



Population dynamics of an endemic and threatened Yellow Catfish *Horabagrus brachysoma* (Günther) from Periyar River, southern Western Ghats, India

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Abstract: Based on the annual length frequency data collected from three major fish landing centres along the River Periyar, draining the southern Western Ghats, the von Bertalanffy growth function (VBGF) estimates of *Horobagrus brachysoma* were worked out as asymptotic length (L_{∞}) = 422mm total length, growth co-efficient (K) = 0.55 yr⁻¹ and growth performance index (ϕ) = 4.99. The total mortality rate (Z) was estimated at 5.64 yr⁻¹, natural mortality rate (M) at 1.04 yr⁻¹, fishing mortality (F) at 4.60 yr⁻¹, and exploitation rate (E) at 0.82 yr⁻¹. Yield per recruit (expected lifetime yield per fish recruited in the stock at a specific age) analysis showed an excessive fishing effort. Using the analysis of probability of capture of each length class, the length at first capture (L_c) of *H. brachysoma* was estimated to be 110mm. An indication of both growth and recruitment fishing is provided by the dominance of year 1 class in the exploited population and the capture of immature individuals below first maturity. Management of *H. brachysoma* fishing should include setting of a minimum mesh size limit of 160–180 mm for gill nets as well as a closed season starting from the month of May till August aimed at protecting the spawning stock. This study on *H. brachysoma*, an endemic and threatened catfish of peninsular India, provides hard evidence that species targeted by artisanal fishermen, in small-scale tropical riverine fisheries, are vulnerable to overexploitation.

Keywords: Artisanal fishery, *Horabagrus brachysoma*, overfishing, small-scale fishery, threatened species

Date of publication (online): 26 February 2012

Date of publication (print): 26 February 2012

ISSN 0974-7907 (online) | 0974-7893 (print)

Editor: Anonymity requested

Manuscript details:

Ms # o2590

Received 29 September 2010

Final received 03 January 2012

Finally accepted 30 January 2012

Citation: Prasad, G., A. Ali, M. Harikrishnan & R. Raghavan (2012). Population dynamics of an endemic and threatened Yellow Catfish *Horabagrus brachysoma* (Günther) from Periyar River, southern Western Ghats, India. *Journal of Threatened Taxa* 4(2): 2333–2342.

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INTRODUCTION

Small scale freshwater fisheries contribute an important source of food security and livelihood to billions of rural communities in the tropics. However, lack of fundamental data on such fisheries has led to failures in management aimed at preventing overexploitation, population decline, and their impact on local livelihoods. Meanwhile, overfishing has currently become an important driver of biodiversity loss in inland waters (Allan et al. 2005) and decline in population of many species are occurring concomitantly with the increase in global inland fish production. In Asia, the world's largest inland fish producing region, wild caught freshwater fisheries have been showing signs of overexploitation with declines in catch per unit effort, age at maturity and also the average size of fishes caught (Dudgeon 2000). In spite of being small-scale and artisanal in nature, the fishery of several important freshwater fish including mahseer (Bhatt et al. 2000, 2004; Raghavan et al. 2011) and catfish (Patra et al. 2005) in India; major carps (de Graaf 2003) in Bangladesh; large cyprinids in the Mekong basin (Baird 2006; Dudgeon 2000) and sturgeons in China (Wei et al. 1997) have shown a characteristic decline in the last decade.

Exhaustive information is currently available on the demography, population regulation and exploitation patterns of large numbers of marine fish species. However, unlike marine ecosystems, datasets on the

dynamics of exploited populations of economically important fish species in rivers, especially those in the developing countries are largely unavailable. This is mainly due to the lack of personnel and financial resources in such countries to undertake research programs (Maccord et al. 2007). These deficiencies are also a cause and consequence of the lack of attention that the sector receives from the government (Anonymous 2002).

As with other small rivers in Asia, Periyar—a 244-km long river in the southern Indian state of Kerala—supports a lucrative inland fishery, largely based on cyprinids and catfish. This fishery, mainly concentrated in the lower stretches of the river is predominantly artisanal. The Yellow Catfish *Horabagrus brachysoma* is one such species which is targeted frequently by the traditional fishermen of Periyar River using gill nets (odakku vala; Malayalam) operated from canoes and also by using hooks and lines. Known locally as ‘manjakoori’, the Yellow Catfish grows to a size of 450mm (Talwar & Jhingaran 1991) and is a gourmet’s delight. Fingerlings of *H. brachysoma*, due to their vibrant yellow coloration are also becoming increasingly popular in the international aquarium pet trade (Raghavan 2006). A multitude of stressors including overexploitation, habitat alteration and pollution has, however, resulted in the population decline of *H. brachysoma* in its native ranges, with the fish getting listed as Vulnerable in the IUCN Red List of Threatened Species (Raghavan & Ali 2011). The peculiar life history traits of the species, including a medium resilience to overfishing and a minimum population doubling time of 1.4 to 4.4 years (Froese & Pauly 2009) also makes this species vulnerable to the overfishing. In spite of its threatened status, declining numbers and specific life history traits, exploitation of *H. brachysoma* for both the food and ornamental markets continues unabated (Ali et al. 2007).

In Vembanad Lake, which is an extensive system of backwaters (and a Ramsar wetland) into which Periyar and five other river systems drain, *H. brachysoma* is the focus of organized artisanal gill net fishery (Raghavan 2006). Landings of the Yellow Catfish in Vembanad Lake have shown a wavy trend from 1995 until 2004, having increased and decreased every few years (Kurup et al. 1995; Bindu 2006; Sreeraj et al. 2007). Despite early reports of the serious population declines of *H. brachysoma* and co-occurring catfish

species in the Vembanad Lake (Kurup et al. 1993), no effort hitherto has been made to assess the dynamics of these exploited stocks from either the lake, or from other water bodies of the state. This paper is the first comprehensive study on the population dynamics of this species.

MATERIALS AND METHODS

Study site

River Periyar has a total catchment area of 5243km² and a length of about 300km (Smakhtin et al. 2009). For a small-sized basin, Periyar nevertheless harbours a number of endemic and threatened species (Molur & Walker 1998; Kurup et al. 2006) which is approximately 70% of the fish species present in the Western Ghats Hotspot (Smakhtin et al. 2009). The present study was concentrated on the lower stretches of the Periyar River between 76°10’–76°23’N & 10°98’–10°73’E (Fig. 1) where *H. brachysoma* is known to be fished intensively.

Data collection

The total length (mm) and weight (g) data of *H. brachysoma* subsamples were measured from well-mixed catches of six to 10 fishermen, operating from three major fish landing centres, namely, Kalady (76°19’N & 10°10’E), Angadikadavu (76°23’N & 10°73’E) and Manjaly (76°10’N & 10°98’E), located in the lower stretches of Periyar River, from January to December 2005. Since males and females were easily distinguishable, they were identified by their big, soft and distended belly with swollen and reddish-pink vent (females) and reddish genital opening (males). Measures of 2638 males and 3382 females were taken for the study. No fish were collected or sacrificed for the purpose of the study. Sampling was carried out twice in each month during the first quarter moon and full moon. Data was collected following the methodology of Gulland & Rosenberg (1992) on the length based approaches to fish stock analyses published by the Food and Agricultural Organization (FAO). During each sampling day, random sub samples of fish were obtained from well mixed catches. The total length of fish was measured to the nearest centimetre. A minimum of 200 fish were measured on each sampling day except on occasions when the catches were low.

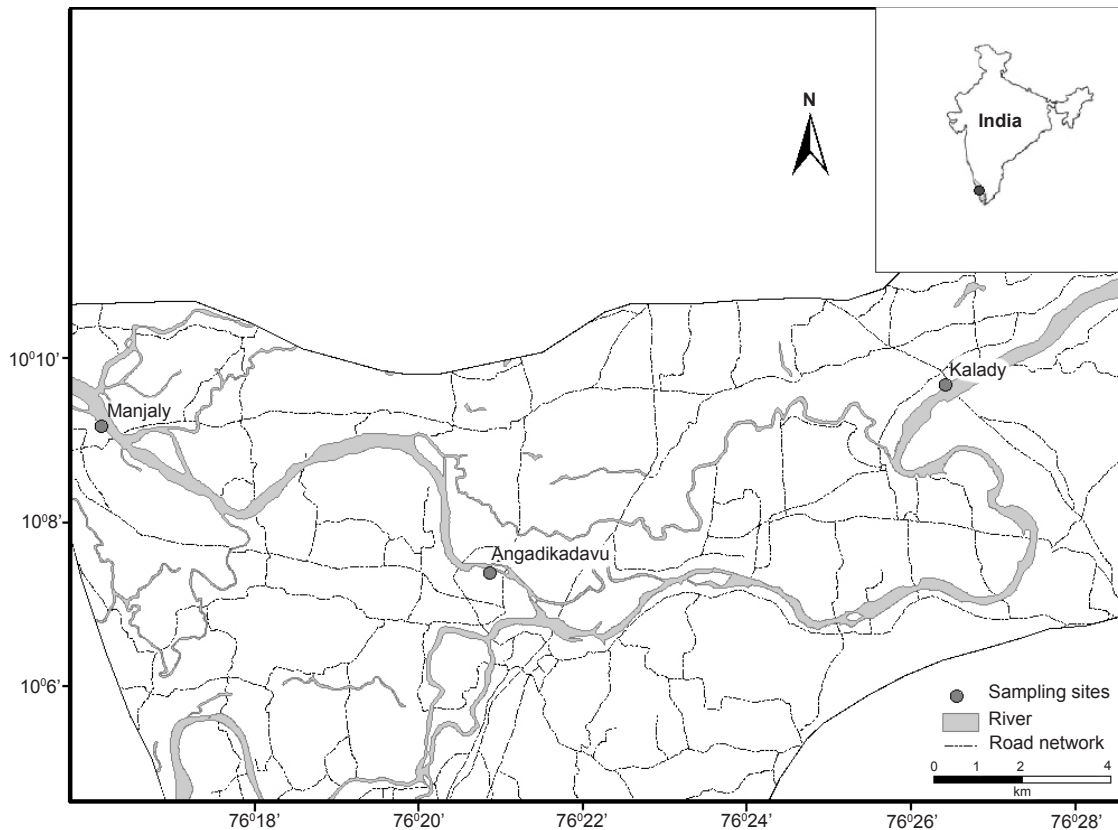


Figure 1. Map showing landing centres

Data obtained from the two sampling days in each month were later pooled and recognized as a 'monthly sample' (mean 219.83 ± 18.60 males and 281.83 ± 26.95 females) by simple addition following Ama-Abasi et al. (2004). This was done to avoid any bias in the data, as in some months there was a variation in the sample size obtained on the two different days.

Data analysis

Parameters a and b in the length-weight relationship equation $W = aL^b$ were estimated by least square regression after logarithmic transformation. Age and growth were estimated based on length-frequency data. It was assumed that the *H. brachysoma* growth conformed to the von Bertalanffy growth (VBG) model (von Bertalanffy 1938): $L_t = L_\infty (1 - \exp[-K(t - t_0)])$ where L_∞ is the asymptotic length (mm), K the growth constant (month^{-1}) and t_0 time (months), when the theoretical length is zero. Growth parameters were obtained using the ELEFAN program (Pauly 1987) from the fitted curve with maximum goodness-of-fit (R_n) index. The growth performance index (f) was computed according to Moreau et al. (1986) as $\phi = \text{Log}$

$K + 2 \log L_a$. Mortality coefficients, viz., total mortality (Z), instantaneous natural mortality (M), fishing mortality (F) and exploitation rate (E) were estimated using FiSAT program (Pauly 1980; Gayanilo & Pauly 1997). Natural mortality was calculated using the empirical formula of Pauly (1980): $\ln M = 0.0152 - 0.2791 \ln L_a + 0.65431 \ln K + 0.4631 \ln T$. The exploitation rate was estimated using the formula $E = F / Z$ (Gulland 1971). Although, we estimated the length-weight relationship as well as age for both males and females separately, the growth and mortality parameters were done only for the pooled populations. This was done so as to minimize any bias because of the difference in number of males and females obtained which may have influenced the results.

The probability of capture was estimated from the left ascending arm of length-converted catch curve. The right descending part of the catch curve was extrapolated backwards, such that the fish that ought to have been caught, had it not been for the effect of incomplete selection or recruitment, were added to those in the curve, with the ratio of expected numbers to those that were actually caught being used to

estimate probabilities of capture. This method provides reasonable estimates of mean size at first capture (L_c) (Hoydal et al. 1982; Jensen 1982). By plotting the cumulative probability of capture against mid-length, a resultant curve was obtained. From this curve the length at first capture L_c was taken as corresponding to the cumulative probability at 50%. The entire length-frequency data was used to reconstruct the seasonal recruitment pattern of the fish by projecting backward all the restructured length-frequency data onto a 1-year time scale (Pauly 1987), along a trajectory defined by the computed VBG function. Then, using the maximum likelihood approach, the Gaussian distribution was fitted to the back-projected data through NORMSEP (normal separation) procedure (Hasselbald 1966).

The relative yield-per-recruit model of Beverton & Holt (1957, 1966) as modified by Pauly & Soriano (1986) and incorporated in the FiSAT program, was used to estimate the 'relative yield-per-recruit' (Y/R) and 'relative biomass-per-recruit', assuming a selection ogive. The computed exploitation rate was compared with the expected values of E_{max} (the value of exploitation rate giving maximum relative yield-per-recruit), $E_{0.1}$ (the value of E at which marginal increase in Y/R is 10% of its value at $E = 0$) and $E_{0.5}$ (the value of E at 50% of the unexploited relative biomass-per-recruit) (Sparre & Venema 1992; Gayanilo & Pauly 1997). The potential longevity of *H. brachysoma* was also calculated (Pauly & Munro 1984): $T_{max} = 3/K$.

The yield isopleths diagram was used to assess the impact on yield created by changes of exploitation rate E and the ratio of length at first capture to asymptotic length (L_c/L_∞) in relation to changes in mesh size. The optimum exploitation length (L_{opt}) was estimated from the empirical equation of Froese & Binholan (2000).

RESULTS

Length-Weight Relationship

The length-weight relationship (LWR) of *H. brachysoma* males from the Periyar River was $W = 0.0093 L^{3.072}$ ($n = 51$, $r = 0.96$, $p < 0.01$) and those for females was $W = 0.0079 L^{3.172}$ ($n = 61$, $r = 0.98$, $p < 0.01$). LWR of combined sexes was found to be $W = 0.0084 L^{3.105}$ ($n = 112$, $r = 0.972$, $p < 0.01$). In all cases, the exponent of length-weight relationship b was higher

than 3 (males 3.072; females 3.127 and pooled 3.105) and the 95% higher and lower confidence interval values were also above 3 indicating that the growth of *H. brachysoma* in river Periyar was isometric.

Exploited stock

The exploited population of *H. brachysoma* in Periyar during 2005 was constituted by individuals ranging from 112 to 340 mm. The highest length class recorded among males was 280–300 mm while the same in female populations was 320–340 mm. The fishery was dominated by individuals in the size range of 170 to 250 mm in both males and females. The size classes 200–220 mm and 240–260 mm (both 19% each) constituted the largest share in males whereas in females it was the 240–260 mm size class (21%) followed by 220–240 mm (17%) size class. Sex ratio was 1:1.3 which was not significantly different from 1:1 ($p > 0.05$).

Growth

The growth parameters estimated in the male population of *H. brachysoma* from Periyar River are given in Table 1. The value of t_0 as estimated by the empirical equation given by Pauly (1979) was found to be -0.0108. The FiSAT output of restructured length frequency data of male population of *H. brachysoma* in river Periyar with superimposed growth curve fitted with highest levels of R_n is given in Fig. 2. The VBGF for male *H. brachysoma* based on the growth parameters in the present study was expressed as: $L_t = 388 [1 - \exp^{-0.51(t+0.0108)}]$. The lengths attained by male *H. brachysoma* following VBGF equation at the end of first, second, third and fourth years were estimated to be 156mm, 249mm, 304mm and 338mm respectively.

For the female population (Table 1), the value of t_0 was found to be -0.0103. The FiSAT output of restructured length frequency data of female population of *H. brachysoma* in Periyar River with superimposed growth curve fitted with highest levels of R_n is given in Fig. 3. The value of t_0 as estimated by empirical equation given by Pauly (1979) plot was found to be -0.0103. The VBGF arrived at, based on the growth parameters in terms of female *H. brachysoma*, can be expressed as $L_t = 400 [1 - \exp^{-0.63(t+0.0103)}]$. The lengths attained by female *H. brachysoma* following VBGF equation at the end of first, second, third and fourth

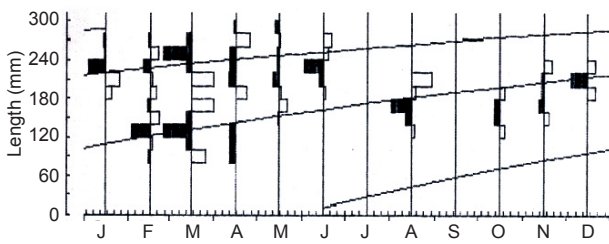


Figure 2. Growth curve of male population of *Horabagrus brachysoma* from River Periyar by ELEFAN 1 superimposed on the restructured length frequency diagram ($L_{\infty} = 388\text{mm}$, $K = 0.51\text{ yr}^{-1}$ and $R_n = 0.325$)

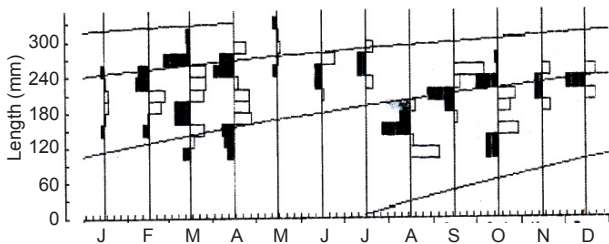


Figure 3. Growth curve of female population of *Horabagrus brachysoma* from River Periyar by ELEFAN 1 superimposed on the restructured length frequency diagram ($L_{\infty} = 400\text{mm}$, $K = 0.63\text{ yr}^{-1}$ and $R_n = 0.314$)

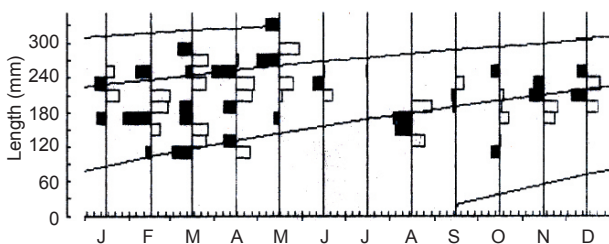


Figure 4. Growth curve of pooled population of *Horabagrus brachysoma* from River Periyar by ELEFAN 1 superimposed on the restructured length frequency diagram ($L_{\infty} = 422\text{mm}$, $K = 0.55\text{ yr}^{-1}$ and $R_n = 0.255$)

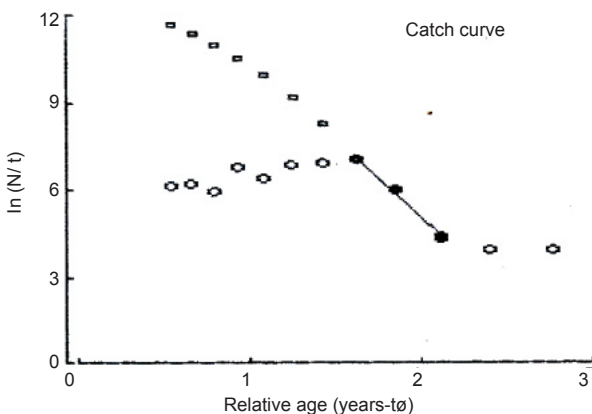


Figure 5. Length converted catch curve of pooled population of *Horabagrus brachysoma* in River Periyar (Z from catch curve = 5.64; $M = 1.04$; $F = 4.60$; $E (F/Z) = 0.82$)

Table 1. Growth parameters in male, female and pooled population of *H. brachysoma* of Periyar River

	L_{∞} mm	K year ⁻¹	R_n	\emptyset
Male	388	0.51	409	4.89
Female	400	0.63	314	5.00
Pooled	422	0.55	255	4.99

years were estimated to be 188mm, 287mm, 340mm, 368mm and 383mm, respectively.

For the pooled population (combined sexes), the value of t_0 was found to be -0.0115 . Fig. 4 provides the FiSAT output of restructured length frequency data of pooled population of *H. brachysoma* in Periyar River with superimposed growth curve fitted with highest levels of R_n . The VBGF in terms of pooled *H. brachysoma* population was expressed as $L_t = 422 [1 - \exp^{-0.55(t + 0.0115)}]$. The lengths attained by pooled *H. brachysoma* following VBGF equation at the end of one, two, three, four and five years were estimated to be 180mm, 282mm, 341mm, 376mm and 395mm, respectively.

Mortality

The FISAT output of mortality estimates of pooled population of *H. brachysoma* in Periyar River by catch curve method is depicted in Fig. 5. The total mortality (Z) was estimated to be 5.64 yr^{-1} at a cut off length of 240mm. The estimates of natural mortality (M) were determined as 1.04 yr^{-1} . The values of fishing mortality coefficient (F) and exploitation rate (E) were worked out as 4.60 yr^{-1} and 0.82 yr^{-1} , respectively. The optimum exploitation length (L_{opt}) was worked out as 259mm. Using the length converted catch curve method, the estimates of probabilities of capture were $L_{25} = 232\text{mm}$, $L_{50} = 260\text{mm}$ and $L_{75} = 288\text{mm}$ (Fig. 6) and the L_c was found to be 110mm. These values were subsequently used as inputs for relative Y/R of Beverton & Holt (1957, 1966). The L_c/L_{∞} and M/K values used for Y/R analysis were 0.2606 and 1.8909 respectively. The relative yield per recruit and biomass per recruit in *H. brachysoma* is presented in Fig. 7. The relative Y/R reached a maximum at an exploitation rate of 0.5744 yr^{-1} and thereafter decreased with an increase in the exploitation rate. It may be noted that the present exploitation rate E (0.82) has clearly exceeded the optimum exploitation rate of $E_{max} = 0.5744$. The values of $E_{0.1}$ and $E_{0.5}$ were estimated as 0.5538 and

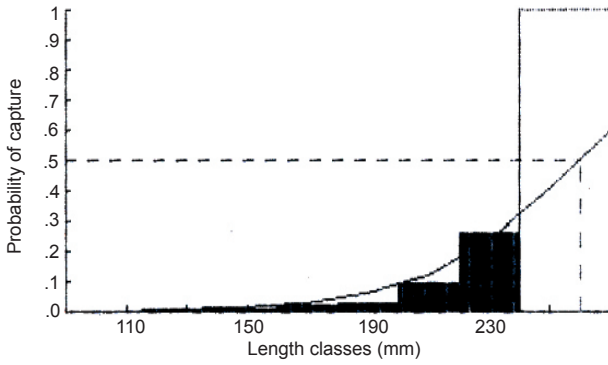


Figure 6. Probabilities of capture pattern of *Horabagrus brachysoma* from Periyar River

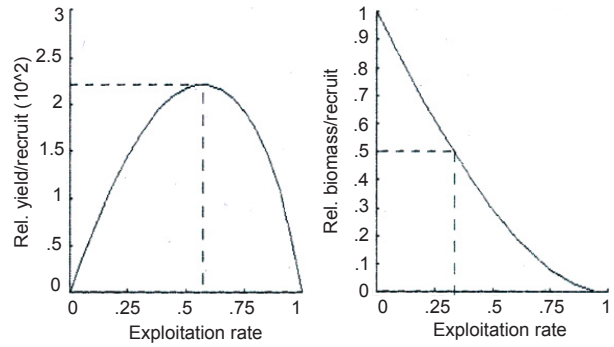


Figure 7. Relative yield per recruit and biomass per recruit of *Horabagrus brachysoma* from Periyar River ($L_c = 422\text{mm}$; $L_c / L_\infty = 0.260$ and $M / K = 1.89$)

0.3333, respectively. The results of length-based virtual population analysis showed that F increases to a maximum of 2.7921 at a body size of 240–260 mm (Fig. 8). The catch increases substantially from 160–180 mm size groups and attains maximum at 240–260 mm.

DISCUSSION

Length-Weight Relationship

Exponential value of the length-weight relationship ‘ b ’ in *H. brachysoma* from Periyar River followed the cubes law indicating an isometric growth pattern, similar to the observations made by Kumar et al. (1999) from Achenkovil and Ali et al. (2008) from Pampa rivers. Nevertheless, in Vembanad Lake, *H.*

brachysoma showed an acute negative isometric growth pattern with ‘ b ’ values in the ranges of 1.7616 (for males) and 1.9441 (for females) (Prasad et al. 2005). This negative growth pattern of the Yellow Catfish in Vembanad Lake was attributed to the poor environmental conditions prevalent in the lake ecosystem, especially the high level of pollution coupled with poor availability of food items.

Growth

Horabagrus brachysoma is known to grow to a maximum size of 450mm (Talwar & Jhingaran 1991). However, the maximum size of this species that was obtained from the exploited stock in the Periyar during this study was 340mm. The dominant size class of *H. brachysoma* exploited from the river (170–250 mm) is more or less similar to those from

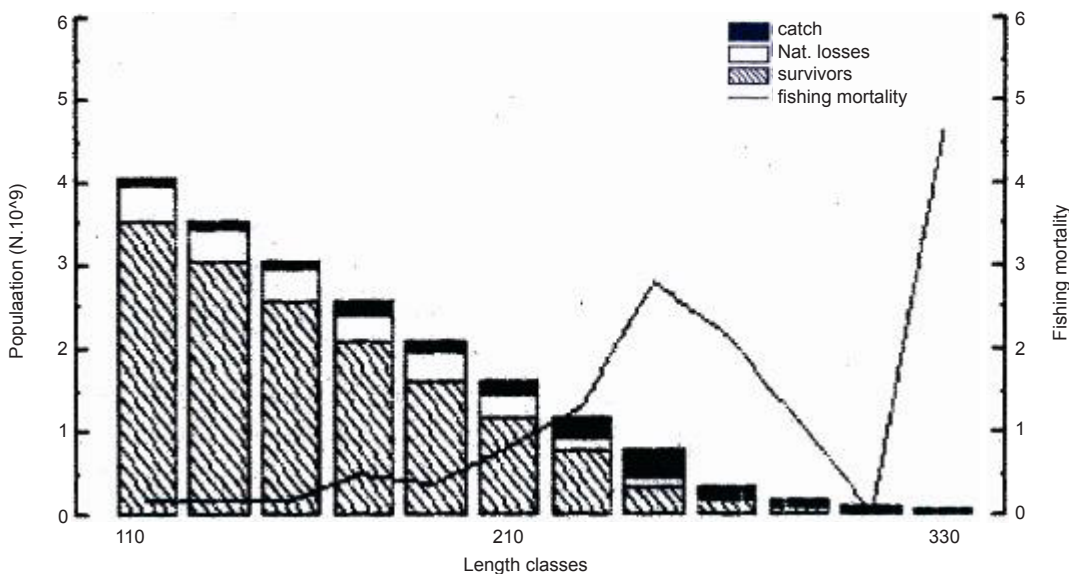


Figure 8. Length based virtual population analysis of *Horabagrus brachysoma* from Periyar River

Vembanad Lake (160–300 mm) (Sreeraj et al. 2007). In general, *H. brachysoma* exploited from various parts of Kerala belonged to more or less the same size class. Assuming that the fish grows throughout its life, L_{∞} is the largest theoretical mean length that it could attain in its natural habitat and K is the speed with which it grows towards this final size (Etim et al. 1999). Growth comparison is a multivariate problem that must take into consideration both the growth rate (K) and the asymptotic size (L_{∞}). Thus, we used the overall growth performance index ϕ (Pauly & Munro 1984) as it meets these criteria, is easy to compute and exhibits the least variance when compared with other alternative indices. The growth performance index value (ϕ) of 4.99 observed in the present study is significantly higher than that obtained for many tropical freshwater catfish species including those belonging to the families Schilbeidae (ϕ between 2.18 and 2.78) (Etim et al. 1999), Claroteidae ($\phi = 2.32$) (Abowei & Davies 2009) and Synodontidae ($\phi = 3.09$) (Ofori-Danson et al. 2001). As ϕ is largely considered to be a species-specific parameter with their values being similar within related groups or taxa, the significantly high ϕ value observed for *H. brachysoma* is an interesting observation. The maximum size that *H. brachysoma* attains during its life is 422mm and the life span estimated from the equation $t_{\max} = 3/K$ (Pauly 1983) is 5.45 years. The comparatively low life span and high growth performance index of *H. brachysoma* is uncharacteristic of freshwater catfishes, which are generally considered to be slow growing.

Mortality

The total mortality (Z) and natural mortality (M) of *H. brachysoma* in the Periyar River were computed as 5.64 yr^{-1} and 1.04 yr^{-1} respectively. Natural mortality being positively correlated with growth rates (Isaac & Ruffino 1996) was higher in *H. brachysoma* when compared to slow growing species of catfish such as *Clarotes laticeps* (0.87) (Abowei & Davies 2009), *Schilbe intermedius* (0.81) (Etim et al. 1999) and *S. mystus* (0.28) (Kolding et al. 1992). The exploitation rate (E) is an index used to assess if a stock is overfished, on the assumption that optimal value of E is equal to 0.5. Computed current exploitation rate E (0.82) is far higher than the optimum exploitation rate E_{\max} (0.5744) indicating that *H. brachysoma* populations in Periyar River are being overexploited. Although the Yellow

Catfish has a longevity of 5.45 years, the exploited populations from river Periyar are constituted by the year 1 class. *H. brachysoma* in Periyar is therefore caught before they grow large enough to contribute substantially to the stock biomass, thus demonstrating growth fishing.

Life history-exploitation relationship

The size at first maturity for *H. brachysoma* in Periyar River was found to be 176.7 mm for females and 196mm for males (Chandran 2009). During the present study, it was observed that the exploited population of *H. brachysoma* in the Periyar during 2005 was constituted by individuals ranging in size from 112 to 340 mm, and that the fishery was dominated by individuals in the size range 170 to 250 mm in both sexes. The fact that immature individuals of *H. brachysoma* are also fished out from the river indicates that recruitment fishing is taking place, damaging the reproductive potential and reducing the spawning stock of the species. Capture of small fish before they mature and breed is also known to lead to a reduction of fisher productivity and profit (Issac & Ruffino 1996).

Conservation and Management

Currently the fishery for *H. brachysoma* in Periyar River appears to be unsustainable as is evident from the high rates of exploitation and the occurrence of growth and recruitment fishing. Such unsustainable exploitation levels of catfish in small-scale inland fisheries have been recorded from Volta Lake in Ghana with *Hemisyndontis membranaceus* (Ofori-Danson et al. 2001) and Cross River, Nigeria with *S. intermedium* (Etim et al. 1999). Being an open access fishery devoid of any management plan, the fishery for the endangered Yellow Catfish in Periyar is vulnerable to collapse if management interventions are not planned and put into practice in the immediate future.

Although regulating total harvest could be the single most important management strategy for protecting *H. brachysoma* stocks, implementation of a plan to reduce fishing effort in an artisanal subsistence fishery is nearly impossible. This is especially so in a region which has no history of any fisheries management in inland waters. Management strategies for *H. brachysoma* in Periyar should hence be based on a combination of different technical measures such

as restrictions on gear, enforcement of size limits and implementation of closed seasons. In order to allow Yellow Catfish juveniles to reach sexual maturity before they are subjected to fishing mortality, a minimum size limit needs to be set at a size greater than the mean size at first reproduction. In the present scenario, a minimum catch size limit of 200mm can be enforced so as to prevent recruitment overfishing. Setting of size limits should also be supplemented with restriction on the mesh size of the gill nets. Currently, the fishers in Periyar use set gill nets with mesh sizes between 25 and 80 mm, resulting in the capture of small-sized juveniles that are below the size at maturity. A minimum mesh size of 160–180 mm should therefore, be mandatory for gill nets used by fishermen targeting *H. brachysoma*. If suitable gear restrictions are effectively implemented, there is little chance that the fishery will come in contact with the animals to be avoided (immature juveniles) (Charles 2001).

Another effective solution for the protection of *H. brachysoma* in Periyar can be through the use of closed seasons. Similar to the trawling ban (seasonal closure) which has been effectively enforced in the marine waters of Kerala for many years, a closed season starting from the month of May until August should be put into practice in the riverine system. These months are known to be the spawning seasons of *H. brachysoma* in the major rivers of Kerala including Periyar (Chandran 2009). This closed season will invariably safeguard the spawning process and bring to an end the capture of ripe females.

Management of riverine fisheries in Kerala has received little or no attention in the past with traditional fishing communities in Kerala often maintaining a relationship of conflict or accommodation with state institutions in fisheries management. Currently, there exists a lack of mutual trust between formal institutions and the traditional riverine fishing communities in Kerala. Formal institutional arrangements have lacked the participation as well as representation of traditional riverine fishing communities (Santha 2007). It is therefore apparent that this top-down and centralized decision making process has undermined the legitimacy and efficacy of fisheries management plans in the region. Therefore, only an organized effort involving the fisher communities can help in achieving success with the fisheries management plans that have

been suggested for *H. brachysoma* in Periyar.

As in the case of *H. brachysoma*, it is also possible that other commercially important and threatened fish species such as *Hypselobarbus curmuca*, *Hypselobarbus kolus* and *Tor khudree* which are targeted by artisanal fishers in different reaches of the Periyar may also be under significant fishing pressures. Hence, studies need to be directed at assessing the dynamics of exploited populations of these threatened species for urgent management interventions. Small-scale fisheries have many features that make them vulnerable to collapse, including overfishing, excess capacity, distortions in markets, climate change (Andrew et al. 2007) and ineffective governance (Berkes et al. 2001). They have remained one of the most poorly understood fishery systems in the world, especially in developing countries. Management of resources in small-scale artisanal fisheries has remained a challenge worldwide, largely due to the scarcity of data on population, exploitation patterns and threats. The results of the current study—the first such work on the dynamics of an exploited fish population in a small-scale fishery in Kerala—could provide the much needed input for policy makers and government institutions in the region to develop and implement management strategies to improve equity and sustainability of freshwater artisanal fisheries in Kerala.

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Acknowledgements: The study was funded by the Kerala State Science Technology and Environment Council (KSTEC), Government of Kerala, India. The authors thank the many local fishers of Kalady, Angadikkadavu and Manjaly for their help during the sampling. The authors are also grateful to the Subject Editor for providing inputs and suggesting necessary changes that greatly improved the manuscript.