the largest stocks of hampala fish in Lake Kerinci had a total length of between 18-36 cm with a different median value of length for each mesh size. The overall selection factor (SF) value of 9 mesh sizes of gill nets used for fishing on Lake Kerinci in this study was 10.75 and common standard deviation (S) value of 3.29, thus the optimum length of Hampala barb fish caught by mesh size 1.75 and 2.0 inches were 18.81 and 21.50 cm respectively. The length at first gonad maturity size (Lm) to Hampala barb fish in Lake Kerinci is 19.38 cm (Samuel *et al.*, 2013) while Zakaria *et al*. (2000) recorded it was at 16,0 cm.

Referring to the statement of the FAO (1995) and Karlsen and Bjarnason (1987) on the principle of responsible fisheries application, then one character is to make sure that the fish resources in the waters can be exploited in a sustainable manner and this can be implemented by giving the opportunity to the gonado maturity size of the certain fish for spawning so that adding the new fish seeds for the survival of the fish populations (Brown, 1977; Matsuoka, 1995). Related to this research, mesh size of gill nets measured less than 2.0 inches should be limited in fishing the Hampala barbs in Lake Kerinci because many fish (especially Hampala) has had mature gonad size was first caught with mesh below 2.0 inches. Hampala barb (*Hampala macrolepidota*) is a fish that inhabit inland waters such as rivers and lakes scattered in Java, Sumatra and Kalimantan (Kottelat *et al*., 1993). In the waters of Kerinci Lake, This fish is quite dominant and a mainstay for the fishermen to improve their income (Samuel *et al*., 2013). The length size of Hampala barb caught by many fishermen ranged from 22.5 to 27.5 cm (30.6%) and the mesh sizes widely used for fishing is between 2.0 to 2.5 inches. This means that the nets with mesh size between 2.0-2.5 inches is the most efficient nets to catch this fish in Lake Kerinci. Based on the information and according to the fishermen and also local regulations, the use of gill nets with sizes of above 2.0 inches was permitted.

Conclusion

Catches of Hampala barb by nine mesh size gill nets in Lake Kerinci generated the overall selection factor (SF) value of 10.75 and common standard deviation (S) value of 3.29. The length size of Hampala barb caught by many fishermen ranged from 22.5 to 27.5 cm (30.6%) and the mesh sizes widely used for fishing was between 2.0 to 2.5 inches. The nets with mesh size between 2.0-2.5 inches was the most efficient nets to catch Hampala barb. To overcome the decreasing population of this fish, gill net fishing with mesh size of less than 2.0 inches should be limited.

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