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Reproductive Capacity of *Noemacheilus rupicola and Sex Ratio* from River Yamuna, Uttarakhand, India

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ABSTRACT

The current study focuses on *Noemacheilus rupicola* (McClelland) fecundity in the snow-fed Yamuna river in India's Doon valley. In fish measuring 55mm to 75mm in length, the reproductive capacity of *Noemacheilus rupicola* (McClelland) varied from 152 to 1612. The weight of the fish influences reproductive capacity more than any other body parameter. In *N. rupicola*, the average sex ratio was 1.60 male: 1.00 female. The overall sex ratio was determined to be non-significant.

Keywords: *Noemacheilus rupicola* (McClelland), Reproductive capacity, Sex-ratio, river Yamuna, India.

INTRODUCTION

Hillstream fish *Noemacheilus rupicola* is an ornamental species. It inhabits the small hill stream and some snow-fed rivers of the Garhwal Himalaya. Understanding a fish's reproductive capacity is essential to successful fisheries management and exploitation. According to Qasim and Qayyums (1962), the success or failure of a species in any waterbody is primarily determined by its spawning potential. Fecundity studies assist in assessing the reproductive capacity of freshwater prawns or fish in general, as well as wide stock development and management plans for prawn or fish hatcheries, as well as stock size assessment of their natural population (Bahuguna and Kumar 2011a; Bahuguna, 2013).

Dobriyal et al. (2007) observed sexual dimorphism in *Puntius conchonius,* a freshwater fish from the Garhwal Himalaya. Bahuguna et al. (2010) reported sexual dimorphism in *Puntius ticto* in the Kumaun area of Uttarakhand. The sexually dimorphic nature of *Noemacheilus rupicola* has not been observed in the River Yamuna in Uttarakhand, India.

Some ichthyologists contributed to research on the reproductive capacity of some fish species in Indian rivers (Bhatnagar 1964; Sinha 1972; Bnegal 1978; Joshi and Khanna 1980; Pathani 1981; Singh et al., 1982; Dobriyal and Singh 1987,1989; Islam and Hossain 1990; Kumar et al., 2006a-b; Bahuguna et al., 2007, 2009, 2010a, 2010c, 2021a-b-c; Dobriyal et al., 2000, 2003, 2010; Joshi et al., 2010, 2013; Bahuguna and Kumar 2011b; Krishna et al., 2011a; Bahuguna 2012; Dobriyal 2012; Rayal et al., 2021a).

Bisht et al., 2005; Bahuguna and Kumar, 2011; Bahuguna et al., 2010b, 2010d, 2011; Krishna et al., 2011b; Bahuguna 2013; Jameela and Ramchandran 2005; Rayal et al., 2021d-f, etc. are some fish biologists who worked on sex-ratio investigations of Garhwal hill-stream freshwater fish and prawn fauna. The current study was in continuation with the previous investigations and it comprises an understanding of the reproductive capacity and sex ratio of freshwater fish *Noemacheilus rupicola* in the River Yamuna from Uttrakhand, India.

MATERIAL & METHODS

Traditional fishing gear was used to catch *Noemacheilus rupicola,* as proposed by Bahuguna et al., 2010d; Bahuguna and Joshi, 2012; Bahuguna 2020; Bahuguna 2021; Rayal 2021a-b. When the sample arrived at the laboratory, it was subsequently preserved with an 8% formalin solution. From January 2021 to December 2021, a total of 111 fish were captured with the help of local fisherman's catch in the snow-fed river Yamuna from Uttarakhand. The Kulhaal site was chosen for sampling. To the nearest 1mm, the overall length was measured. The total body weight was measured using a digital balance with a 0.001 mg precision. Each ovary's length and weight were calculated to the nearest 1mm and 0.001mg, respectively. The anterior, middle, and posterior regions are used to determine fecundity. The anterior, middle and posterior parts of the ovary were sampled for fecundity assessment, and the number of ova in each sample was counted using a binocular microscope.

The sex ratios were calculated for the entire period of the study and their significance was assessed using the Chi-Square test (χ^2) using the following equation:

$$\chi^2 = \Sigma (O-E)^2/E,$$

Where;

O = Observed value

E = Expected value.

Significance was determined by using the table value at the $F_{0.05}$ variable.

RESULTS

Table-1 shows the reproductive capacity as well as different body parameters of *N. rupicola*. Fish lengths ranged from 55mm to 75mm, and body weights ranged from 1612mg to 4162mg. The fish with the lowest reproductive capacity 152 had a length of 55mm and a bodyweight of 1612mg. The maximum reproductive capacity (1612) was estimated in fish measuring 75mm in length and weighing 4162mg. The straight-line relationships of reproductive capacity with different body parameters were determined and are presented in Figs. 1-4. Mathematical equation (RC = A + b. x) obtained were as follow:

RC = -3899.5 + 68.504 FL	r= 0.9545	r^2 = 0.9112
RC = -740.34 + 0.5141 FW	r= 0.9992	r^2 = 0.9985
RC = -785.42 + 90.565 OL	r= 0.9839	r^2 = 0.9682
RC = -229.49 + 1.7808 OW	r= 0.9708	r^2 = 0.9426

Where:

RC = Reproductive capacity

FL = Fish length

FW = Fish weight

OL = Ovary length

OW = Ovary weight

r = coefficient of correlation.

The reproductive capacity was more dependent on the fish weight (r= 0.9992) than on the other fish body parameters.

Out of 111 individuals, 53 were females and the rest 58 were males. Maximum fish were collected in the month of July (13 individuals) and minimum in the months of January, May, and September (07 individuals in each). The highest sex ratio was recorded as 1.60 male:1.00 female in the month of July (Table-2).

DISCUSSION

Noemacheilus rupicola is an ornamental snow-fed fish with a good reproductive capacity considering its body length. The fishes in snow-fed rivers show great variation in their breeding potential. Rayal et al. (2021a) observed the fecundity of the snow-fed minor carp *Barilius bendelisis* from the river Yamuna, in Uttarakhand, India. The fecundity of the snow-fed water fish varies from a lowest 162 to a highest 4203, the fish measuring 58mm to 120mm respectively. It is observed that reproductive capacity was maximum depending upon the fish weight than any other body parameters.

Table-1: Reproductive capacity of snow-fed fish *Noemacheilus rupicola* from River Yamuna.

Fish Length (mm)	Fish weight (mg)	Ovary Length (mm)	Ovary weight (mg)	Fecundity
55-59	1612-2010	8-11	190-215	152-209
57.67±0.35	1820±210.17	10.± 0.50	201.51± 9.60	176±20.11
61-65	1898-2244	10-14	258-367	220-368
63.75±0.41	2022.3±185.25	12.35 ± 1.02	312.65± 35.15	324.31±45.50
66-69	2363-2930	14-19	349-678	429 -775
67.19±0.72	2631.56±271.85	16.65± 0.72	568.70± 29.40	608± 76.15
71-75	3484-4162	20-23	641-997	845-1612
73.27± 0.50	3841.32±212.34	21.55± 0.70	779.15± 95.75	1234± 321

Min – Max; Average ± SD*

Table-2: Month-wise Sex ratio of *Noemacheilus rupicola* from January 2021 to December 2021 from spring-fed river Aasan.

Month	Total no. of fish	M	F	% of M	% of F	Sex Ratio M	Sex Ratio F	χ^2	Remarks
January	07	4	3	57.14	42.86	1.33	1.00	0.071	NS
February	08	4	4	50	50	1.00	1.00	0	*
March	11	5	6	45.45	54.55	1.00	1.2	0.045	NS
April	10	5	5	50.00	50.00	1.00	1.00	0	*
May	07	4	3	57.14	42.86	1.33	1.0	0.071	NS
June	08	3	5	37.5	65.5	1.00	1.66	0.25	NS
July	13	8	5	61.54	38.46	1.60	1.0	0.346	NS
August	10	6	4	60	40	1.50	1.00	0.2	NS
September	07	4	3	57.14	42.86	1.33	1.00	0.071	NS
October	10	5	5	50	50	1.00	1.00	0	*
November	08	4	4	50	50	1.00	1.00	0	*
December	12	6	6	54.55	45.45	1.00	1.00	0.000	*
Total	111	58	53	52.25	47.75	1.09	1.00	0.115	NS

M = Male fish; F = Female fish; χ^2 = Chi square value; NS = Non-Significant.

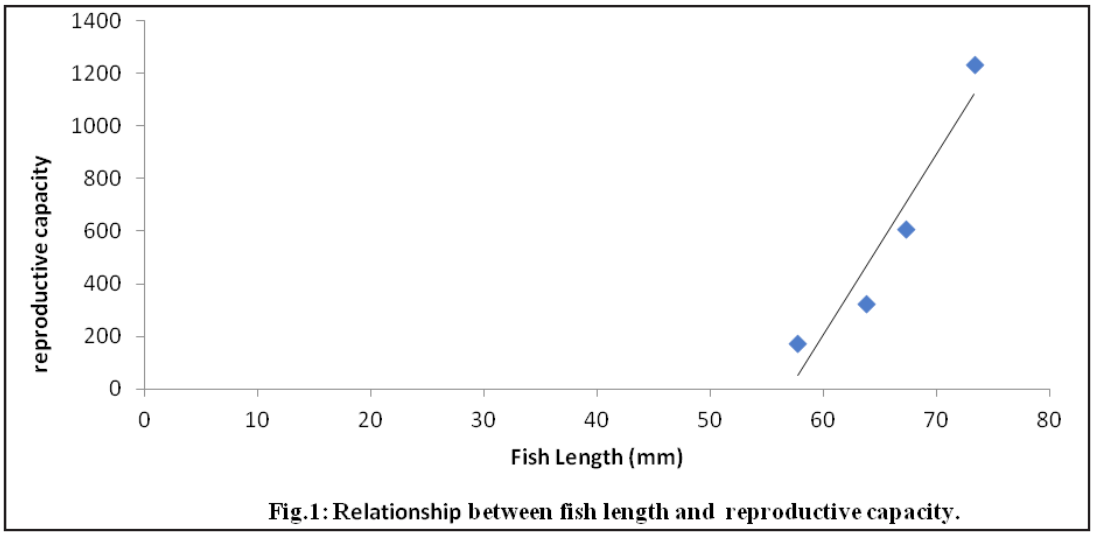

Fig.1: Relationship between fish length and reproductive capacity.

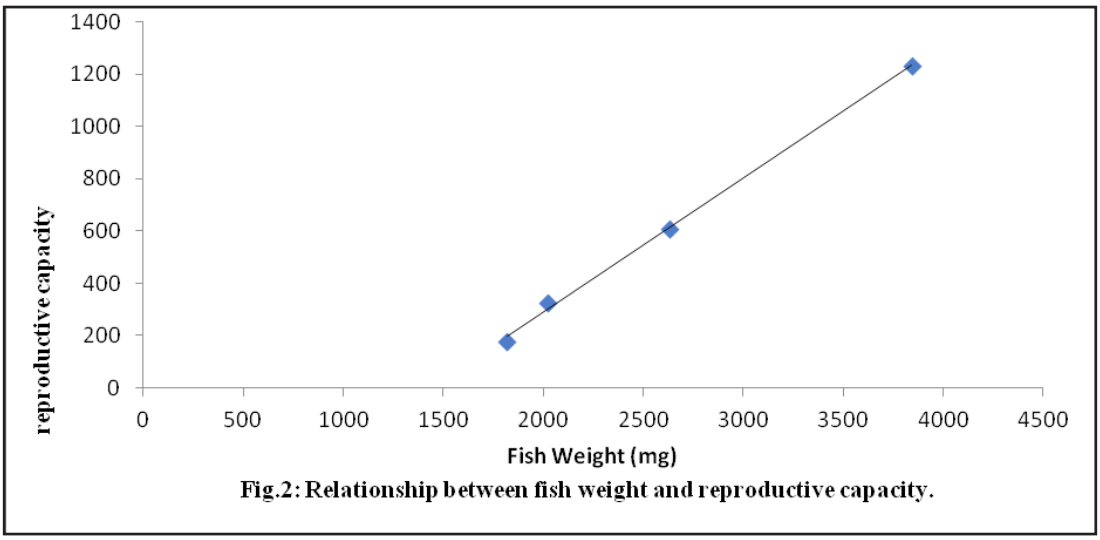

Fig.2: Relationship between fish weight and reproductive capacity.

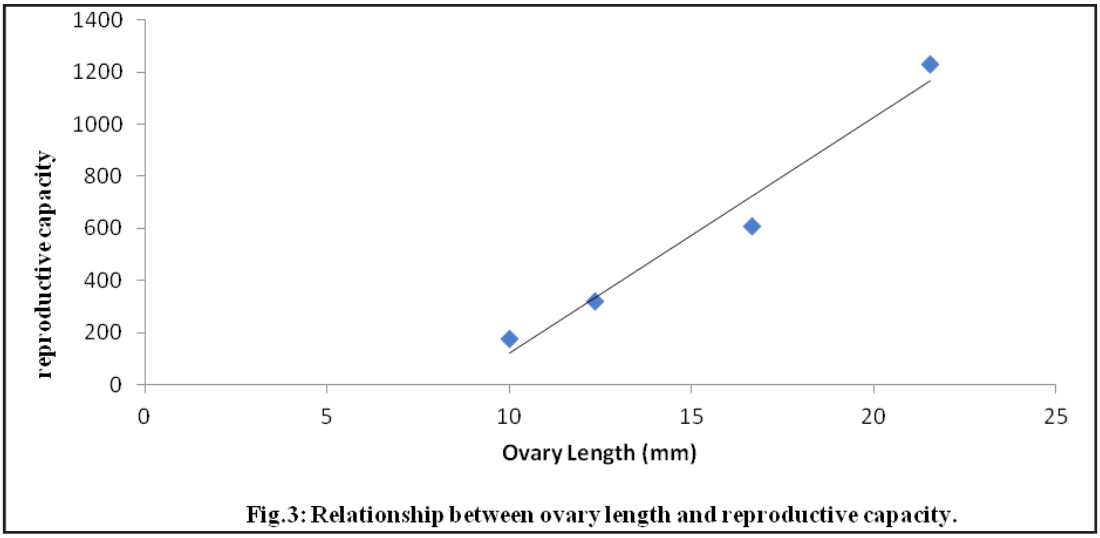

Fig.3: Relationship between ovary length and reproductive capacity.

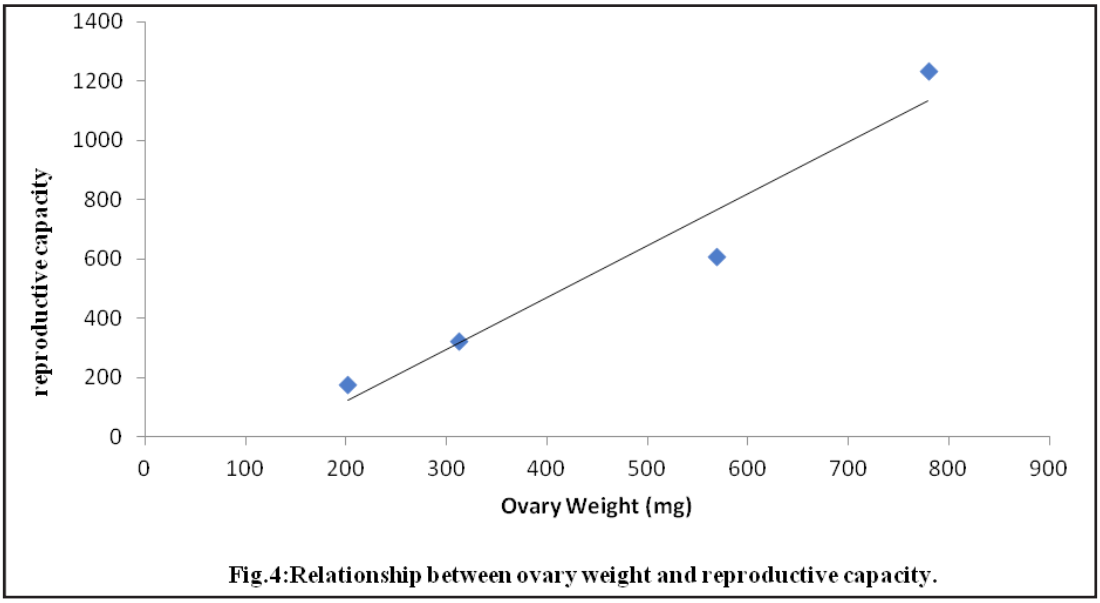

Fig.4:Relationship between ovary weight and reproductive capacity.

Kumar et al. (2006a) noticed that the fecundity of *Botia dayi* Hora was 2225 to 8840 in the length groups ranging from 10.1 to 14.5 cm and weighing 17.72gm to 38.6gm. According to Bahuguna et al. (2009), the fecundity of *B.vagra* varies from a minimum of 510 to a maximum of 7214 in the length group ranging from 55-89mm from the Garhwal region. Bahuguna et al. (2010c), studied the reproductive capacity and sex ratio of a beautiful hill-stream loach fish *Noemacheilus denisoni Day* from river Mandal in Garhwal Himalaya. The maximum fecundity was 3729 calculated for a fish measuring 83mm and weighing 5500mg whereas the minimum fecundity was 300 in the fish measuring 63mm and weighing 2601mg respectively.

Puntius ticto was in the range of 50 to 78mm in length and 2519.86 to 8212.37mg in body weight. The lowest reproductive potential was 383 calculated for a fish 50mm and weighing 2519.86mg whereas the highest reproductive potential was 1240 calculated in fish measuring 78mm and weighing 8212.37mg (Bahuguna et al., 2021b). Bahuguna and Dobriyal (2019) reported from the Mandal river, that the fecundity of *Puntius conchonius* varies from 360 to 1727 in the length groups ranging from 52 to 79mm. Rayal et al. (2021a) reported that the number of fecundity varied from 162 to 4203 and fish measuring 58m to 120mm from River Yamuna. In the present study, low fecundity was observed in fish found in snow-fed rivers as compared to fishes in spring-fed conditions.

In fishes, habitat and area, as well as other factors such as seasonal effect, the influence of riparian vegetation (Sagir et al., 2018; Baluni and Chandola, 2019), availability of the food like microzoobenthos (Pesic et al., 2019a-b,

2020a-b; Bahuguna et al., 2019; Bahuguna and Dobriyal, 2020; Bahuguna et al., 2020a-b; Negi et al., 2021a-b), macrozoobenthos (Dobriyal et al., 2009, 2011; Bahuguna et al., 2019; Mamgain et al., 2021), periphytons (Baluni et al., 2017, 2018; Bahuguna and Baluni 2019; Baluni 2020), gonad maturity (Bahuguna and Kumar, 2011; Dobriyal, 2013; Bahuguna and Dobriyal, 2013; Rayal et al., 2020; 2021b;), Ageing biology (Tesch, 1971; Dobriyal et al. 2004; Bahuguna 2013; Bahuguna and Balodi, 2015; Joshi et al., 2017; Bahuguna and Dobriyal, 2019), sex, health and differences in the estimated length range of the fish, etc. may affect the length-weight relationship (Bahuguna et al., 2005, 2009a-b, 2017, 2021a-b, Kumar et al., 2006; Bahuguna and Joshi, 2010; Joshi et al., 2009, 2014; Rashid et al., 2019). In the current investigation, four linear relationships for *Noemacheilus rupicola* were observed, each with a high correlation coefficient value. Fish weight was shown to have a greater impact on fecundity than any other body parameter.

In the present study, *N. rupicola* had an overall average sex ratio of 1.60 male: 1.00 female. The overall sex ratio was found to be non-significant. In *P. vittatus*, the male-female sex ratio was determined to be 1:2 (Jameela and Ramchandran, 2005). According to Bhatnagar, the presence of more females in most of the months might be related to female susceptibility (1964). In *N. multifasciatus*, Bahuguna et al. (2021c) reported a 1.66 female to 1.00 male ratio. In *P. stigma*, Islam and Hossain (1990) found a 1:1 proportion. *Puntius conchonius* from the Mandal River in the Garhwal Himalaya was found to have a 01 male: 1.17 female ratio (Bahuguna and Dobriyal, 2019).

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