POPULATION DYNAMICS OF THREE SPECIES OF CYPRINIDS IN KEDUNGOMBO RESERVOIR, CENTRAL JAVA

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Abstract

A study the growth, mortality, exploitation rate and recruitment of three species of cyprinids (*Puntius gonionotus, P. bramoides* and *Mystacoleucus marginatus*) was carried out in Kedungombo reservoir, Central Java. Monthly gillnet sampling in six sub-fishing areas of the reservoir was conducted for a 12 month period. Von Bertalanffy growth parameters, mortality, exploitation rate and recruitment were examined applying the ELEFAN programme for length-frequency data. Length-weight relationships of the three species indicated that *P. gonionotus* and *P. bramoides* grew isometrically, while *M.marginatus* grew allometrically. Von Bertalanffy growth parameters, $L\infty$ and K of *P.gonionotus, P. bramoides* and *M. marginatus* stocks were 41.90 cm and 0.54 yr^{-1}; 31.24 cm and 0.86 yr^{-1}; and 19.40 cm and 1.13 yr^{-1}, respectively. Based on the values of mortality, the exploitation rates of the three stocks were below optimum levels. Recruitment pattern of the three populations indicated two pulses of recruitment per year. These recruitment patterns related to the duration of the spawning activity over a year.

KEYWORDS: Population parameters, *Puntius gonionotus, Puntius bramoides, Mystacoleucus marginatus*, reservoir

Introduction

The initiation of reservoirs in Indonesia is usually followed by accelerated development of fisheries in those water bodies. Capture fishing is the dominant activity in most of the reservoirs because it is easy to operate and relatively low in cost. However, the exploitation of the fish resources in reservoirs is generally not based on knowledge of the fish stock, sharp reduction of the catch per unit effort may occur. Very little is known about the population dynamics of the constituent species of these fisheries, although knowledge of the fish stocks is important to plan and implement effective management of the stocks. Moreover, studies on growth, mortality, recruitment, exploitation rate and other related factors of Indonesian freshwater fish populations are rare. Preliminary studies on growth, mortality and exploitation rate of *Hampala macrolepidota* and *Puntius gonionotus* stocks in Jatiluhur Reservoir, West Java have been conducted by Kartamihardja (1988a) and Kartamihardja (1988b), respectively. A similar study was conducted in Ranau Lake, South Sumatra for *Oreochromis mossambicus* (Utomo *et al.* 1990). All studies were based on length frequency data.

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Construction of Kedungombo Dam has resulted in the development of fisheries, though, data on the fisheries of the reservoir were limited. Until recently, there was no study on the fish population dynamics in the reservoir. Several studies conducted in the reservoir were limited to limnological aspects, observation and identification of fish species.

At present, several methods for studying the dynamics of fish stocks in tropical waters are available e.g. Pauly (1982; 1983a; 1984a; 1984b; and 1987); Pauly and Murphy (1982) and Sparre *et al.* (1989).

The present study was conducted to estimate growth, mortality, recruitment and exploitation rate of three dominant cyprinid fish species, i.e. *Puntius gonionotus*, *P. bramoides*, and *Mystacoleucus marginatus*. The dynamics of these stocks were considered fundamental to the development and management of fisheries in the reservoir.

Materials and Methods

Sampling Procedure

Fish samples were collected using two fleets of monofilament floating gillnets. A fleet of gillnets consisted of nine pieces with different mesh sizes. Descriptions of the gillnets are summarised in Table 1.

Fish sampling was conducted systematically in six sub-fishing areas of the reservoir (Figure 1) once a month for a 12 month period. The fleet of gillnet was set prior to sunset and lifted the next morning. The number of fish caught was recorded. The total length and the weight of each fish was measured to the nearest 1 mm length and 5 g weight, respectively.

Table 1. Description of the monofilament floating gillnets.

Description	Stretched Mesh Size (cm)								
	2.5	3.8	5.1	6.4	7.6	8.9	10.2	11.4	12.7
Length of net (m)	35	35	35	35	35	35	35	35	35
Number of mesh depth	100	70	50	40	35	30	25	23	20
Area of net (m2)	62.2	63.3	62.2	62.1	65.3	65.3	62.2	64.4	62.3
Number of floats *)	36	36	36	36	36	36	36	36	36
Number of sinkers **)	71	71	71	71	71	71	71	71	71
Diameter of twine (mm)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Hanging ratio (%)	40	40	40	40	40	40	40	40	40

*) Polyprophylene float
**) Lead sinker with a weight of 25 g

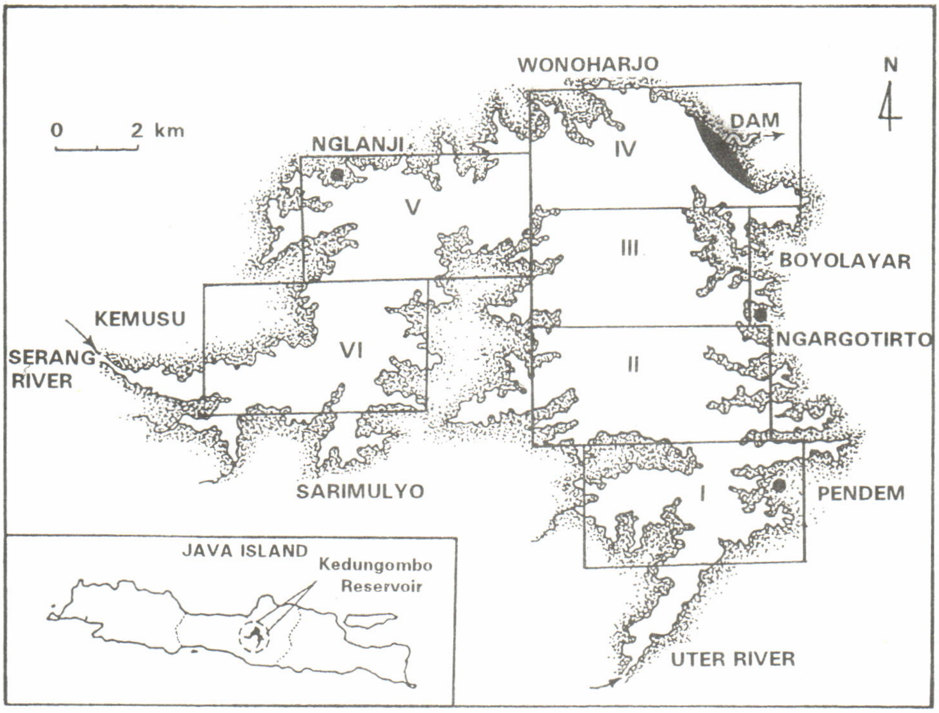

Figure 1. Map of Kedungombo Reservoir showing the six sub fishing areas

Length-Weight Relationship and Condition Factor

The length-weight relationships were analysed for each species using the formula:

$$W = a\ L^b$$

where W is fish weight in g, L is total length in cm, a and b are constants. In analysing this relationship the computer programme of FISHFARM of FSAS system (Saila *et al.* 1988) was used.

The condition factor which indicated the condition of fish was calculated using Fulton's condition factor (Ricker 1987) according to the formula:

$$K_n = \frac{W}{L^3} x\ 100$$

where K_n is condition factor; W is weight in g of fish; L is length of fish in cm.

Estimation of Growth Parameters

The von Bertalanffy Growth Formula (VBGF) was used to compute the growth in term of length.

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

where L_t = predicted length at age t; $L\infty$ = asymptotic length; K = growth constant; t_0 = age of fish at length zero

The von Bertalanffy growth parameter $L\infty$ was first estimated by using a modification of the Wetherall Plot of ELEFAN II. The length frequency data of each species were summed and applied to estimate $L\infty$ and Z/K. The value $L\infty$, was used to estimate the von Bertalanffy growth parameters using ELEFAN I (Pauly and David. 1981) as a part of the Compleat ELEFAN package (Gayanilo *et al.* 1988). In order to avoid bias from gear selectivity, length-frequency data used for the ELEFAN I estimates of growth parameters were corrected. For this purpose a length-converted catch curve was applied and an estimated M (derived from Pauly's equation; Pauly, 1980b) was adopted. The estimated probability values were then applied to the original length-frequency data and the corrected data were run in the search routine of the ELEFAN I programme. The estimates of growth parameters from uncorrected data were compared to those of corrected data.

Estimation of Mortality and Exploitation Rate

Total mortality (Z) of the fish stock was estimated using ELEFAN II (Gayanilo *et al.* 1988). The estimated Z was derived from a length-converted catch curve as described by Pauly (1980a; 1982; 1983a; 1983b; 1984b; 1984c and 1984d).

The estimation of natural mortality (M) of the fish stock was calculated using Pauly's equation (Pauly 1980b):

$$\log M = 0.0066 - 0.279 \log L\infty + 0.6543 \log K + 0.4634 \log T$$

where T is the mean environmental temperature in 29°C for the stock. Following the estimations of M (natural mortality), and the fishing mortality (F) was calculated by subtracting Z using the equation, F = Z - M.

After obtaining the F value, the exploitation rate (E) was calculated from equation E = F/Z. With the assumption that the optimum value of F in a given exploited stock (F_{opt}) is about equal to M, the optimum exploitation (E_{opt}) is expected to be equal to 0.5 (Gulland 1971).

Recruitment Pattern

Recruitment patterns were obtained by projecting the length-frequency data on the time axis using the estimated values of the growth parameters (Pauly, 1982) using the ELEFAN II programme. Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) were estimated from the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986).

Results and Discussion

Length-Weight Relationship and Condition Factor

Table 2 shows the length-weight relationships of the three fish species. The t-test showed that the value of b for *M.marginatus* differed significantly from that for the other two species ($p<0.01$). It means that *P. gonionotus* and *P.bramoides* grew isometrically, while *M.marginatus* grew allometrically. A similar relationships were found in *P. gonionotus* and *P. bramoides* populations in Jatiluhur Reservoir (Hardjamulia *et al.* 1988).

Table 2. Length-weight relationships of the three fish species from Kedung-ombo Reservoir.

Fish species	N	a	b	r
P. gonionotus	289	0.008227	3.184	0.994
P. bramoides	269	0.011927	3.009	0.938
M. marginatus	235	0.006197	3.256*	0.926

N : number of fish samples; a : intercept; b : slope;
r : coefficient of correlation; * : significantly different from 3

Since *P. gonionotus* and *P. bramoides* grew isometrically, the condition factor of the species were equal to value of a, an intercept of the regression. These values were 0.82% and 1.19%, respectively. The relative condition factor (K_n) was then calculated for *M. marginatus*. The mean value of K_n for *M.marginatus* was 0.62%.

Growth Parameters

Monthly length-frequency data of *P.gonionotus*, *P.bramoides* and *M.marginatus* are presented (Tables 3, 4 and 5). Figure 2 shows the estimate of L∞ and Z/K of the three fish stocks using the Wetherall Plot method of ELEFAN II.

Table 3. Length-frequency distribution of *P. gonionotus* caught with experimental gillnets in Kedungombo Reservoir.

Lm (cm)	S	O	N	D	J	F	M	A	M	J	J	A
	1991				1992							
10.5	-	3	1	-	-	-	2	1	1	-	-	-
11.5	-	4	2	-	1	1	2	3	2	1	-	-
12.5	-	2	1	-	1	2	3	5	3	2	-	2
13.5	-	2	2	1	2	2	5	7	4	4	2	3
14.5	-	1	3	1	3	3	11	9	5	5	3	3
15.5	-	2	4	1	4	5	14	8	9	7	6	4
16.5	-	2	3	2	6	9	16	6	7	8	11	7
17.5	2	2	3	4	12	10	17	6	4	10	10	10
18.5	6	4	6	10	13	12	18	4	7	7	3	11
19.5	9	5	9	16	16	11	21	5	7	7	2	9
20.5	7	13	13	20	18	9	20	6	6	4	5	8
21.5	4	7	14	25	20	11	19	7	5	3	7	5
22.5	3	6	10	17	16	17	12	13	4	5	5	4
23.5	2	5	9	15	12	6	10	14	6	8	9	3
25.5	3	5	10	12	10	3	7	16	7	9	9	6
24.5	4	7	7	11	9	2	5	11	11	10	10	6
26.5	5	6	6	9	6	2	2	8	9	11	13	11
27.5	6	7	4	7	5	1	1	6	4	10	10	9
28.5	9	8	3	7	4	2	1	5	2	7	9	7
29.5	3	11	2	8	3	3	1	2	2	3	5	5
30.5	2	5	1	10	2	3	1	3	2	2	2	2
31.5	1	4	-	5	1	1	2	3	3	37	2	2
32.5	2	3	-	3	1	-	1	2	4	5	4	4
33.5	2	4	-	2	1	-	1	1	3	4	5	3
34.5	2	5	-	1	-	-	1	1	2	3	3	2
35.5	1	5	-	-	-	-	-	1	1	2	2	1
36.5	1	3	-	-	-	-	-	1	1	1	1	2
37.5	-	2	-	-	-	-	-	-	1	1	1	1
38.5	-	1	-	-	-	-	-	-	-	1	2	2
39.5	-	1	-	-	-	-	-	-	-	-	1	-
Total	74	135	113	187	166	115	203	154	122	150	142	132

The resultant curve and the values of the probability of capture corresponding to each length for each species are shown in Figure 3. Adjusted length frequency data according to probability of capture were run in ELEFAN I as corrected data.

Table 4. Length-frequency distribution of *P. bramoides* caught with experimental gillnets in Kedungombo Reservoir.

Lm (cm)	S	O	N	D	J	F	M	A	M	J	J	A
	1991				1992							
6.5	-	-	-	-	-	-	-	-	4	1	-	-
7.5	-	-	-	-	-	-	-	-	10	3	-	-
8.5	-	-	-	-	-	-	-	1	37	9	2	-
9.5	-	1	-	-	-	-	-	3	17	21	9	-
10.5	1	5	-	-	-	-	4	5	8	14	10	3
11.5	3	3	2	2	-	-	9	6	14	9	27	9
12.5	2	7	5	3	3	-	8	13	17	16	20	7
13.5	4	5	5	9	4	3	4	11	11	12	16	21
14.5	27	7	8	13	12	3	8	6	11	6	15	17
15.5	13	17	16	23	13	6	5	5	13	4	5	15
16.5	11	15	13	11	21	7	19	9	7	4	5	9
17.5	9	16	9	7	13	6	20	11	4	3	5	9
18.5	10	12	17	11	15	13	23	9	6	3	9	3
19.5	8	9	15	13	5	5	10	13	8	7	5	7
20.5	7	7	9	19	7	3	10	21	9	9	4	6
21.5	3	11	6	7	7	3	5	11	6	5	2	8
22.5	3	13	5	3	8	4	7	5	10	3	7	8
23.5	1	23	3	3	6	6	2	7	7	2	3	6
24.5	-	17	4	2	4	7	3	11	3	1	1	4
25.5	-	11	4	1	2	3	4	5	4	1	-	2
26.5	-	4	2	1	3	4	3	3	5	2	-	2
27.5	-	3	-	-	2	3	2	2	2	3	-	3
28.5	-	2	-	-	2	3	2	3	1	1	-	2
29.5	-	-	-	-	-	-	3	1	-	-	-	-
Total	102	188	123	128	127	79	151	161	214	139	145	141

Table 6 shows the estimated values of growth parameters L∞ and K using uncorrected and corrected version of the length-frequency data. The fitting of the growth curve for each species at estimated values of L∞ and K derived from the corrected data are shown in Figure 4.

Growth parameters of L∞ and K for the three fish stocks estimated from uncorrected data were similar to those obtained from the corrected version of length-frequency data. Length-frequency were not caused by gear selectivity. A typical curve of gillnet selectivity is bell shaped (Holt 1963; Lagler 1968; and

Table 5. Length-frequency distribution of *M. marginatus* caught with experimental gillnets in Kedungombo Reservoir.

Lm (cm)	S	O	N	D	J	F	M	A	M	J	J	A
	1991				1992							
6.5	-	-	-	18	2	-	-	9	11	-	-	-
7.5	-	-	-	15	5	1	-	17	13	1	-	2
8.5	-	2	3	10	7	2	1	8	7	3	1	8
9.5	-	7	11	12	15	8	7	8	5	4	3	9
10.5	-	5	7	7	6	11	19	9	5	9	5	10
11.5	1	6	6	2	9	5	16	20	8	20	10	11
12.5	5	14	12	1	19	4	14	36	12	36	23	15
13.5	9	8	15	1	31	3	10	28	7	28	32	18
14.5	18	8	8	-	29	4	5	12	6	12	20	25
15.5	20	12	6	-	11	5	2	7	2	7	6	14
16.5	11	2	2	-	7	5	-	3	-	3	2	3
17.5	2	1	-	-	5	2	-	1	-	1	-	2
Total	66	65	70	66	146	50	74	114	76	114	102	117

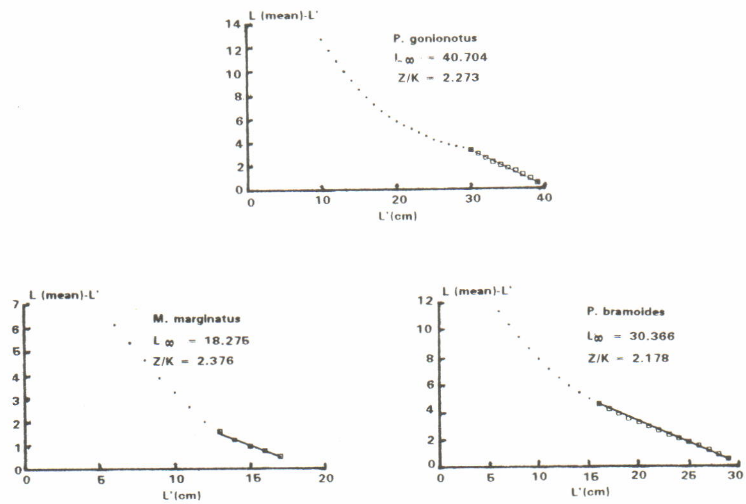

Figure 2. The modified Wetherall plot for the three fish species.

Hamley 1975). However, selectivity of a fleet of gillnets of different mesh sizes was considered similar to trawl selectivity (Sparre *et al.* 1989). In this study, therefore, probability of capture using a fleet of gillnets was assumed to be similar to the probability of capture by trawl as applied in the ELEFAN. The growth parameters obtained after correction for gear selection probably give better estimates.

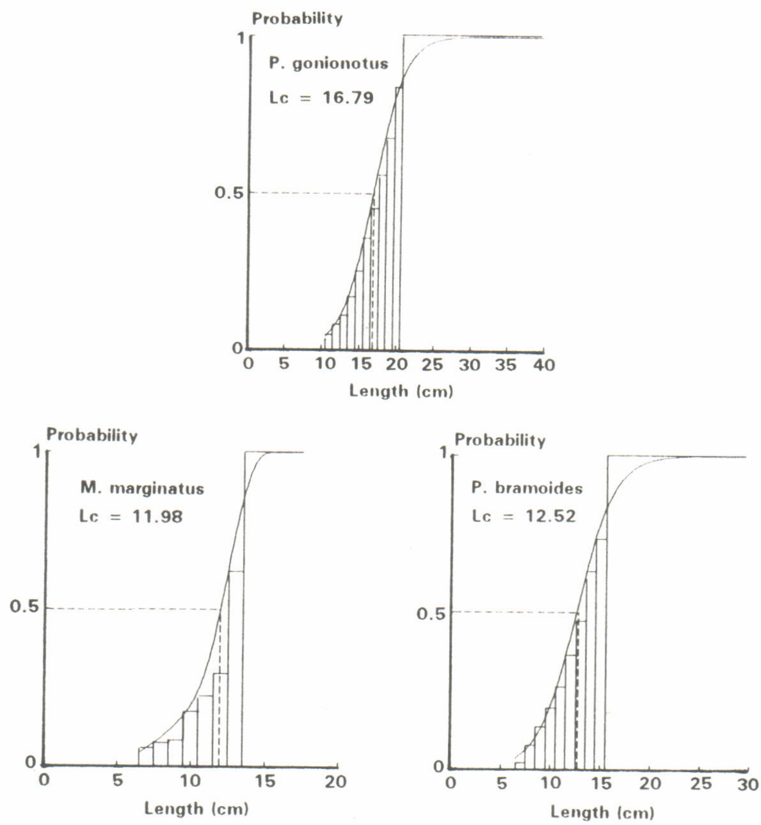

Figure 3. The resultant curve of the probability of capture for the three fish species.

There are no other complete data on growth performance of *P. gonionotus*, *P. bramoides* and *M. marginatus* populations. Therefore, to evaluate the reliability of estimated growth parameters of these populations, the growth parameters for other member of the same family, Cyprinidae, based on the relationship of $\phi' = \ln K + 0.67 \ln W\infty$ (Sparre *et al.* 1989) was used. The results are shown in Table 7.

Table 6. Estimates of growth parameters based on the Wetherall method (ELEFAN I) using uncorrected and corrected data.

Fish species	Wetherall		ELEFAN I uncorrected		ELEFAN I Corrected	
	L∞ (cm)	Z/K	L∞ (cm)	K (yr)	L∞ (cm)	K (yr)
P. gonionotus	41.48	2.9	41.33	0.50	41.90	0.54
P. bramoides	30.89	2.5	31.25	0.82	31.24	0.86
M. marginatus	18.28	2.4	19.05	1.21	19.40	1.13

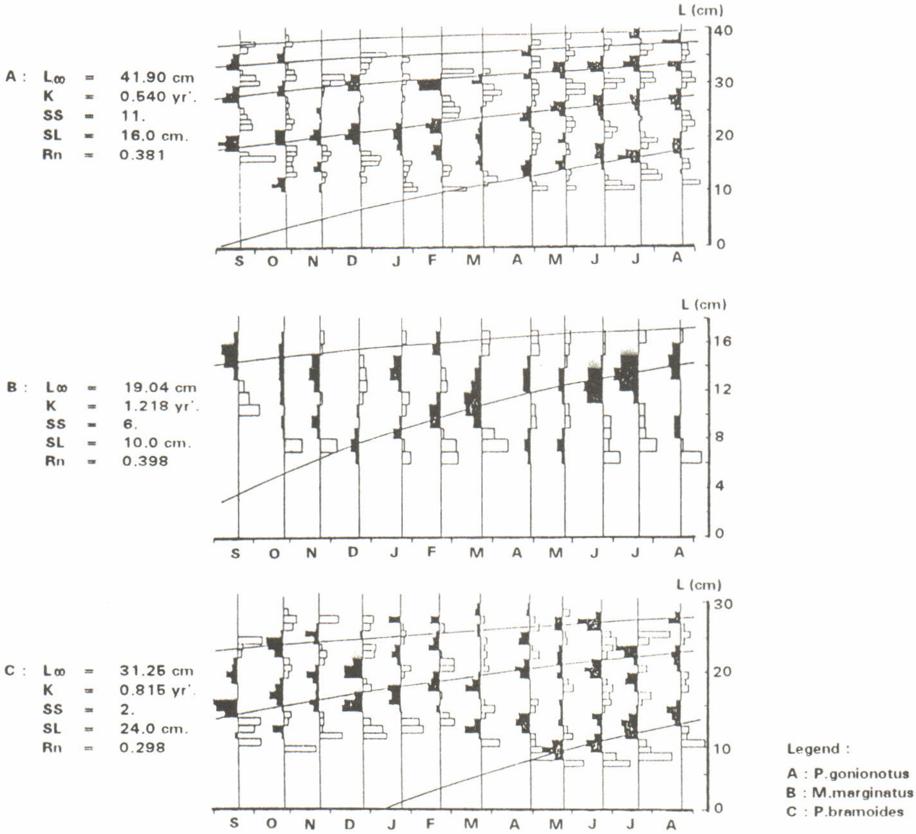

Figure 4. The growth curve of the three fish species superimposed to structure of length frequency data.

Table 7. Comparative values of overall growth performance (ϕ') for some species of Cyprinidae.

Species	W∞ (g)	K (yr)	ϕ'	Source
Osteochilus haselti	554.0	1.15	4.37	Yap (1982)
Labiobarbus festiva	578.0	1.35	4.56	Yap (1982)
Thynnichthys thynnoides	221.6	0.58	3.07	Ambak (1984)
Puntius schwanenfeldii	176.7	0.38	2.50	Ambak (1984)
Amblyrhynchichthys truncatus	289.5	0.43	2.95	Ambak (1984)
Puntius gonionotus	1203.3	0.54	4.14	This study
Puntius bramoides	363.6	0.86	3.80	This study
Mystacoleucus marginatus	96.7	1.13	3.18	This study

The calculated index of growth performances for Cyprinidae populations ranged from 2.50-4.56 with an average of 3.49±0.82. The growth performances of *P. gonionotus*, *P. bramoides* and *M. marginatus* in this study ranged from 3.18-4.14. These values are very close to the ϕ' values from the early studies.

Mortality and Exploitation Rate

Assuming the exploitation rate was optimum at a value of E = 0.5, the exploitation of all the stocks was below the optimum level. Mortality estimates (Figure 5) of the three fish populations suggested that the exploitation rates of the stocks are low, especially that for *P. bramoides* (Table 8).

Table 8. The estimates of mortality and exploitation rate of the three fish stocks in Kedungombo Reservoir

Fish species	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	E=F/Z
P. gonionotus	1.51	1.10	0.41	0.27
P. bramoides	1.95	1.57	0.38	0.19
M. marginatus	3.78	2.33	1.45	0.38

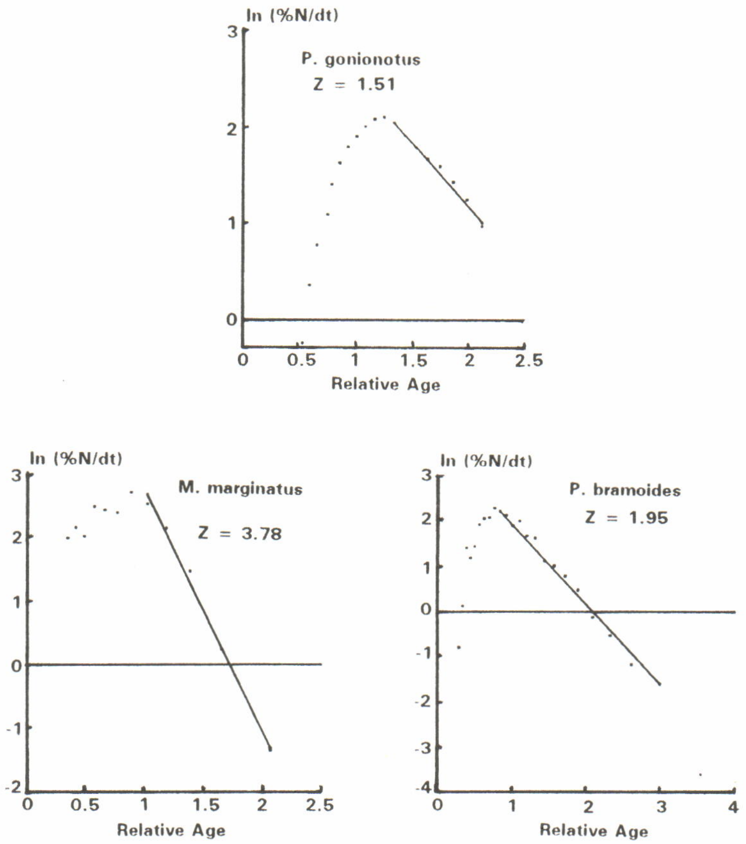

Figure 5. Length converted catch curve of the three fish species.

Recruitment Patterns

Recruitment patterns of all three of the fish stocks showed two pulses of recruitment (Figure 6), though, the two pulses of recruitment are most visible in the data for *M. marginatus*. The recruitment patterns were related to spawning activity (Pauly 1982). Using the final value of $L\infty$ and K together with the probabilities of capture obtained from the selection curve, relative yield per recruit and biomass per recruit were computed as shown in Figure 7. Relative yield and biomass per recruit of the populations showed that the maximum exploitation rates were found to be in the range of 0.52-0.55, while the present exploitation rates of the fish stocks ranged from 0.19-0.38.

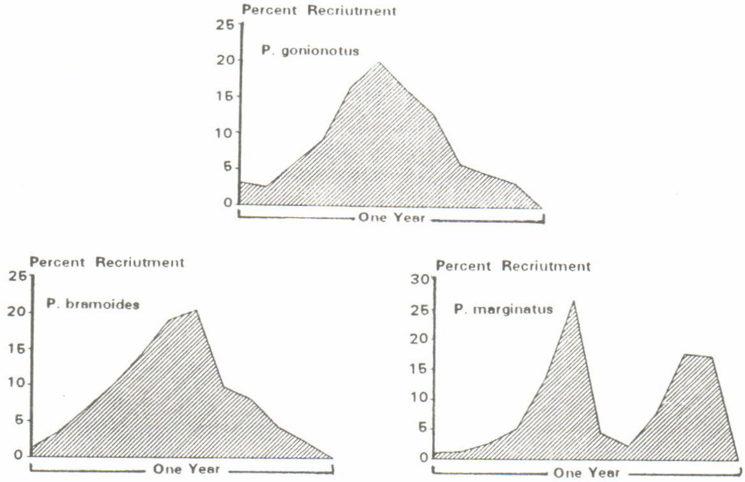

Figure 6. Recruitment pattern of the three fish species.

Kedungombo Reservoir is a new reservoir. During the first few years of impoundment, fish production of the reservoir would be expected to increase from a low level exploitation. The exploitation rate will be expected to increase gradually in the future.

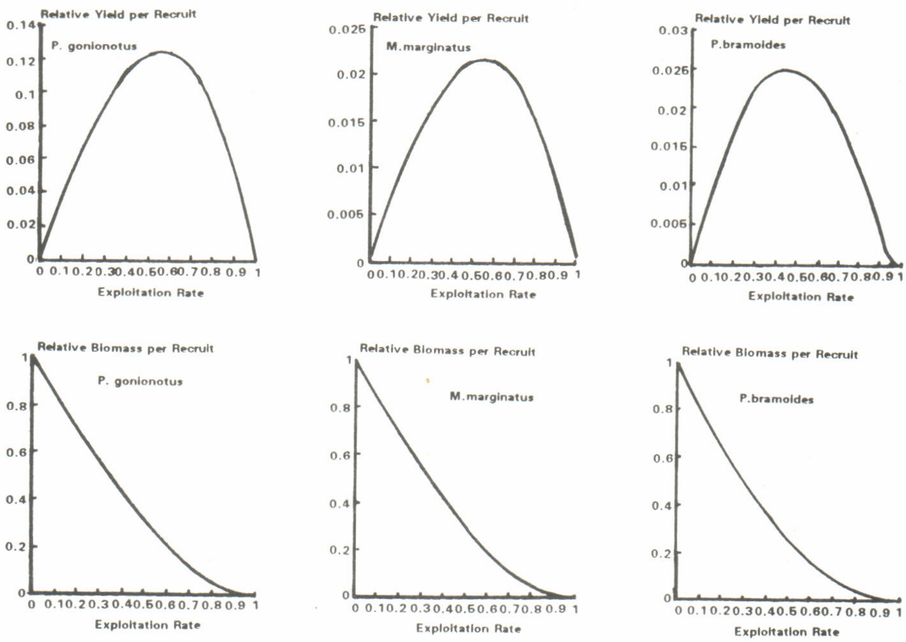

Figure 7. Relative yield and biomass per recruit in the three fish stocks.

Conclusion

In order to develop sustainable capture fisheries in the Kedungombo Reservoir, an effective management system should be established. This should include management of habitat, fish population, regulation of fisheries, and social, economical and institutional aspects.

The current level of fishing intensity is at a low level, although the *M.marginatus* stock is more heavy exploited. However, fishes in the reservoir are extremely vulnerable to capture by modern gillnets, a plans for the regulation of both fishing effort and mesh size should be developed.

In order to avoid conflict among the users in the reservoir, zoning of the reservoir is necessary. Zoning of the reservoir should include provision for capture fisheries, aquaculture, fisheries conservation, and tourism.

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