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Virtual Population Analysis and Recruitment Pattern of *Osteobrama vigorsii* (Sykes, 1839) from Nira River, Bhor Maharashtra

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ABSTRACT

Environmental pressure and anthropogenic activities have a tremendous effect on the habitat of fishes. Concerning the 26 species from Western Ghats of India, lacking data in terms of the studies carried out on their reproductive biology, Osteobrama vigorsii (Sykes, 1839) is the endemic species from the Western Ghats, it is data deficient in various aspects of the reproductive biology. In the present studies, values obtained when computed in the FISAT II analysis tool disclosed the length-frequency expressed in the superimposed curve with the idealistic suitable exponent (Rn=0.914). Growth performance index (Ø), length at first capture (Lc), Total mortality represented by (Z), natural mortality by (M), and fishing mortality has been studied. The harvesting level is calculated by implementing relative output per recruit (Y/R), and proportional mass per recruit (B/R) analysis which is settled on the knife-edge assortment. This is a clear indication that the present level of fish harvesting (E_{curr}) is still far away from the (E_{max}) level that is been computed for the fish under study. The results depict a high degree of morality in the fish population during a young age this would help the fishery unit to plan strategies in assigning programs for the sustainability of the fish in its natural habitat.

Keywords: *FISAT II analysis, Growth performance index, Von Bertalanffy growth parameters, Recruitment pattern*

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INTRODUCTION

The Asian continent is considered the world's biggest fish-producing region concerning inland fishes. There have been numerous signals reflecting the over-harvesting of fishes from their natural habitat, where the size of the fish harvested is below average and their low age of mortality (Dudgeon, 2000). Concerning around 290 fish species from the Western Ghats of India, around 189 are natives to the western ghats, where 26 species fall under the category of data deficient species (Molur *et al*., 2011). About 58% of the endemic species harboring the Western Ghats of India are vulnerable to near extinction compared with the non-endemic species from the region (Raghavan *et al*., 2011). Due to the open-access fishing technique which takes place in the Western Ghats, various endemic species of fish are been exploited (Raghavan *et al*., 2018). Survival of the larval stage is an important stage in the recruitment process1. High quality of fecudity rate, produced by older female, may be more likely to survive and reach adult stage (Palumbi, 2004; Barneche *et al*., 2018).

The work has been carried out to interpret the population status of *Osteobrama vigorsii* (Sykes, 1839) which belongs to the family Cyprinidae, which is native to the Western Ghats of India. In the state of Maharashtra, *Osteobrama vigorsii* (Sykes, 1839) is found in the riverine systems of rivers namely Krishna, Mahanadi, and the Godavari. The study reveals that the fish is found in various fast-flowing streams of the riverine system (IUCN, 2011). The present work will help in estimating the environmental pressure on the species as well as the anthropogenic effect which is causing tremendous stress on the natural habitat of the *Osteobrama vigorsii* (Sykes, 1839). The study would help in the conceptualization yield model which can suit the various planning program for the species to sustain in the habitat without being over-harvested (Bal & Rao, 1984).

Many studies focus only on the relationship between estimates of recruitment and spawning stock biomass (SSB), thus ignoring a few key steps along the path to recruitment (e.g., reproductive behavior, egg production and / or phases premature health survival (Rothschild, 2000; Somarakis *et al*., 2019). There has been a decline in the freshwater fish population in India namely Mahaseer, catfishes (Bhat *et al*., 2000; Patra *et al*., 2005; Raghavan *et al*., 2018). There has been very few reports about the diversity observed in many carps, and as a result, it is called the the recruitment problem (Munch *et al*., 2018). There has been an urgent need to set up a strategic planning methodology for the conservation of the endemic fish species in their natural habitat. There is no literature concerning the Statistical analysis of various important endemic fish species even for *Osteobrama vigorsii* (Sykes, 1839). Various reasons along with the unavailability of financial support systems to carry out research activity in the developing countries (Maccord *et al*., 2007). A sustainable fishery program should be implemented to strike a balance between the fishing activity and the population in the habitat. This study will present the exploitation scenario of this endemic fish species from the Western Ghats of India. Thereby various strategies can be planned and effectively implemented by the fishery unit of the state of Maharashtra.

MATERIALS AND METHODS

Specimens of *Osteobrama vigorsii* (Sykes, 1839) were gathered from the Nira river with the help of a gill net **(Figure 1)**. The total random specimen collected accounted for 424. The method used by (Gulland, 1985) was enforced for perusing the length-weight ratio investigation. Vernier caliper (Standard Indian make) was used to measure the standard length (mm) of each fish specimen and the measurement was estimated to the nearest mm. The standard length values obtained for each fish specimen were placed in the length class interval of 10 mm. Presumptuous, that the growth of *Osteobrama vigorsii* (Sykes, 1839) precedes the von Bertalanffy growth formula (VBGF), the VBGF parameters, $L\infty$, K and $t\O$ were estimated using the FISAT (FAO – ICLARM Stock Assessment Tools II (FISAT II version 1.2.2) computer software program package (Gayanilo & Pauly, 1997) for the investigation of the obtained data. The data assembled from *Osteobrama vigorsii* (Sykes, 1839) was used to estimate the parameters namely, (fishing mortality denoted as -F), (total mortality-denoted as- Z), (exploitation ratio denoted as-E) and (instantaneous natural mortality -M), implementing FISAT program (Pauly, 1980; Gayanilo & Pauly, 1997).

Figure 1. Specimen of *Osteobrma vigorsii* (Sykes,1839) from Nira River Bhor, Maharashtra.

Growth and potential longevity
Growth coefficient *(K)* and Asymptotic lent *(L∞)* was computed by implementing ELEFAN 1 method (Pauly & David, 1981; Pauly, 1982; Pauly, 1984; Pauly & Morgan, 1987).

past improvement of standard von Bertalanffy growth function (VBGF) as follows:

$$L_1 = L\infty * [(1\text{-Exp} (-K (t\text{-}t_o)] \quad (1)$$

Where L∞ represents asymptotic length, while K stands for the VBGF curvature parameter (growth constant), *l1* denotes length at the time *t* while t_o represents hypothetical length at age length zero. The growth performance index *(Ø')* for *Osteobrama vigorsii* (Sykes, 1839*)* was calculated (Pauly, 1980), using the growth parameters (L∞ and VBGF curvature parameter (K).

$$(\O') = \text{Log } K = 2 \log L1 \quad (2)$$

Total mortality denoted as -(Z) for *Osteobrama vigorsii* (Sykes, 1839) was calculated by implementing the length converted catch curve method (Gayanilo & Pauly, 1997). Natural mortality denoted as- (M) has been calculated by computing the empirical formula. While Pauly's (Pauly, 1980) method has been utilized to study the Natural mortality denoted as-(M).

The empirical formula:

$$\text{In } (M) = -0.0152\text{-}0.278 \text{ In } (l_\infty) = 0.6543 \text{ In } (K) + 0.463\text{In } (T) \quad (3)$$

Where (M) represents Natural mortality

(L) and (K) express the Growth parameters of VBGF ∞; (T) expresses the yearly mean temperature of the water body, since water is a natural habitat for fish species under the present study. In the study carried out, (T) was confiscated as 26^0 C.

To understand the Instant rate of fishing, the mortality-(F) value and the natural mortality-(M) value was subtracted from total mortality denoted as -(Z).

$$F =(Z - M) \quad (4)$$

By implementing the formula of (Gulland, 1985), the values obtained of (F) and (Z) were computed in estimating the occurrent exploitation rate of fish under study which is denoted by *(E):*

$$E=F/Z \quad (5)$$

The status of sustainability of *Osteobrama vigorsii* (Sykes, 1839), in its natural habitat, was The present fish understudy is sustainable or not in its natural environment was premeditated accordant to (Etim *et al*., 1999). Wherein if the Z/K ration ≈2, it reflects that the fish has been over-harvested from its natural habitat.

Virtual population analysis (VAP)
Virtual Population Analysis (VPA) helps in the understanding status of the fish population in its natural habitat. Beverton and Holt's method was deployed to understand the current level of exploitation (E). knife-Edge selection method of (Beverton & Holt, 1966) was used to understand the biomass by recruit (B'/R) and the comparative yield per recruit (Y'/R). The degree harvesting of fish also known as exploitation rate, which is reflected in debased of the unexploited biomass by (50 %) was designated by E_{50} whereas E_{max} represented the utilization rate producing extreme yield, was studied by plotting Y'/R vs B'/R vs E. The measure of fishes harvested was depicted as L25 (length at which 25% of fishes harvested), L_{50} (length at which 50% of fishes harvested), and L75 (length at which 75% of fishes harvested) and was analyzed. The computed curve, which reflected the length at first harvest *Lc* was reasoned as equal to the additive improbability at 50%.

Probability of capture and recruitment pattern
The chance of harvest has been calculated by implementing the method used by (Pauly, 1984) computing the length converted catch. The Recruitment pattern renders assemblage affiliated to the number of pulses in twelve months while the relational capability of apiece pulse has been estimated by analyzing recruitment pulses obtained for a period of sequence of length-frequency values (Moreau & Cuende, 1991).

RESULTS AND DISCUSSION

The present study on *Osteobrama vigorsii* (Sykes, 1839) to understand the length-weight ratio by using the statistical tool. The maximum and the minimum data of standard weight for each fish and its weight has been tabulated. the minimum and maximum values of standard length, and weight for pooled data is been tabulated. Individual fish accounted for 425 were studied and the values were computed. The analysis based on the harvest and observation depicted that the largest individual of fish was obtained in June, while the smaller ones were in April- May. The values when computed in the FISAT II analysis tool disclosed the length-frequency for *Osteobrama vigorsii* (Sykes, 1839) expressed the super obligatory curve with ideal fit index (*Rn*=0.914) **(Figure 2)**. The estimated coefficient of growth (K) for the fish understudy was 0.60 year^{-1}. The asymptotic length *(L∞)* for the fish understudy was calculated to be 200 mm. Implementing the von Bertalanffy growth parameters relating to the growth hypothesis, mortality parameters for *Osteobrama vigorsii* (Sykes, 1839) have been estimated by implementing the length converted catch curve which has been tabulated **(Table 1)**.

Table 1 . Growth, mortality, and exploitation parameters of *Osteobrama vigorsii* (Sykes, 1839) from Nira River Bhor, Maharashtra, India.

Pooled	n	SL		Weight (W)	
		Min	Max	Min	Max
	424	35.55	189.01	3.56	97.03
Growth and longevity parameters		**Mortality and exploitation parameters**			
Asymptotic length (L_∞)	210	Total mortality (Z)	0.83 year $^{-1}$		
VBF growth constant (K)	0.60 year $^{-1}$	Natural mortality (M)	0.72 year $^{-1}$		
Min length (L_{min})	35.55	Fishing mortality (F)	0.11 year $^{-1}$		
Max length(L_{max})	189.01	Length at first capture (L_c)	67.88mm		
Growth performance index (Ø’)	4.423	Exploitation ratio E_{cur}	0.456		
Potential longevity(t_{max})	5yrs	Exploitation ratio E_{Max}	0.531		
Normalization constant(a) of LWR	0.0029	Exploitation ratio E_{50}	0.318		
Scaling power (b) of LWR	2.138	Z/K ratio	1.38		

The growth performance index *(Ø)* of the fish understudy was estimated to be 4.423. Length at first capture *(Lc)* was estimated as 67.88mm, while the total mortality *(Z)* value obtained was 0.83 year$^{-1,}$. The natural mortality coefficient denoted as -*(M)* has been computed to 0.72 year^{-1}. Fishing mortality is estimated to be 0.11 year$^{-1.}$ **(Figure 3)**. The obtained values were analyzed and tabulated **(Table 1)**. The virtual population has been studied and is been presented in **(Figure 6)**. The present study showcases that there is a high degree of morality in the fish population during a young age.

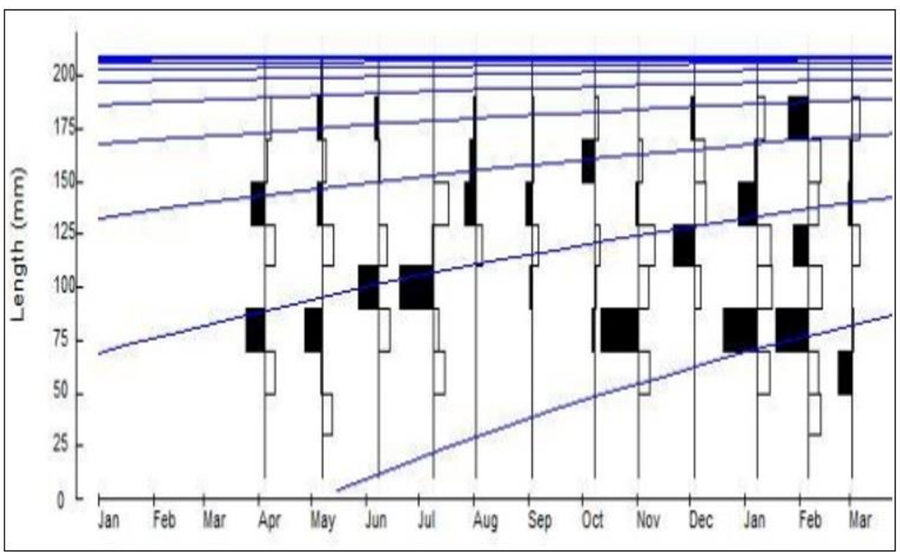

Figure 2. The von Bertalanffy growth curve superimposed over length-frequency data of (*Osteobrama vigorsii* Sykes, 1839) from Nira River, Maharashtra, India.

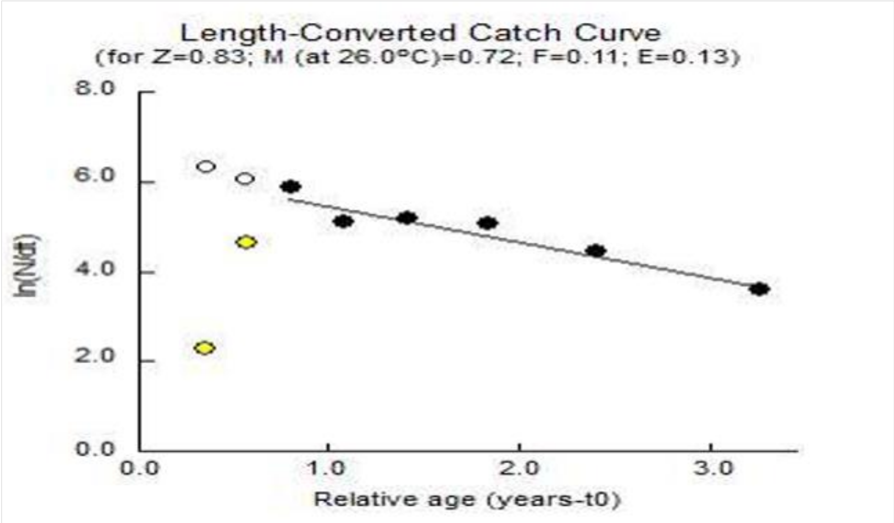

Figure 3. Length-converted catch curve for *Osteobrama vigorsii* (Sykes, 1839) from Nira River, Maharashtra, India

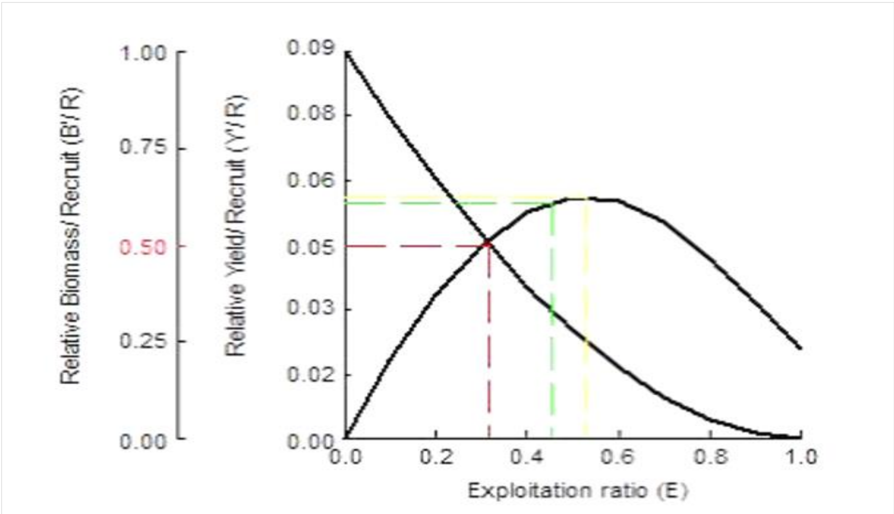

Figure 4. Relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) analysis for *Osteobrama vigorsii* (Sykes, 1839) from Nira River, Maharashtra, India.

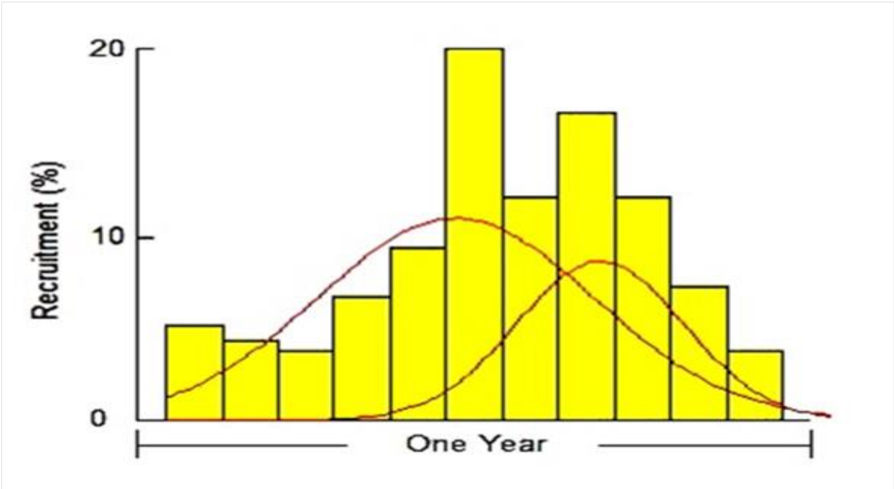

Figure 5. Recruitment patterns for *Osteobrama vigorsii* (Sykes, 1839) from Nira River, Bhor, Maharashtra, India.

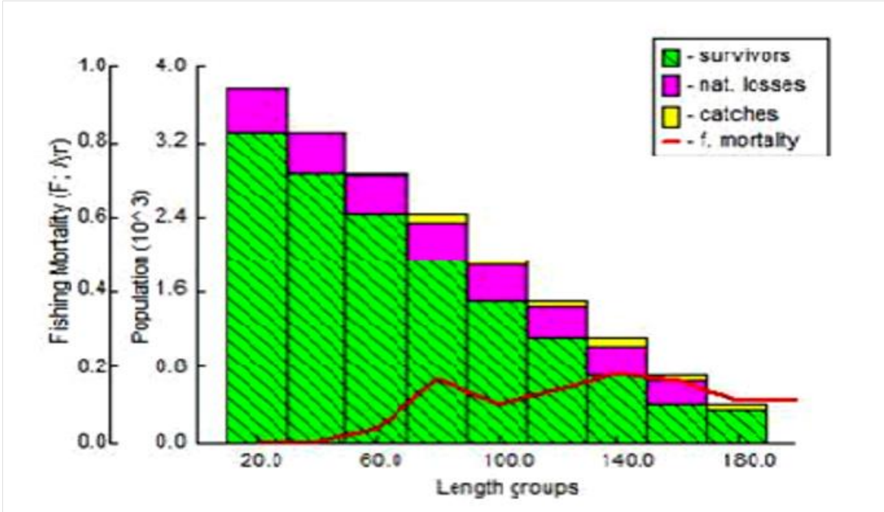

Figure 6. Length-based virtual population dynamics for *Osteobrama vigorsii* (Sykes, 1839) from Nira River, Maharashtra

In the present study on *Osteobrama vigorsii* (Sykes, 1839) the harvesting level was calculated by implementing relative yield per recruit (Y/R), and relative biomass per recruit (B/R) analysis which is based on knife-edge selection was computed to 0.318. **(Figure 4)**. *(E_{50})* and *0.531(E_{max})* while for *(E_{curr})* value calculated was *0.456* **(Figure 2)**. This is a clear indication that the present level of fish harvesting *(E_{curr})* is still far away from the *(E_{max})* level that is been computed for the fish under study. As per the data analysis, The Recruitment pattern shown by *Osteobrama vigorsii* (Sykes, 1839) expresses a bimodal pattern, wherein the major pulse occurs between the month of August-September (20.13%) while the minor one occurs in the month of March-April (4.12%) **(Figure 5)**. Length-based virtual population dynamics **(Figure 6)** display higher mortality during a young age despite the fishery practice targeting adult individuals.

Growth patterns expressed by fishes are an essential component of population studies. It is an indispensable factor to undertake concrete measures on the conservation and management issues of fishery units (Devries & Frie, 1996). Considering the status of endemic species of fishes dwelling in the Western Ghats around 10% are listed in the data deficient group (IUCN, 2011). *Osteobrama vigorsii* (Sykes, 1839) is placed under the least concern category and no information is accessible on the exploitation status of this fish in its natural habitat, hence this study will help in planning strategies for the conservation plans.

In the present work on *Osteobrama vigorsii* (Sykes, 1839), the growth performance index (Ø') was established at 4.423. The value is relatively high compared with other tropical fish species. In the study taken on the synodontidae family the value estimated for Ø' was 3.09 (Ofrori-danson *et al*., 2001). The higher growth rate obtained can be related to the affirmative parameter concerning the fishery administration pattern for the species from its natural habitat (Raghavan *et al*., 2018). The pi prime *(Ø')* is a highly species-specific parameter that is related inside the related groups (Prasad *et al*., 2012). In the natural habitat, the growth index is usually cadaver constant inside the population. The performance index value remains invariant concerning the population of the identical species (Pauly, 1982; Pauly & Morgan, 1987).

The present work off *Osteobrama vigorsii* (Sykes, 1839) reviled the value for length at first capture, which is designated as *(Lc)* was calculated to be 67.88mm. The maximum realizable expected extreme length was 210mm. The value obtained is higher than 50% where the fish has been harvested before the fish attain maximum size. The *Lc* provides us with statistical complacent regarding the approximation of the factual size of fish under study. This information would be beneficial for the fishery management program to be undertaken by the fishery unit, there the fishing of the young age fishes could be avoided from their natural habitat. It can also help in setting the minimum size that can be determined for the fish for harvesting from their natural habitat (Siddik *et al*., 2015; Raghavan *et al*., 2018).

The rate of mortality for fish from their habitat is a capital factor in estimating the rate of the fish population (Sparre & Venema, 1992). In the existing study, natural mortality was estimated as 0.72 year $^{-1}$. Temperature of the water body in the natural habitat directly affects early growth and survival, but may have an indirect effect on the reproductive behavior of adults (Mbaye, *et al.* 2020). Present values are on the higher side when compared with the work done by various workers (Raghavan *et al*., 2011), estimated the observed mortality rate (0.67 year^{-1}) in the studies carried out on *Tor khudree* from Kerala. In other studies on *Clarotes laticeps* the value obtained was (0.97 year $^{-1}$). There are various factors responsible for high mortality, natural environmental factor and anthropogenic activities are one of the major factors (Raghavan *et al*., 2018). Many studies using indicators such as environmental factors, food availabilty geogrpahical region have noted a deterioration or change over time in recruitment pattern of species (Zwolinski & Demer, 2019; Smith *et al.,* 2020). In the current studies, the mortality of larger-size fishes clearly expresses the fishing pressure on *Osteobrama vigorsii* (Sykes, 1839).

As per the literature available, the value of mortality due to fishing in the population needs to be at par with the natural maturity, which is designated as (*F=M*) (Gulland, 1985) while the rate of exploitation of the fish designated by *(E)* inevitably has to be 0.50. Haroon (Haroon *et al*., 2001) work carried on revealed a very low exploitation rate for *L. rohita* from the Sylet basin projected a low exploitation rate which was calculated to be 0.52. In the wok on *Osteobrama vigorsii* (Sykes, 1839) the estimated rate of due to fishing mortality was 0.72. On the other hand, the exploitation (E_{max}) value for *Osteobrama vigorsii* (Sykes, 1839) was estimated to be 0.53., which clearly states that the fish is not fully harvested. The rate of harvesting close to the maximum limit (E_{max}) reflects the status of the fish population is under optimal fishing potential with a +1 deviation on either side (Ahmed *et al*., 2004; Ahamed & Ohtomi, 2011). The present work on *Osteobrama vigorsii* (Sykes, 1839) reflects that it is under the fishing pressure from the study area is the Nira River Bhor, Maharashtra.

CONCLUSION

The present study on *Osteobrama vigorsii* (Sykes, 1839) from the Nira River, can help the fishery units, plan strategies whereby the over-exploitation of the endemic fish from their natural habitat can be restricted. It will also help in resurfacing the endemic species in their natural habitat and from being extinct shortly. The study would help in instituting an awareness program to guide the fishermen in selecting proper mesh size gears thereby allowing the younger fishes to escape and thereby harvest the older ones.

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ETHICS STATEMENT: The fish was collected from the local fish market which were brought to sell. Hence there is no Ethical issue regarding the work.

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