Asian Fisheries Science **21**(2008):147-158
https://doi.org/10.33997/j.afs.2008.21.2.002

Asian Fisheries Society, Manila, Philippines

Population Parameters of Important Species in Inland Fisheries of Bangladesh

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Abstract

The von Bertalanffy growth model parameters (L_∞ and K) and mortality coefficients (Z, M and F) were estimated for 12 fish species caught by fishers in five Community-Based Fisheries Management project sites in Bangladesh. The exploitation ratio (E=F/Z) and gear selectivity (L_{50}) were also estimated for each species. The growth and exploitation parameters obtained were compared with available estimates to evaluate the consistency of the results with current knowledge about the species in the region. The estimates for L_∞ (7.0 – 24.0 cm) and K (1.077±0.328 year^{-1}) obtained were consistent with those available in literature. Relatively high K (and low L_∞) values, typical of short-lived tropical fishes, were obtained for nine species. Estimates for Z (1.86 – 6.55) and M (1.22 - 3.06) imply low annual rates of survival and high turnover rates. The estimates for M obtained were consistent with those available in the literature for the 12 species. The exploitation rate was estimated to be between 34 and 53% and the length at first capture was estimated to be approximately 32-56% of L_∞. The study indicated that the length-at-first-capture/L_∞ seems to be a simple parameter which could be used to make a rapid assessment of the status of the stocks.

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Introduction

The vast inland waters of Bangladesh exist in the form of rivers, canals, depressions (*beels*), floodplains and reservoirs, and cover about 4.5 million hectares. Fisheries in these water bodies are a lifeline to many subsistence communities and depend to a large extent on the productivity of the system and associated physical and biological attributes (Silvius et al. 2000). The period from April-June is the peak spawning period for most inland open water fish in Bangladesh (de Graaf et al. 1994; Halls et al. 1998; Craig et al. 2004). More than 300 species of fish and prawns inhabit the wetlands of the country (Rahman 1989). Some information on the population parameters and exploitation levels of inland water fishes of Bangladesh published by de Graaf et al. (2001), Halls et al. (1999; 2000) and de Graaf (2003) indicate high exploitation levels and a relation among the extent of annual flooding, exploitation levels and growth rate. The present study was undertaken to estimate population dynamics parameters and the extent of exploitation to support decision making in the Community Based Fisheries Management project implemented by the WorldFish Center. The project, managed in partnership with the Bangladesh Department of Fisheries and 11 NGOs, has established community control over 116 water bodies. These are spread over 48 *Upazilas* (Sub-districts) in 22 of the 64 districts in Bangladesh and include closed *beels*, open *beels*, floodplains and rivers.

Study area and background

The study was conducted in five perennial water bodies within the Community Based Fisheries Management (CBFM) project (de Graaf & Mustafa 2003) (Figure 1) which is working in the inland waters of Bangladesh to manage fisheries resources in 117 water bodies involving up to 23,000 poor fisher families. The key characteristics of the water bodies and major species diversity are presented in table 1.

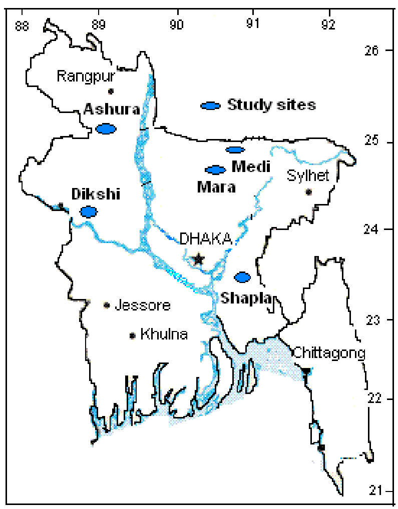

Figure 1. Waterbodies covered by the study

Table 1. Location of water body, area and major species diversity (Mustafa 2003; de Graaf & Mustafa 2003)

Water body	Location: Thana	Location: District	Area (ha): Min	Area (ha): Max	Area (ha): Ave.	Dominant species and % contribution in catch			
Ashura *beel*	Nawabganj	Dinajpur	100	400	221	*Puntius sophore*	26.4	*Chanda ranga*	6.6
						Exopalaemon styliferus	19.2	*Wallago attu*	8.9
						Mystus tengra	9.3	*Salmostoma bacaila*	5.6
						Mastacembelus armatus	6.7	*Others*	17.4
Dikshi *beel*	Chatmohor	Pabna	2	250	126	*Channa punctatus*	20.1	*Channa striatus*	5.4
						Puntius sophore	18.3	*Puntius ticto*	5.2
						Exopalaemon styliferus	18.8	*Others*	26.8
						Mastacembelus armatus	5.5		
Mara *beel*	Phulpur	Mymensingh	60	148	104	*Puntius sophore*	21.7	*Mastacembelus pancalus*	6.2
						Exopalaemon styliferus	15.4	*Glossogobius giuris*	5.3
						Macrobrachium villosimenus	15.1	*Channa punctatus*	4.2
						Chanda ranga	6.5	*Others*	25.7
Shapla *beel*	Nasirnagar	B. Baria	161	195	178	*Puntius sophore*	32.0	*Glossogobius giuris*	2.3
						Mystus tengra	7.4	*Nandus nandus*	2.0
						Mastacembelus armatus	7.1	*Anabas testudineus*	1.8
						Channa striatus	2.7	*Others*	44.8
Medi *beel*	Kalmakanda	Netrokona	18	180	83	*Puntius sophore*	6.8	*Mastacembelus pancalus*	1.5
						Macrobrachium spp	27.3	*Others*	47.7
						Mystus tengra	13.3		
						Channa punctatus	3.4		

Materials and Methods

The study was conducted from October 2002 to September 2003. Monthly length-frequency data were collected from the Ashura *beel*, Dikshi *beel*, Mara *beel*, Shapla *beel* and Medi *beel*. The lengths of major fish species in the catch of individual fishers were recorded to the nearest 0.5 cm during a 20 day period in each month. For each sample the gear type and mesh size were recorded. All length-frequency data for each month were pooled across species, gear types, mesh size and study areas.

Simultaneous catch data were collected for a duration of four to eight days per month per site every month. The daily catch of every individual fisher was considered as the catch per unit of effort (CPUE), the numbers and weights of the dominant fish species in the catch were recorded. Furthermore, the gear-type and its mesh size were recorded.

Catch and effort data analysis

Average daily catch per gear type was calculated as:

$$cpue = \frac{Catch_{s,y,i}}{Fishing\ Hours_{s,y}}$$

The total monthly catch for each water body was calculated as:

$$Monthly\ Catch\ per\ site = N * \sum_{i,j=1}^{n} \overline{f}_{i,j} * \overline{cpue}_{i,j}$$

where, N = number of days per month and F = average daily number of gears, per gear type.

The average number of gear per day was used to estimate the total number of gear-wise fishing effort for that month as well as for the whole year. Simultaneously, mean gear-wise catch rate was used to estimate the total catch for that month, as well as for the whole year.

Length-frequency data analysis

For the estimation of the growth rates, only samples from non-selective gears, such as lift net, scoop net and seines were used and aggregated in monthly periods. Population parameters were estimated using the

FAO-FISAT software (Gayanilo et al. 1997). In Bangladesh, fish growth exhibits a distinct seasonal pattern with high growth during the monsoon and low growth during winter (Halls et al. 1998; de Graaf et al. 2001; de Graaf 2003). A seasonal version of the Von Bertalanffy Growth Function (VBGF) was therefore fitted to the data which has the following form:

$$Lt = L\propto (1 - \exp(-K(t-t_0) + S_{ts}-St_0)$$

Where,

$S_{ts} = (CK/2\pi) * \sin(2\pi(t\text{-}ts));$

$S_{t0} = (CK/2\pi) * \sin(2\pi(t_0\text{-}ts));$ and,

Lt is the length at time t.

$$Lt = L\infty * \left(1 - e^{-k*(t-to)-(CK/2\pi)*[\sin 2\pi(t-ts)-\sin 2\pi(to-ts)]}\right)$$

Where:

$L\infty$ = L infinity is the asymptotic length, i.e. the mean length the fish of a given stock would reach if they were to grow indefinitely;

K = growth coefficient parameter, or the rate at which $L\infty$ is approached;

t0 = T-zero, or the "age of the fish at zero length" if it had always grown in a manner described by the equation;

Ts = the onset of the first oscillation relative to t=0; and,

C = the intensity of the (sinusoid) growth oscillations.

For this model, the winterpoint (WP) or period with the slowest growth, was set at 1 or December/January (WP=ts+0.5) as these are the months with the lowest water temperature. The instantaneous total annual mortality rate (Z) was estimated using the length converted catch curve incorporating seasonal growth (Moreau et al. 1994). The natural mortality (M) was estimated using the empirical relationship derived by Pauly (1980) where the mean annual water temperature was set at 26°C.

The exploitation ratio, E was estimated as: E = F/Z = F/(F+M). Length at first capture (L_c or L_{50}) was estimated following the method of Pauly (1984) while longevity was calculated as 3/K.

Correlation among different parameters

Correlation among the estimated values for area (ha), relative fishing effort (no. fisher•ha^{-1}•year^{-1}), catch per unit of area (kg•ha^{-1}•year^{-1}), catch per unit of effort (kg•fisher^{-1}•day^{-1}), exploitation rate (%), growth (cm), longevity (year) and Lc50/L_∞ in the different sites were determined with SPSS with a significance level of 0.05.

Results

Growth

The estimated growth parameters and longevity for the major species in Ashura, Dikshi, Mara, Medi and Shapla *beels* are given in table 2. The K values vary between 0.5 (*Mastacembelus pancalus*) and 1.7 (*Colisa fasciatus*) with mean K values equal to 1.051±0.341 year^{-1}. The longevities (year) vary between 1.8 (*C. fasciatus*) and 6.0 (*M. pancalus, Heteropneustes fossilis*) with mean longevities equal to 3.5, 2.5, 3.6, 2.9 and 3.3 in Ashura, Dikshi, Mara, Medi and Shapla *beels*, respectively. Major species in Ashura and Mara *beels* showed higher longevity than those in Dikshi, Medi and Shapla *beels*.

Table 2. Estimates of growth parameters, for 12 species in five CBFM sites during the period October 2002 to September 2003

Name of *beels*	Species	L∝ (cm)	K (year^{-1})	C	Longevity
Ashura	*Glossogobius giuris*	21.0	0.7	0.6	4.3
	Mastacembelus pancalus	23.0	0.8	0.0	3.8
	Lepidocephalus guntea	11.0	0.6	0.7	5.0
	Puntius sophore	13.5	1.6	0.8	1.9
	Channa punctatus	24.0	1.1	0.1	2.7
	Mystus tengra	16.0	0.9	1.0	3.3
Dikshi	*Mastacembelus pancalus*	23.0	1.4	0.9	2.1
	Exopalaemon styliferus	8.0	0.8	1.0	3.8
	Colisa fasciatus	12.0	1.7	0.5	1.8
	Puntius sophore	13.3	1.49	0.8	2.0
	Channa punctatus	24.0	1.2	0.2	2.5
	Mystus tengra	16.0	0.9	0.6	3.3

Table 2. Estimates of growth parameters, for 12 species in five CBFM sites during the period October 2002 to September 2003 (cont'd.)

Name of *beels*	Species	L∝ (cm)	K (year^{-1})	C	Longevity
Dikshi	*Puntius ticto*	11.0	1.4	0.8	2.1
Mara	*Glossogobius giuris*	21.0	0.8	0.7	3.8
	Mastacembelus pancalus	23.0	0.5	0.9	6.0
	Chanda ranga	7.0	0.7	0.2	4.3
	Exopalaemon styliferus	8.0	1.1	0.9	2.7
	Puntius sophore	13.5	1.0	0.4	3.0
	Channa punctatus	24.0	0.9	0.9	3.3
Shapla	*Glossogobius giuris*	21.0	0.7	0.4	4.3
	Anabas testudineus	17.1	1.4	0.5	2.1
	Colisa fasciatus	12.0	1.1	0.1	2.7
	Nandus nandus	21.0	0.7	0.2	4.3
	Puntius sophore	13.5	1.1	0.6	2.7
	Channa punctatus	24.0	1.2	1.0	2.5
Medi	*Puntius ticto*	11.0	1.5	0.5	2.0
	Mastacembelus pancalus	23.0	1.3	0.5	2.3
	Heteropneustes fossilis	25.0	0.5	0.5	6.0
	Puntius sophore	13.5	1.6	0.5	1.9
	Channa punctatus	24.0	0.9	0.5	3.3
	Mystus tengra	16.0	1.0	0.7	3.0

Exploitation and yield per recruit

The mortality and exploitation rates and lengths at first capture for the major species in the *beels* are given in table 3.

Estimates of E values varied between 0.2 (*Colisa fasciatus*) and 0.74 (*Glossogobius giuris*) with mean E values equal to 0.47±0.152.

The relative yield per recruit for the major species in the *beels* are given in figure 2. The yield per recruit analysis based on Beverton and Holt (1964) revealed that *Mastacembelus pancalus* are over exploited in Ashura, Dikshi, Mara and Medi *beels*. It was found that *Mystus tengra* and *Glossogobius giuris* were over exploited in Ashura beel. *Channa punctatus*

Table 3. Estimates of exploitation parameters for 12 species in five CBFM sites during the period October 2002 to September 2003

Name of *beels*	Species	M (Year[1])	F (Year[1])	Z (Year[1])	E	L_{50} (cm)	L_{50}/L_{∞}
Ashura	*Glossogobius giuris*	1.55	2.51	4.06	0.62	5.34	0.25
	Mastacembelus pancalus	1.65	3.10	4.75	0.65	9.75	0.42
	Lepidocephalus guntea	1.63	0.48	2.11	0.23	7.02	0.64
	Puntius sophore	2.93	3.62	6.55	0.55	7.44	0.55
	Channa punctatus	2.01	1.60	3.61	0.44	10.12	0.42
	Mystus tengra	1.98	4.31	6.29	0.69	7.80	0.49
Dikshi	*Mastacembelus pancalus*	2.32	2.86	5.18	0.55	10.24	0.45
	Exopalaemon styliferus	2.22	1.97	4.19	0.47	2.77	0.35
	Colisa fasciatus	3.25	1.42	4.67	0.30	6.27	0.52
	Puntius sophore	2.81	2.91	5.72	0.51	7.65	0.58
	Channa punctatus	2.13	2.95	5.08	0.58	12.46	0.52
	Mystus tengra	1.98	4.45	6.43	0.69	7.69	0.48
	Puntius ticto	2.85	2.59	5.44	0.48	2.40	0.22
Mara	*Mastacembelus pancalus*	1.70	4.71	6.41	0.74	5.65	0.27
	Exopalaemon styliferus	1.18	3.25	4.43	0.73	9.76	0.42
	Colisa fasciatus	2.11	2.45	4.56	0.54	1.79	0.26
	Puntius sophore	2.73	1.58	4.31	0.37	3.86	0.48
	Channa punctatus	2.16	0.97	3.13	0.31	6.18	0.46
	Mystus tengra	1.76	1.21	2.97	0.41	11.53	0.48
Shapla	*Glossogobius giuris*	1.55	1.81	3.36	0.54	10.91	0.52
	Anabas testudineus	2.52	1.27	3.79	0.34	11.57	0.68
	Colisa fasciatus	2.44	0.61	3.05	0.20	7.35	0.61
	Nandus nandus	1.55	1.10	2.65	0.41	12.86	0.61
	Puntius sophore	2.36	0.64	3.05	0.23	6.38	0.47
	Channa punctatus	2.13	1.40	3.53	0.40	14.80	0.62
	Puntius ticto	2.98	1.17	4.15	0.28	5.83	0.53
Medi	*Mastacembelus pancalus*	2.27	3.81	6.08	0.63	8.43	0.37
	Heteropneustes fossilis	1.15	0.80	1.95	0.41	12.28	0.49
	Puntius sophore	3.02	3.21	6.23	0.52	5.65	0.42
	Channa punctatus	1.76	1.40	3.1	0.45	11.08	0.46
	Mystus tengra	2.12	1.14	3.26	0.35	3.04	0.19

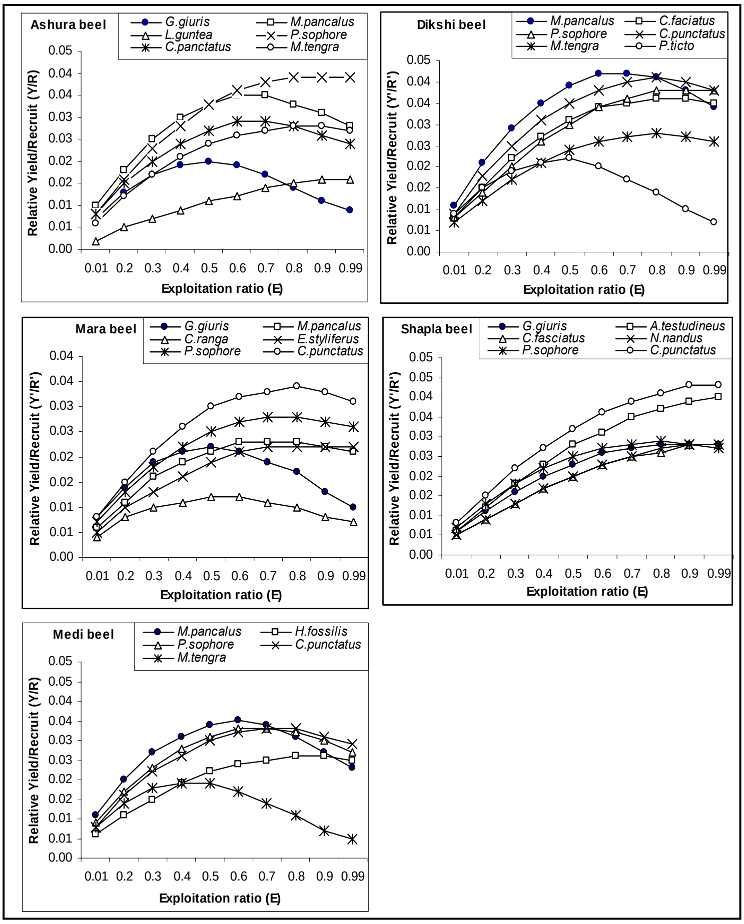

Figure 2. Estimation of relative yield per recruit for the major species in Ashura *beel*, Dikshi

and *Mystus tengra* were over exploited in Dikshi *beel*. *Exoplalemon styliferus* and *Colisa fasciatus* were overexploited in Mara *beel*.

The correlation among the different parameters estimated at five sampled sites (Table 4) indicates that only the value of Lc_{50}/L_{∞} is significantly related to the exploitation rate, whereby increased exploitation rate reduced the ratio, i.e. smaller fish were caught.

However, in this analysis values of mixed species (CPUA and CPUE) are used. Looking at the individual species then only CPUA and Lc_{50}/L-infinity are significantly related to *Channa punctatus* (Figure 3).

Table 4. Correlation between the different parameters estimated at the five sampled sites

	Area	Relative fishing effort	Exploitation rate	CPUA	CPUE	Phi	Longevity	Lc_{50}/L_{∞}
Area	NS*	NS	NS	NS	NS	NS	NS	NS
Relative fishing effort	NS	NS	NS	NS	NS	NS	NS	NS
Exploitation rate	NS	NS	NS	NS	NS	NS	NS	-0.809
CPUA	NS	NS	NS	NS	0.896	NS	NS	NS
CPUE	NS	NS	NS	0.896	NS	NS	NS	NS
Longevity	NS	NS	NS	NS	NS	NS	NS	NS
Lc_{50}/L_{∞}	NS	NS	NS	NS	NS	NS	NS	NS

* Not significant

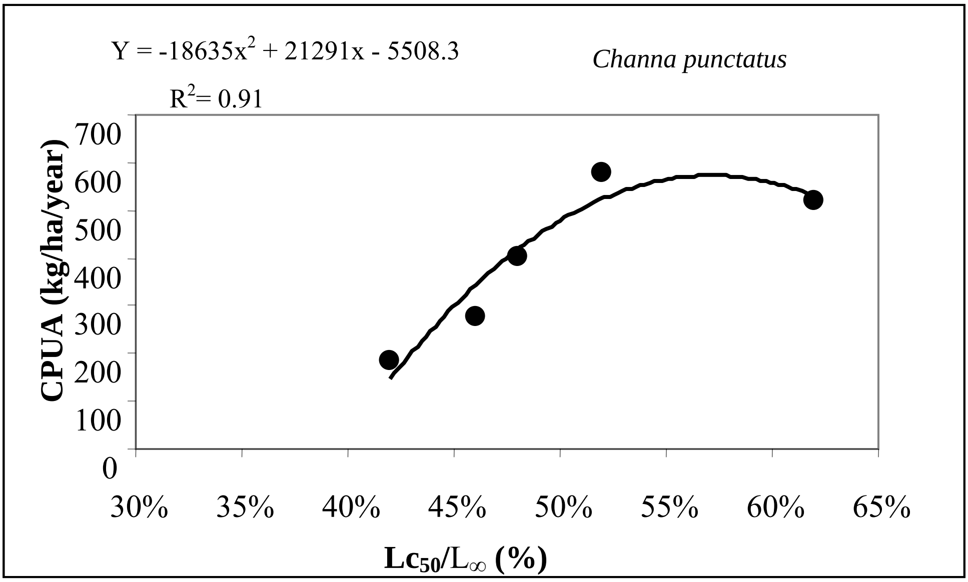

Figure 3. Correlation between CPUA and Lc_{50}/L_{∞} for *Channa punctatus*

Discussion

The specific objectives of this study were to determine the population parameters and assess the exploitation level of the water bodies managed by the fisher communities. The growth rate (K) estimates are consistent with those reported by Halls et al. (1999; 2000) and de Graaf (2003) for a similar ecosystem in Bangladesh, and Froese & Pauly (2000). The exploitation rate obtained for the 12 species out of the five waterbodies are relatively lower compared to other available studies of same species. A previous long term study conducted by de Graaf et al. (2001) and de Graaf (2003) for *Puntius sophore* showed the mean exploitation rate to be 0.75 in Tangail district, Bangladesh. The study indicated that it was not easy to compare the multi-species multi-gear fisheries with standard fish stock assessment method so the best option would be to convince all stakeholders that we reached the limit and that no new gears can enter the fishery. However, the correlation among the different parameters estimated at the five sampled sites indicate that Lc_{50}/L_∞ is significantly related to the exploitation rate and the ratio of Lc_{50}/L_∞ could be used to monitor the health of fish stock by the fisher's communities.

Acknowledgements

The authors acknowledge Alan Brooks, Malcolm Dickson, Janssen Johannes, Neil Andrew and Ashley Halls for their valuable suggestions and helpful comments on the manuscript. This work was funded by the UK Department for International Development (DFID). The project is implemented by the WorldFish Center. The views expressed are not necessarily those of DFID.

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Received: 30 July 2006; Accepted: 24 June 2007