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Reproductive biology of freshwater murrel, *Channa punctatus* (Bloch, 1793) from river Varuna (A tributary of Ganga River) in India

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Abstract: *Aspects of reproductive biology such as sex ratio, size at first maturity, spawning, gonadosomatic index, ova diameter and fecundity of Channa punctatus from river Varuna were investigated for a period from March 2007 to February 2008. On the basis of monthly variation, the overall sex ratio (M: F) was 1: 1.33. Chi-square test showed no significant departure in sex ratio. Five stages of maturity were recognized in both the sexes. For the population, 50% of individuals belonging to the size of 125 mm were mature for the first time. The spawning season extends from June to October. Gonadosomatic index reaches maximum in August. Only one batch of ova is produced to be released in one spawning act. Absolute fecundity varied from 3,678-27,853 with an average value of 12,546 in the individuals ranging between 116-231mm in length and 18-139.8 g in weight. Length wise, the average relative fecundity recorded was 708 eggs/mm body length and weight wise it was 175 eggs/g body weight of the fish. Relative fecundity per mm of ovary length was 2,729 and per gm of ovary weight was 5,449. Mean absolute fecundity increased with total length, body weight, ovary length, ovary weight and exhibit linear regression equation derived from the logarithmic transformed data. The results of the present study will be useful for selective breeding programme, conservation and sustainable fishery management of C. punctatus in its natural habitat.*

Key Words: *Channa punctatus*, River Varuna, Maturity, Spawning, Fecundity

Introduction

The spotted murrel, *Channa punctatus* (Bloch, 1793), is generally a warm water teleost widely available in lakes, ponds and rivers as well as in confined water bodies of Southeast Asia (Jayaram, 1999). It prefers stagnant water in muddy streams (Talwar and Jhingran, 1991). *C. punctatus* contributes to considerable landings among inland fishes available in local markets and fetches a good price due to taste and fewer intramuscular spines (Haniffa *et al*., 2003), but has been identified as a threatened species as a result of habitation loss and pollution (CAMP Report, 1998).

Studies on the reproductive life history parameters of fish are essential for evaluating the commercial potentialities of its stock, life history, culture practice and management (Doha and Hye, 1970). Such studies in species also help to reveal differences between stocks from different areas (Begg, 1998). The determination of spawning and frequency of reproduction within the season and within the life-cycle of the fish are prerequisites in assessing the reproductive potential of a population (Jhingran

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and Verma, 1972). The knowledge on the fish length at first sexual maturity is indispensable in order to estimate size of the spawning stock (Neja, 1992). Size at maturation are tightly linked to lifetime fecundity of individuals (Stearns, 1992; Bernardo, 1993), and therefore to stock productivity. Assessing these parameters in commercially exploited fish stocks is therefore of high importance (Marshall *et al*., 1998; Murawski *et al*., 2001). The gonadosomatic index is a good indicator of reproductive activity, being used to determine the stages of gonadal maturation (Le Cren, 1951; Hojo *et al*., 2004). In addition, the GSI provides a basis for determining the period of greatest reproductive intensity. These strategies can vary within a species, even within a sex and may occur in most taxa (Gross, 1996). Fecundity is an important index of the biology of great practical utility in evaluating the commercial potentialities of its stock, variations in the level of fish population, life history, fish culture for proper planning of the hatching and nursery operations and actual management of the fishery (Lagler, 1956; Doha and Hye, 1970; Marimuthu *et al*., 2009). The number and size of the brood stock to be maintained for achieving a certain set target of fish seed production related to life processes such as age and growth also calls for the knowledge of the fecundity of the species in the question (Ludwig and Lange, 1975). There are several studies on the reproductive pattern of other species of the genus *Channa*: *C. marulius* (Khan, 1924; Quasim and Qayyum, 1962; Devraj, 1973; Parameswaran and Murugesan, 1976), *C. striata* (Raj, 1916; Khan, 1924; Quasim and Qayyum, 1962; Parameswaran and Murugesan, 1976) and *C. gachua* (Mishra, 1991; Routray and Nanda, 1993).

C. punctatus is said to be a prolific breeder, with pair of spawning (in India) throughout the year, peaking before and during monsoon months (Jhingran, 1984; Talwar and Jhingran, 1992). The breeding habits and spawning season on this species was studied by a number of workers such as Raj (1916) in Madras, Khan (1924) in Punjab, Mookerjee (1945) in Bengal, Jones (1946) in Madras, Hosaini and Rahimullah (1946) in Hyderabad, Tandon (1963) in Punjab, Qayyam and Quasim (1964) in Aligarh, Parameswaran and Murugesan (1976) in the swamps of Karnataka, Reddy (1979) in Guntur, Andhra Pradesh, Bhuiyan and Rahman (1984) in Bangladesh, Lowe-McConnell (1987) in Punjab and Shrestha (1990) in Nepal. Fecundity of this species was studied by Qasim and Qayyam (1963) from Aligarh, Dehadrai (1976) from swamps and derelict-waters of Barrackpore, Rath and Hejmadi (1976) from Bhuvaneswar and Reddy and Rao (1989) from a polluted lake of Hussain Sagar, Hyderabad.

In the present study, observations were therefore made on the reproductive parameters such as sex ratio, maturity stages, size at first maturity, spawning, gonado-somatic index, ova diameter and fecundity of *C. punctatus* to fulfill the vacuum of knowledge on the reproductive biology of the population of wild freshwater fish from the river Varuna which have not been reported so far from particular water body. This study shall provide information to impose adequate regulations for proper conservation and management of its fishery in river Varuna and similar freshwater ecological habitats.

Materials and Methods

The present study is based on the sampling of 372 specimens: 160 males and 212 females ranging in total length from 68 mm to 231 mm collected from river Varuna (tributary of Ganga River) passing from Phulpur situated in Allahabad, Uttar Pradesh (Latitude 25^0 33' N and Longitude 82^0 5' E) by using gill nets from March, 2007 to February, 2008. Specimens collected were measured for total length (mm),

total mass (g), ovaries length (mm) and mass (g), and gonad maturation stage (Braga, 1990). The specimens were than preserved in 10% formalin for further studies.

Maturity and Spawning.

Sex Ratio: The sex and maturation stage of each specimen was determined microscopically, considering coloration, transparency, superficial vascularization, and, for ovaries, the visualization and appearance of the ova. The maturity stages of the male and female gonads were classified according to Biswas (1993) and computed monthly to ascertain the breeding seasons. The overall percentage frequencies of the stages were also estimated.

Size at First Maturity: Size at first maturity (for both sexes) was determined from the length measurements of the specimens and observation of maturity stages. For the population, size at first maturity was obtained from the smallest mean size that gave 50% of mature individuals computed from the length frequency records of mature fish (Ellis, 1971).

Spawning Season: Various stages of maturity were grouped in different months and spawning season was determined by the occurrence of ripe (stage IV) individuals.

Gonado Somatic Index (GSI). The GSI was calculated according to Vazzoler (1996):

$$GSI = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \times 100$$

Gonado-somatic index was plotted monthly to identify the spawning seasons.

Diameter of ova. Intra-ovarian eggs were taken out and their diameter was measured under a compound microscope with the help of an ocular micrometer at a set magnification, each micrometer division representing 0.026 mm, as suggested by Clark (1934), and the measurements were grouped into 9 ocular divisions and the percentage were calculated monthly.

Fecundity: The fecundity studies were based on the examination of ripe gonads. The mature ovaries were taken out from formalin, washed with water, kept on a blotting paper until the moisture was removed. 100 mg sub-samples of eggs were then carefully detached from the anterior, middle and posterior regions of each ovary with forceps and needle and counted directly under a binocular stereo microscope to determine fecundity (Otobo, 1978). The absolute fecundity of the fish was obtained by using the formula given by LeCren, (1951):

$$F = \frac{\text{Gonad Weight}}{\text{Sample Weight}} \times 100$$

Where F is the fecundity and N is the number of eggs in the sample.

Relative fecundities (number of ova in unit body length, body weight, ovary length, and ovary weight) were also recorded. In addition, relationship of fecundity with various body dimensions like body length, body weight, ovary length and ovary weight was then log transformed and relationships fitted by least squares regression equation (Bagenal, 1978):

$$\text{Log } F = \log a + b \log X$$

Where:

F = Clutch size (fecundity); X = Length/Weight; a = Regression constant and b = Regression coefficient

Relative fecundity was obtained as the number of eggs per unit length (cm) and number of eggs per unit weight (g) of fish (Ekanem, 2000).

A Student's t-test (Sprinthall, 2007) was used to check if the estimated b-values differed significantly from the isometric value (H_0: b = 3) ($P < 0.05$).

Results and Discussion

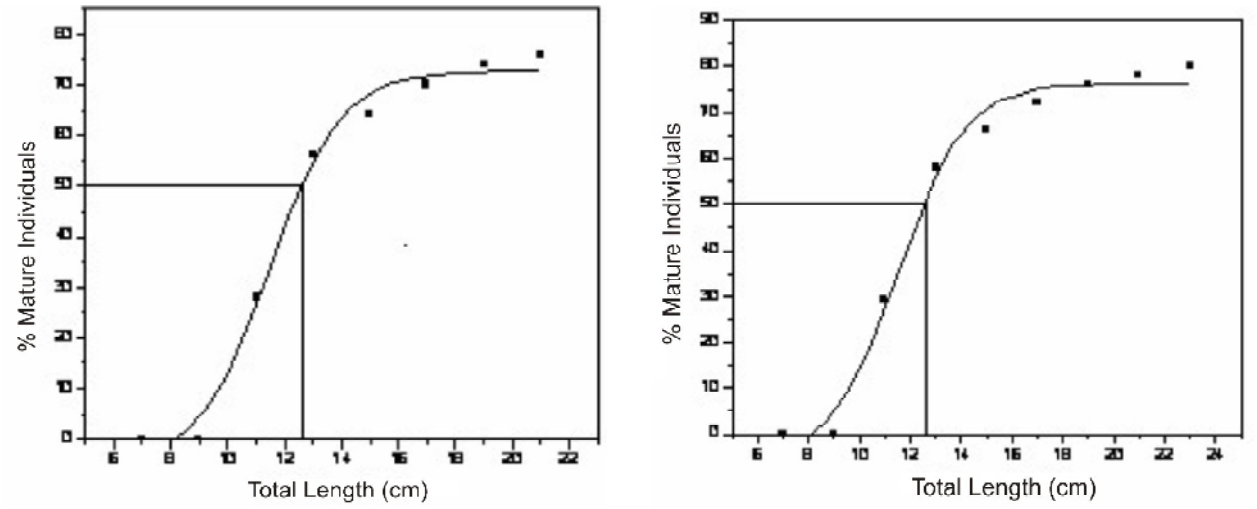
Sex ratio. Monthly variations in abundance of male and female individuals of *C. punctatus* collected from river Varuna shows overall predominance of female individuals over male. The sex ratio (M: F) varied from 1:0.90 to 1:1.80, with an average mean value being 1:1.33 (Table 1). The ratio was tested by chi-square analysis for differences from hypothetical ratio 1:1, which showed no significant departure from this hypothetical ratio. The predominance of females over males may probably be due to differential catching efficiency (Pathak and Jhingran, 1977). Several other reasons have been suggested for the dominance of one sex in the catches: segregations of sexes through various periods of the year; size differences; gear selectivity related to sex differences in morphological and physiological activity; and differences either by natural or by artificial mortality. The results of the present study are very similar to those obtained by Bhatt (1968) in *Heteropneustes fossilis*, Prasadan (1971) in *Etroplus suratensis*, Bhatnagar (1972) in *Labeo fimbriatus*, Pathak and Jhingran (1977), Khumar and Siddiqui (1991) in *Labeo calbasu* and Neja (1992) in *Scomber scombrus*.

Chi- square value was significantly different at 5% level, the tabular value being 3.841

Size at First Maturity. To determine the size at which *C. punctatus* mature first, data pertaining to maturing individuals were tabulated into various length groups of 20 mm class interval. The percentage of individuals maturing at each length groups has been depicted in Fig. 1. It is evident from the figure that no mature male and female (Stage IV) was encountered in the sample below the mean length of 110 mm. Fifty percent of male and female individuals were mature at a mean length of 125 mm during the spawning season which indicates its size at first maturity. It can be stated that first maturity is attained at this length group when the fish is in the first year of its life (Qayyum and Qasim, 1962; Arumugam, 1966; Parameswaran, 1975). Reddy (1979) considers that *C. punctatus* attains first maturity at a length of 120 mm at Guntur.

Table 1. Monthly fluctuations of sexes in the samples of *C. punctatus* collected from river Varuna

Months	Males	Females	% of Males	% of Females	Combined No.	Sex Ratio (M:F)	Chi-square (χ^2)
January	16	26	38.09	61.91	42	1:1.6	2.38
February	14	19	42.42	57.58	33	1:1.4	0.75
March	11	11	50.00	50.00	22	1:1.0	0.0
April	14	16	46.66	53.34	30	1:1.4	0.13
May	12	15	44.44	55.55	27	1:1.3	0.33
June	11	14	44.00	56.00	25	1:1.3	0.36
July	09	16	36.00	64.00	25	1:1.8	2.12
August	12	11	52.17	47.83	23	1:0.9	0.04
September	17	22	43.58	56.42	39	1:1.3	0.65
October	13	17	43.33	56.67	30	1:1.3	0.54
November	21	35	37.50	62.50	56	1:1.7	3.74
December	10	10	50.00	50.00	20	1:1.0	0.0
Total	160	212	43.01	56.99	372	1: 1.33	0.33



(A) Male (B) Female

Fig. 1. Cumulative relative frequency of the length at first maturity *C. punctatus* in different size groups collected from river Varuna: (A) Male (B) Female, the 50% maturity is marked by thin horizontal line

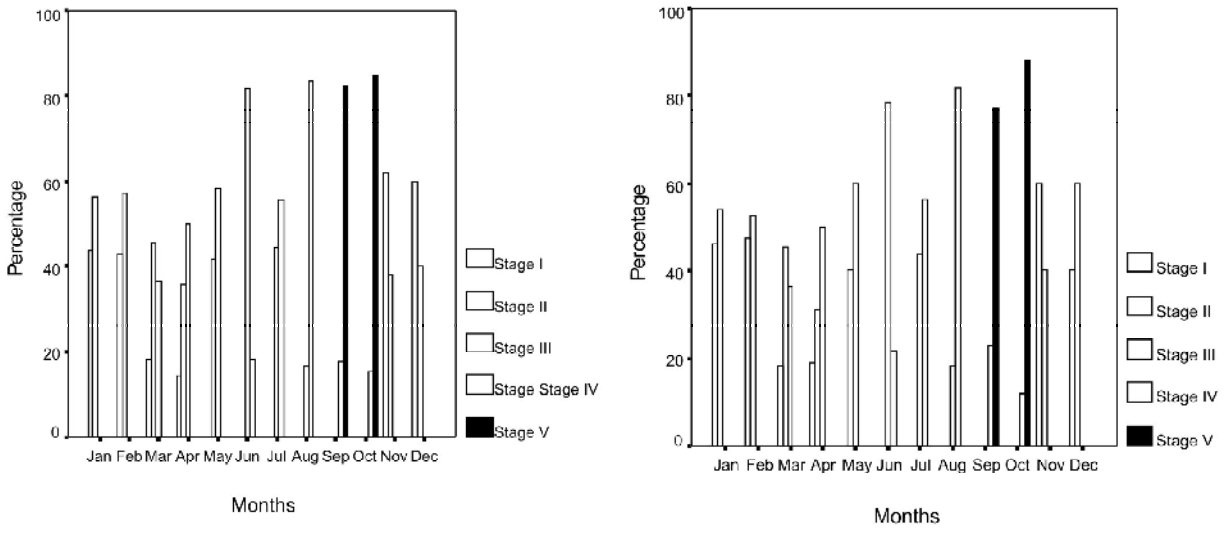
Spawning Season: Stage IV gonads were recorded from June to October, which obviously is the spawning season (Fig. 2). However, the peak spawning season might be in August as more than 80% of ripe gonads were recorded during this month.

The observations regarding the spawning season are further supported by the studies on the GSI (Fig. 3) and size progression of ova during different months (Fig. 4).

Gonadosomatic Index (GSI). The lowest values of GSI were recorded in both sexes from November to February and gradually increases from March, when the gonads begin to mature, to reach the maximum in August, when most of the adults are fully mature (stage IV). In September there is noticeable fall due to the presence of spent adults (Fig. 3).

Frequency of Spawning. The diameter of intra-ovarian ova from March to October and their percentage frequency distribution are presented in Fig. 4. In the March when the fishes reach ripening stage, ova size ranged from 0.34-0.44 mm. In June when fishes reach the spawning stage, ova size ranged from 0.56-0.66 mm. Fully developed and ripe eggs were ranged from 0.67-1.10 mm which was recorded during the period of July to October.

In the present study, stage IV (ripe) gonads were witnessed during the period of June to October indicating spawning period of the fish. The observation regarding the spawning season was further supported by the gonadosomatic index (GSI) and the studies on size progression of ova during different months. Qasim and Qayyum (1962) reported that spawning of *C. punctatus* is linked with monsoon and post monsoon months in north India. Various workers have reported different breeding seasons of this fish at different locations: Raj (1916) reported spawning period during January to February and July to August in Madras; Khan (1924) and Tandon (1963) reported spawning period during April to August respectively from Punjab; Mookrjee (1945) reported June-August as spawning period in Bengal; Hosaini and Rahimullah (1946) suggested spawning period throughout the year in Hyderabad; reported April to August as spawning period in Karnataka; Reddy (1979) stated that spawning occurs once per year during July to October, with maximal spawning between July and August in Andhra Pradesh Province, southeastern India, Lowe-



(A) Male (B) Female

Fig. 2. Maturity stages of *C. punctatus* in different months collected from river Varuna: (A) Male (B) Female

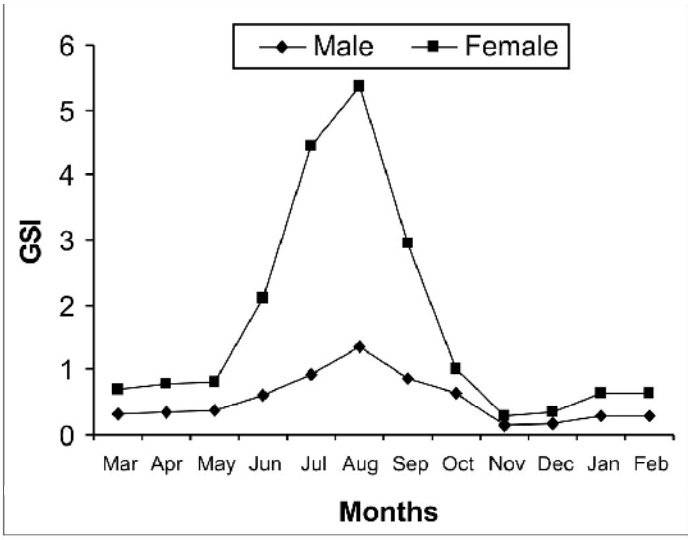


Fig. 3. Gonadosomatic index of male and female *C. punctatus* in different months in the samples collected from river Varuna

McConnell (1987) gave April to July as the spawning period in Punjab Province. India, cited brood size as up to 500 individuals; Bhuiyan and Rahman (1984) reported a single annual spawning between April and August in Bangladesh and spawning in southern Nepal occurs from June until August (Shrestha, 1990).

Fecundity. The number of ripe and unspawned eggs (absolute fecundity) varied from 3,678-27,853 with an average value of 12,546 in the individuals of *C. punctatus* ranging between 116-231 mm in length and 18-139.8 g in weight. The largest individual fish with total length 231 mm and body weight 139.8 g was observed to carry 27,853 eggs and the smallest sized fish with total length of 116 mm and body weight 18 g was found to carry 3,678 eggs. Length wise,

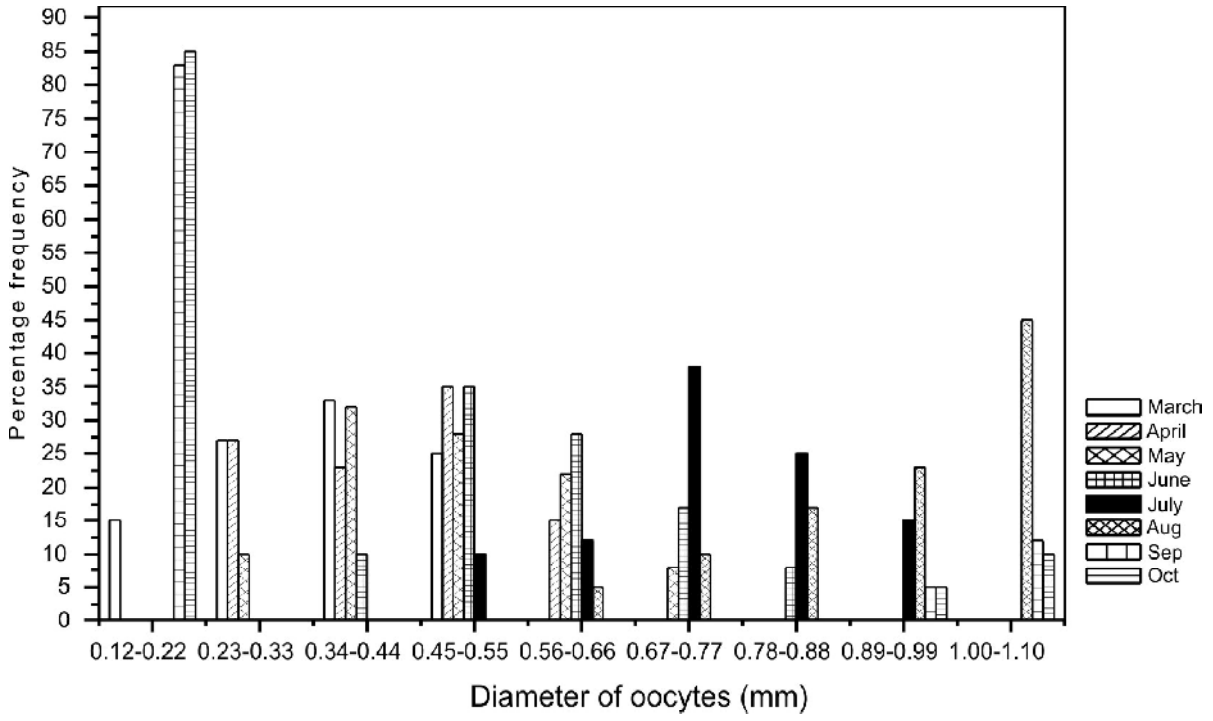


Fig. 4. Size frequency distribution of maturing oocytes of *C. punctatus* from March to October collected from river Varuna

the average relative fecundity recorded was 708 eggs/mm body length and weight wise it was 175eggs/g body weight of the fish. For further insight into the phenomenon of fecundity, ovaries ranging between 22-68 mm in size and 0.49-4.80 g in weight were also studied. It was observed that the number of ova per mm of ovary length was 2,729 and per gm of ovary weight was 5,449.

Fecundity of this fish ranged from 2,300-29,600 from Aligarh (Qasim and Qayyum, 1963) and 2,477-25,483 from swamps and derelict (Dehadrai 1976), somewhat similar to the present record. However, Rath and Hajmadi (1976) found 733-9,225 eggs from Bhubaneswar and Reddy and Rao (1989) recorded a range of 1,004-9,869 from Hussain Sagar, Hyderabad. Doha and Hye (1970) reported that the change in the fecundity estimation of two different populations is very common and observed that the number of eggs produced in fishes by an individual female is dependent on several factors like size, age, space, food availability, season, climatic conditions, environmental habitat, nutritional status and genetic potential (Mookeerjee and Mazumder, 1946; Bagenal, 1957; Bromage *et al*., 1992). In the present study, variation in fecundity was not found in the female with equal length and body weight. The present finding is similar to those of Qasim and Qayyum (1963) and Dehadrai (1976). However, Musa and Bhuiyan (2007) in *Mystus bleekeri* and Marimuthu *et al*. (2009) in *Anabas testudineus* reported variation in the fecundity even with equal length and body weight. Comparison of the quantitative variation in fecundity with both length as well as weight of the ovary revealed a marked increase in egg production with increase in ovary length. The results of the present study are very similar to those obtained by Pathak and Jhingran (1977) in *Labeo calbasu*, Kabir *et al*. (1998) in *Gudusia chapra*, Narejo (2003) in *Monopterus cuchia* and

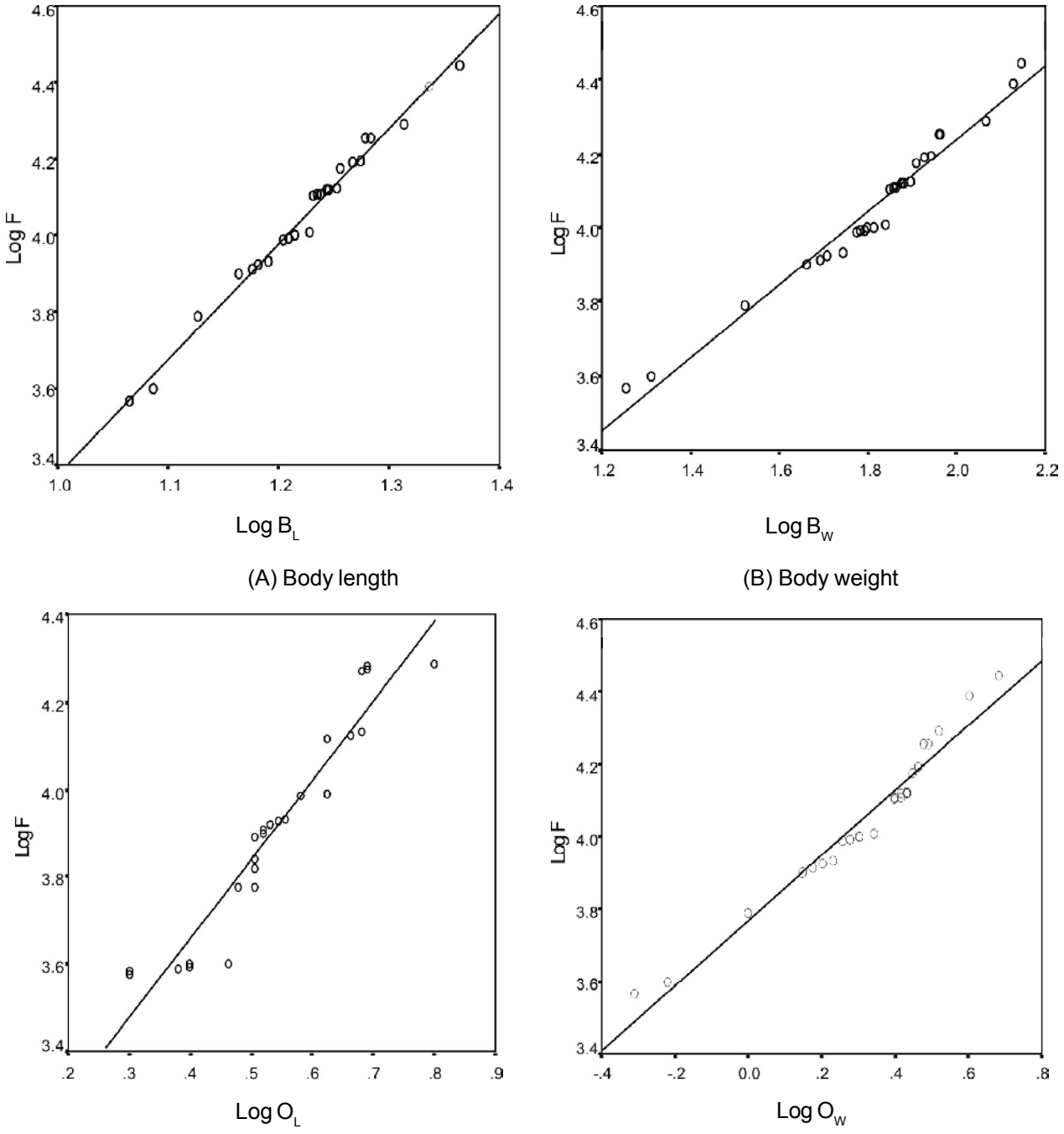


Fig. 5. Relationship between fecundity and (A) body length (B) body weight (C) ovary length (D) ovary weight of *C. punctatus* collected from river Varuna

Mastacembelus armatus and Rahman *et al*., (2006) in *Mastacembelus armatus*. The number of eggs per unit body length exceeded the number of eggs per unit body weight. Similar results were obtained by Pathani, (1981) in *Tor putitora*, Piska and Waghray, (1989) in *Salmostoma bacaila*.

The fecundity and corresponding total body length, total body weight, ovary length and ovary

weight of fish were plotted as a scatter diagram (Fig. 5). In the logarithmic form the relationship between fecundity and different total body length (B_L), total body weight (B_W), ovary length (O_L) and ovary weight (O_W) of fish can be expressed in form of regression equation and correlation coefficient (r) as:

$\text{Log } F = 0.354 + 3.020 \text{ Log } B_L \qquad r = 0.993^*$

$\text{Log } F = 2.269 + 0.985 \text{ Log } B_W \qquad r = 0.984^*$

$\text{Log } F = 2.851 + 1.909 \text{ Log } O_L \qquad r = 0.983^*$

$\text{Log } F = 3.767 + 0.896 \text{ Log } O_W \qquad r = 0.979^*$

*Significant at $P<0.05$

The value of coefficient of the regression equation 'b' for fecundity-body length relationship was found to be 3.020. It has been shown by Kesteven (1942) that the number of ova holds some exponential relation with the length of the fish in the same way as does the weight. Piska and Waghray (1989) and Hoda and Qureshi (1989) observed value of 'b' to be 3 in *S. bacaila* and *L. klunzingeri*, respectively. The value of 'b' for fecundity-body weight was much lower than that for the fecundity-body length relationship, suggesting that the rate of egg production in relation to increase in weight of this fish was lower than the rate of egg production in relation to increase in its length. Allen (1951) found that the relationship between number of ova and fish weight was curvilinear, but when he plotted the egg number against fork length it gave a straight line. Simpson (1951) found that fecundity is related nearly to the cube of the length and is thus directly proportional to fish weight as will be observed theoretically because that number of ova is dependent upon the volume of ovary and so should better correlated with the cube of the length. However, Smith (1947) stated that the number of ova was "related to the weight of volume of the fish than to the length".

The studies on reproductive biology of *C. punctatus* are lacking though few initiatives were undertaken by earlier workers. Our new approach concerned in this study on reproductive parameters such as maturity stages, size at first maturity, GSI and fecundity will be useful in assessing the reproductive potential of the studied fish. The study thus provides fundamental information on the reproductive pattern of *C. punctatus* to assist in understanding useful biological processes that may be responsible for maintaining the underlying stock structure for proper conservation and management in its natural habitat.

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