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# POPULATION DYNAMICS OF ASIAN FRESHWATER STINGING CATFISH, *Heteropneustes fossilis* (BLOCH, 1794) FROM LAKSHAM, CUMILLA, BANGLADESH

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## ABSTRACT

Population parameters of 1630 specimens of *Heteropneustes fossilis* were estimated from length-frequency data, collected from the fish market of Laksham, Cumilla from November, 2019 to October, 2020. For the purpose of estimating the parameters FAO-ICLARM Stock Assessment Tool (FiSAT II) software was used. Asymptotic length ($L_\infty$) and growth coefficient (K) of this fish were estimated to be 28.88 cm and 0.70/year, respectively. Instantaneous rate of natural mortality (M), fishing mortality (F) and total mortality (Z) were estimated to be 1.43, 0.34 and 1.77, respectively. Recruitment pattern of the species was short with one peak, during May to August. The $L_{25}$, $L_{50}$ and $L_{75}$ were found to be 20.78 cm, 23.51 cm and 24.81 cm, respectively. Relative yield per recruit (Y′/R) and biomass per recruit (B′/R) were 0.655 and 2.042, respectively. Value of exploitation (E) was found to be 0.19 which indicated that *H. fossilis* was not over fished (E > 0.50) in the study area. Maximum exploitation ($E_{max}$) value was 0.55. It indicates that more fish can be harvested. .

**Key words:** Stinging catfish, population dynamics, VBGF, Bangladesh

## Introduction

*Heteropneustes fossilis* (Bloch 1794) (locally known as *shinghi*) is a valuable catfish species, has high medicinal, nutritional (protein, calcium and iron) as well as commercial value (Ahmed *et al.*, 2012, Jayalal and Ramachandran, 2012). Distribution of this species is wide in Bangladesh, Pakistan, India, Myanmar, Nepal, Sri Lanka, Laos and Thailand (Talwar and Jhingran, 1991). It is classified as least concern species both in Bangladesh (IUCN Bangladesh, 2015) and worldwide (IUCN, 2021). Despite of the high commercial and nutritional importance of this catfish, no major attention has yet been paid on its population dynamics in Bangladesh. Sustainable exploitation of fisheries resources requires understanding and information on population dynamics of fish stocks. Population dynamics are the processes responsible for changes in abundance or biomass of a population through time, which can provide greater insight into the fish population regarding how a population has arrived at its current state and how it might change in the future (Pope *et al.*, 2010). Recruitment, growth, and mortality rates are the primary population dynamics (often termed as rate functions) that influence the harvestable segment of a fish population (Brown and Guy, 2007). If these rates are measured over different time intervals, the harvestable surplus of the fishery can be determined (King, 2007). In Bangladesh, population dynamics of several fishes have been studied by many authors (Azadi and Quddus, 1995; Mustafa and Azadi, 1995; Azadi *et al.*, 1995, 1996, 1997; Azadi and Barua, 1999; Azadi, 2000; Rashed-Un-Nabi *et al.*, 2007; Azadi and Mamun, 2009; Parvez and Rashed-Un-Nabi, 2015; Rahman *et al.*, 2015; Sarkar *et al.*, 2017; Nazrul *et al*., 2018; Hossen *et al.*, 2018 and Ara *et al.*, 2019). In abroad population dynamics of several fishes have been done by authors such as Goswami and Devraj (1996), Athukorala and Amarasinghe (2010), Fofandi (2012), Qamar *et al.* (2016), Edmond *et al.* (2017) and Asiedu *et al*. (2021). However, literature review revealed that studies on population dynamics of the catfish *Heteropneustes fossilis* has not been done in Bangladesh excepting the work of Mustafa and De Graaf (2008). However, to overcome the collection of costly hard parts (such as otolith, scales and other body parts) and to use the easily available length frequency data for the study of fish population dynamics, several computer-based programs are used, such as Length-based Fish stock Assessment (LFSA) (Sparre, 1987), MULTIFAN (Fournier *et al*., 1990) and FiSAT (Gayanilo and Pauly, 1997). In the present study, the population dynamics based on growth parameters, mortality, selection pattern, exploitation rate, recruitment pattern and yield of *H. fossilis* were investigated from length frequency data analysis using FiSAT II (FAO ICLARM Stock Assessment Tools) (Gayanilo *et al.*, 1996). It is resulted from the merging of LFSA (Length based Fish Stock Assessment) developed by FAO (Sparre, 1987) and the Complete ELEFAN (Electronic Length Frequency Analysis) package (Gayanilo *et al*., 1989).

## Materials and Methods

**Collection of data:** For the present study a total of 1630 specimens of *Heteropneustes fossilis* with total length ranging from 8.5-28.5 cm were collected monthly for one-year period (November 2019 to October 2020) by random sampling from the fish markets of Laksham, Cumilla, Bangladesh. Total body weight of each individual fish was weighed in an electronic balance, whereas total length was recorded to the nearest centimeter with a measuring tape. Monthly collected length frequency data were merged to facilitate the calculation and analysis.

**Data analysis:** FiSAT II (Gayanilo *et al*., 1996) was used to find the asymptotic length ($L_\infty$), growth co-efficient (K), total mortality (Z), Fishing mortality (F), natural mortality (M), exploitation rate, recruitment pattern, selection pattern, relative yield-per-recruit and biomass-per-recruit. Length frequency data were then analyzed by electronic length frequency analysis using the correct routines in FiSAT II package (Pauly and David, 1981; Pauly, 1984, 1986, 1987) and Gayanilo *et al*., 1996).

**Estimation of asymptotic length ($L_\infty$) and growth coefficient (K):** Growth parameters, asymptotic length ($L_\infty$) and growth coefficient (K) were estimated following the von Bertalanffy growth equation (von Bertalanffy, 1938):

$L_t = L_\infty (1\text{-exp} - K (t\text{-}t_0))$, where,
$L_t$ is the length at age t,
$L_\infty$is the asymptotic length,
K the growth coefficient and
$t_0$ age at which fish would have had zero length.

Parameters of $L_\infty$ and K were computed from the ELEFAN I.

**Mortality estimation: T**otal mortality coefficient (Z) was estimated using the length converted catch curve analysis in the FiSAT II program using the input parameters $L_\infty$, K and $t^0$C (Pauly, 1984). The theoretical equation used in this analysis is,

$(N_i/\Delta t_i) = a + b \times t_i$, where,
$N_i$ = Number of fish in length class i,
$\Delta t_i$= Time needed for the fish to grow through length class i,
$t_i$ = Age corresponding to the mid length of class i, and
b = Estimate of Z (with sign changed).

Natural mortality (M) was estimated using the empirical relationship derived by Pauly (1980) where the mean annual temperature (T) was set at $28^0$C.

$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.06543 \ln K + 0.463 \ln T$. where,
M is the natural mortality,
$L_\infty$ is in cm,
K is annual and T is the mean annual temperature (in $^0$C).

Fishing mortality (F) was calculated using the formula,
F = Z - M, Where,
F= Fishing mortality,
Z = Total mortality, and
M = Natural mortality.

**Probability of capture:** Probability of capture can be estimated by backward projection of the number that would be expected if no selectivity had taken place.

Equation: $N_{i-1} = N_i' \times EXP(Z\Delta t_i)$ Where,

$N_i$ = Terminal population,

$N_i'$ = Number of fish under the length groups that are not recruited under gear,

$\Delta t_i$ = Time needed for the fish to grow through length class i,

$Z = (Z_i+Z_i+1)/2$, $Z_i = M + F_i$, $F_i-1 = F_i- X$, $X = F/$ (No. of classes below $P_1+1$), and

P=1st length group with a probability of capture equal to 1 and whose lower limit is an estimate of L′.

The extrapolation points were used to approximate the probability of capture.

**Recruitment pattern** was derived using the program of Gayanilo *et al.* (1989).

**Exploitation ratio** E was estimated as E = F/Z = F/(F+M).

**Length at first capture ($L_c$ or $L_{50}$)** was estimated following Pauly (1984).

**Probabilities of capture by length** (Pauly, 1984) were estimated by calculating the ratio between the points of extrapolated descending arm and the corresponding ascending arm of the length converted catch curve.

**Relative yield-per-recruit and biomass-per-recruit:** Relative yield-per-recruit (Y/R) and biomass-per-recruit (B/R) were obtained from the estimated growth parameters and probabilities of capture by length (Pauly and Soriano, 1986). The relative yield per recruit (Y′/R) was predicted by considering Y′/R as a function of U, E and M/K by employing Beverton and Holt Y′/R analysis (knife edge) in the FiSAT II package. The relative yield per recruit equation which gives a quantity proportional to Y'/R was derived from the method of Beverton and Holt (1956, 1957, 1966) through a number of algebraic manipulations. The predicted values were obtained by substituting the input parameters of $L_c/L_\infty$ ($L_c$ is the minimum length captured, obtained from the extrapolation of length converted catch curve) and M/K in the FiSAT II package, and according to the model.

## Results and Discussion

**Asymptotic length ($L_\infty$) and growth coefficient (K):** The growth parameters of the von Bertalanffy growth formula, asymptotic length or $L_\infty$ and growth coefficient or K (year$^{-1}$) estimated for *H. fossilis* were found to be 28.88 cm and 0.70/year respectively. Estimated (through ELEFAN-I) correlation co-efficient ($R^2$) (ESP/ASP) was 0.151. Computed growth curves produced for *H. fossilis* with those parameters are shown over its restructured length distribution in Fig.1.

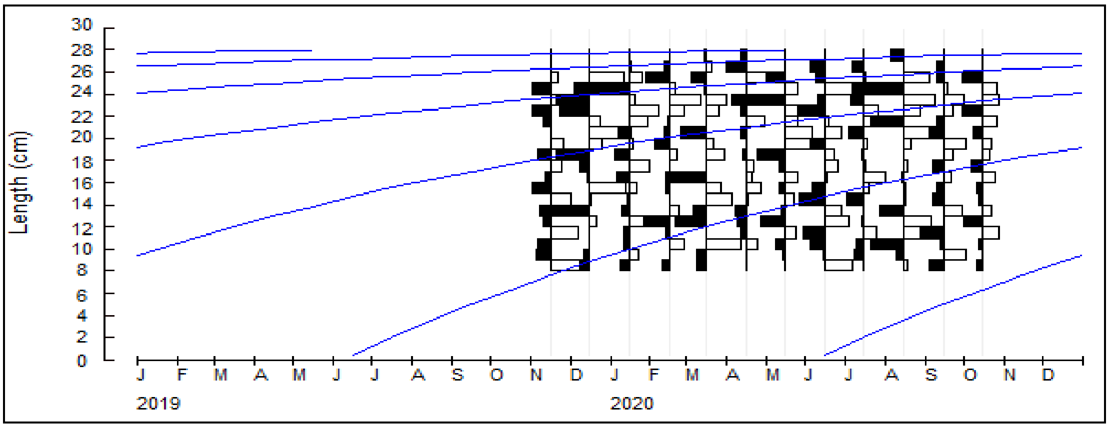


Fig. 1. Restructured length frequency histogram for *Heteropneustes fossilis* of Laksham region, Cumilla, $L\infty$ = 28.88 cm, Growth co-efficient (K) = 0.70; $R^2$= 0.151, Peak Spawning during June, SS=5, SL=12.0 cm

Value of asymptotic length ($L_\infty$) and growth coefficient (K) estimated in the present study was found close to the findings of Mustafa and De Graaf (2008). For another catfish species, *Arius thalassinus*, Sultana *et al.* (2019) recorded $L_\infty$ as 97.60 cm and K as 0.33/year in the Bay of Bengal coast of Bangladesh, whereas, Prasad *et al.* (2012) obtained $L_\infty$ = 422 mm and K = 0.55/year for yellow catfish *Horabagrus brachysoma* from Indian coast which contradicted with the present study because the species were different.

**Mortality and exploitation rate:** Natural mortality (M), fishing mortality (F) and total mortality (Z) were estimated to be1.43, 0.34 and 1.77 respectively for *H. fossilis*. Fig. 2 shows the length converted catch curve utilized in the estimation of Z. The dark circles represent the points used in calculating Z through least square linear regression. The blank circles represent points either not fully recruited or nearing to $L_\infty$, hence discarded from calculation. Good fit to the descending right-hand limits of the catch curve was considered. From the Gulland (1971) equation (E = F/F+M), exploitation ratio 'E' had been estimated. From the range of values of F and Z, the rate of exploitation E was 0.19. Mustafa and De Graaf (2008) estimated Z = 1.95, F = 0.80, and M = 1.15 for *H. fossilis* which agreed with the present study. The optimum yield of a fishery is taken when the fishing mortality (F) is about equal to the natural mortality (M), F = M or E = F/Z = 0.5 and F = 0 or Z = M in an unexploited virgin stock (King, 2007). The value of E was found to be 0.19, which is very much lower than the optimum level of E ($E_{max}$= 0.55). This was probably because the species *H. fossilis* was not commercially being exploited in the study area and a very few fishing activities were prevailing on the species.

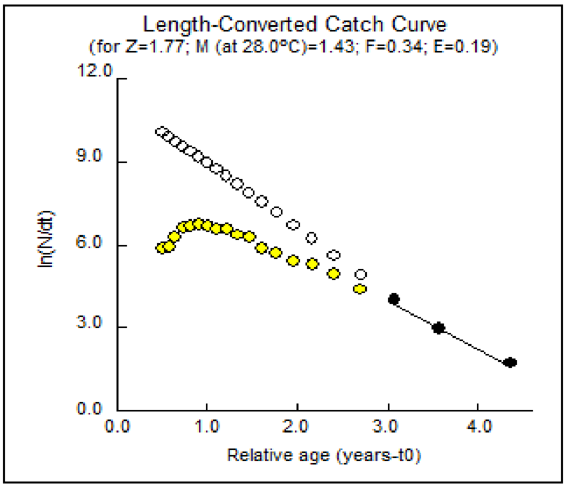


Fig. 2. Length converted catch curve of *H. fossilis* for all length groups. Natural mortality (M) = 1.43, Fishing mortality (F) = 0.34, Total mortality (Z) = 1.77, Exploitation ratio (E) = 0.19

**Selection pattern/probability of capture:** From selection pattern, $L_{25}$, $L_{50}$ and $L_{75}$ were found to be 20.78 cm, 23.51 cm and 24.81 cm, respectively (Fig. 3). The estimated $L_{50}$ or $L_c$ value indicated that the fish became susceptible to the fishing gears when it reached at 23.51 cm total length and at this length the fish had 50% chance of being retained by the gears used to capture it, as also reported by King (2007).

**Recruitment pattern:** Through the ELEFAN II analysis (Pauly and David, 1981), with the separation of the normal distribution of the peaks by means of the NORMSEP program, the recruitment pattern was determined which showed one recruitment pulse during May to August (Fig. 4).

**Relative yield-per-recruit and biomass-per-recruit:** The relative yield-per-recruit and biomass-per-recruit were determined as a function of $L_c/L_\infty$ and M/K, which were 0.814 and 2.042, respectively. The present exploitation rate, E = 0.19 (Fig. 5) which did not exceed the E-max (0.55), indicated that the fish was not over fished in the studied region as Gulland (1971) stated that E value above 0.5 indicated over fishing of a species in an area.

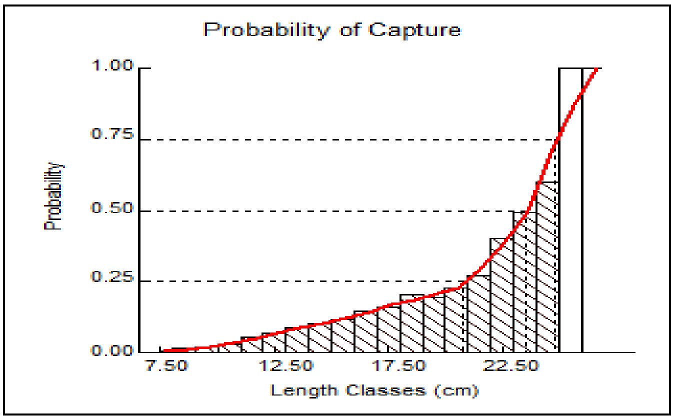


Fig. 3. Selection pattern of *H. fossilis*. $L_{25}$ =20.78 cm; $L_{50}$= 23.51 cm; $L_{75}$=24.81 cm

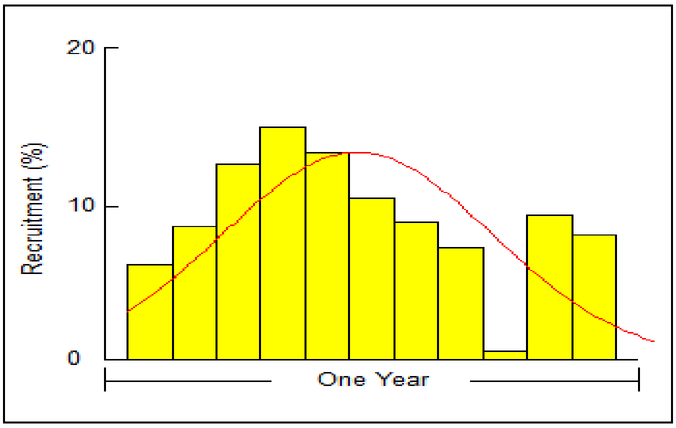


Fig. 4.Recruitment pattern of *H. fossilis* produced through recruitment pattern module of FiSAT II program

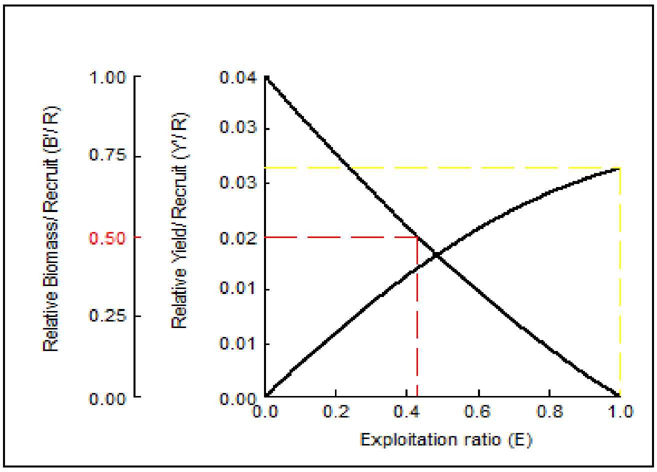


Fig. 5. Exploitation ratio of *H. fossilis* showing the biomass per recruit (B′/R) and yield per recruit (Y′/R)

**Uses of the present findings**: Population parameters are valuable approaches for the evaluation of the status of fish stocks and are vital means for the management of exploited fish populations (Sparre and Venema, 1997). Information on the population parameters of *H. fossilis* is very deficient, therefore, the present study provides a complete description on the above-mentioned issue including asymptotic length ($L_\infty$), growth co-efficient (K), total mortality (Z), fishing mortality (F), natural mortality (M), exploitation rate, recruitment pattern, selection pattern, relative yield-per recruit and biomass-per-recruit using a number of individual *H. fossilis* collected from the Laksham region, Cumilla Bangladesh.

**Challenges for population enhancing of freshwater stinging catfish:**

- Natural habitat is reduced.
- Natural breeding grounds are destroyed.
- Induced breed fries are not cheap and also not available to the farmers.
- Indiscriminate use of insecticide and pesticide in crop field kills the wild fish including cat fish.
- Harvesting device should be improved, so that, the cat fish cannot hide in mud.

## Conclusion

From the present study it may be concluded that, if the fish is exploited properly, the total production will increase from this study region and large number peoples suffering from mal-nutrition will be benefitted by the constant supply of this highly nutritive valued fish with lower price. Hence, this study would be an effective tool for fishery managers, fish biologists and conservationists to initiate a sound management policy for improving the production of the species.

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