E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(4): 235-238

www.fisheriesjournal.com
Received: 22-05-2018
Accepted: 24-06-2018

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Maturation Biology And Spawning Ethos Of A Hillstream Catfish *Pseudecheneis Sulcatus* (McClelland) In A Glacier-Fed Stream Alaknanda, Garhwal Himalaya, Uttarakhand

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Abstract
Pseudecheneis sulcatus (McClelland) is an important catfish of the Himalayan rivers which is well adapted for lotic environments. Present communication deals with its maturation biology and spawning behavior based on the microscopic and macroscopic observations to decide its maturity stages, spawning time and frequency. Parameters like frequency polygons of ova diameter measurement, percentage occurrence of fish of various maturity stages during different, months, Gonado-Somatic Index and Dobriyal index were taken as a tools of study. The fish is a protracted spawner having a single frequency of spawning during late July-Early September.

Keywords: *Pseudecheneis sulcatus* (McClelland), Maturity stages, GSI, DI, Spawning season, Spawning frequency

1. Introduction
Fish contribute significantly to the economy of Uttarakhand state, as several glacier and spring fed rivers flow through its lap. Apart from this the reservoir fishery and fish farming in tarain region is also worth mentioning. Alaknanda is a major tributary of Ganga river system which abodes more than forty indigenous fish species. *Pseudecheneis sulcatus* is an important sisorid catfish of this streams. Knowledge of breeding biology is highly essential for proper management of any species. Fish perform different types of spawning behavior which can be studied from development of intra-ovarian eggs, observations on the Gonado-Somatic index, Dobriyal index and percentage occurrence of fish of various maturity stages round the year. Some significant contributions to the spawning biology of fish in India have been made by Desai (1973) [3], Varghese (1976) [21], Sobhana and Nair (1977), Vasudevappa and James (1980) [13], Thakre and Bapat (1981) [20], Singh *et al*. (1985) [17], Dobriyal and Singh (1989 a,b, 2008) [6, 7], Negi and Dobriyal (1997) [15], Dobriyal *et al*. (1999, 2000, 2009) [9-11], Rautela *et al*. (2006) [16], Dobriyal (2012) [4] and Bahuguna and Dobriyal (2013) [1].

2. Materials and Methods
Random sampling of fish was done with the help of local fishermen from river Alaknanda in a 65 km stretch from Karnaprayag to Srinagar Garhwal. The fishes were brought to the laboratory in fresh condition and their morphometric data were recorded. For maturity stages, ova samples were taken from ovaries hardened in 5% formalin solution. Ova diameters were measured by means of an ocular micrometer. The different maturity stages were determined according to the ICES scale (Wood, 1930) [24]. The frequency of spawning and the spawning season were studied by tabulation of percentage occurrence of fish at various stages month wise and size wise. For determining the size at first maturity, fish in fourth, fifth and sixth stages were considered mature. The gonado-somatic index (GSI) and Dobriyal Index (DI) were also calculated (Dobriyal *et al*. 1999) [9] for each fish. Some important ecological parameters like water temperature, velocity of water current, dissolved oxygen and pH were also studied only at Srinagar Sampling station.

3. Observations

3.1 Habitat ecology

The abundance, distribution and biology of fish in any aquatic body depend upon its limnological characteristics. The important ecological parameters which have a great bearing on the dynamics and diversity of fish in the hill streams to a large extent are: water temperature, velocity of water current, turbidity, pH and dissolved gasses. Water temperature was maximum in April (18.5 ± 0.7 ^{0}C) and minimum in January (7.0±0.0 ^{0}C).The maximum velocity of water was recorded in July (1.16 ± 0.025 m/sec) and the minimum in January (0.43 ± 0.012m/sec.) Dissolved oxygen concentration had its higher limit in January (11.6 ± 0.18 mg/l) and lower in July (7.2 ± 1.2 mg/l).Value of pH was recorded maximum in January (8.1) and minimum (7.7) in July. Higher turbidity values were recorded in July (90 NTU) and least during January (5 NTU).

3.2 Maturity and Spawning

The maturity stages of *Pseudecheneis sulcatus* are classified on the basis of microscopic examination of the gonads and are presented in Table-1. The ova diameter frequency polygons are drawn initially for each month and finally after analysis of entire data, the overall ova diameter frequency polygons of each stages were determined.

3.3 Development of ova to Maturity

Summarised view of the ova diameter frequency polygons of different maturity stages is presented in Fig. 1. The majority of ova in the ovary of stage I (Immature I) fall in a size group of 5-15 omd with mode at 50 omd. In satge II.

Table 1: Classification of maturity stages of *P. sulcatus*

Maturity Stages	Ocular Micrometer Divison (1omd= 0.018mm)	Peaks
I Immature Ist	5-15 omd	5
II Immature IInd	5-35 omd	15
III Maturing Ist	10-55omd	35
IV Maturing IInd	15-65 omd	55
V Mature Ist	25-85 omd	75
VI Spawning	55-95 omd	95
VII Spent condition	15-45 omd	15

(Immature II), the first batch of ova got separated from the general egg stock with a mode at 15 omd and a maximum size of 35 omd. Similarly in stage III (maturing I) the first group had its mode at 35 omd with a miximum size of 55 omd. In stage IV (maturing II) the first group of ova further increased its mode at 55 omd with maximum size of 65 omd. In stage V (mature) the continuous development of ova extended the mode up to 75 omd with a range of ova from 25-85 omd. At the stage VI of maturity (Spawning) the highest ova diameter was recorded with a mode at 95 omd. The minimum ova diameter at this stage was 55 omd. In stage VII (spent) most of the mature ova were spawned. A few unspawned eggs up to 45 omd were recorded (1 omd=0.018mm).

3.4 Frequency of Spawning

The frequency distribution of ova diameter measurements from a mature ovary showed that a continuous growth of ova with a mode at 95 omd in a range of 55-95 omd. In the course of the study it is seem that the fish spawned in more than one attempt from July-August. A few fish were also observed spawning in September. Study confirms a single frequency of spawning in the fish.

3.5 Ganado-Somatic Index (GSI)

Monthly average G.S.I values for *Pseudecheneis sulcatus* are presented in Table 2. The maximum GSI values for female and male fish were observed to be as 10.65±1.06 and 4.45±1.96 respectively in the month of July. The minimum values observed in October were 1.4±1.31. for female and 2.07±0.276 for male.

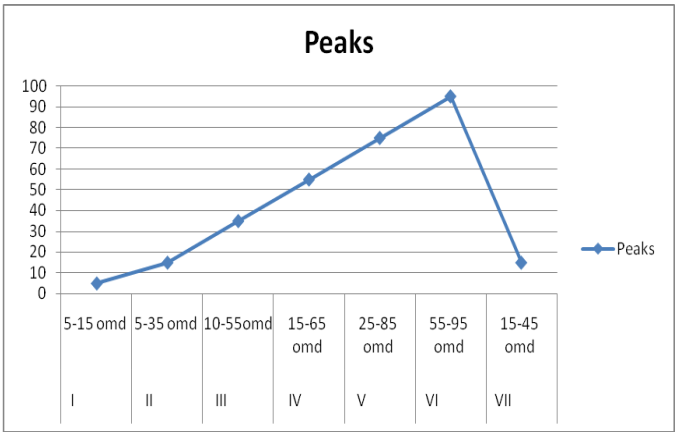

Fig 1: Graphical representation on Classification of maturity stages of *P. sulcatus* (Range of ova size and Peaks are shown ;1omd = 0.18mm)

Table 2: Monthly average values of Gonado-Somato-Index (GSI) for *P. sulcatus* (Mc Clelland) during January, 2000-December 2001.

Months	GSI(male)	GSI(female)
Jan	2.155 ± 0.527	3.68 ± 1.165
Feb	2.802 ± 1.120	4.455 ± 0.544
Mar	2.816 ± 2.623	4.658 ± 1.988
Apr	3.21 ± 1.146	5.52 ± 0.82
May	3.34 ± 0.86	9.82 ± 0.255
Jun	4.23 ± 1.246	10.6 ± 2.617
Jul	4.45 ± 1.957	10.64 ± 1.06
Aug	4.024 ± 1.755	4.16 ± 3.611
Sep	2.69 ± 0.43	2.084 ± 0.28
Oct	2.07 ± 0.276	1.4 ± 1.315
Nov	2.452 ± 0.50	1.45 ± 0.32
Dec	2.39 ± 0.26	3.65 ± 1.301

3.6 Dobriyal Index (D.I.)

Dobriyal Index (Dobriyal *et al*. (1999) [9] is a much reliable index to indicate spawning season as it does not involve body weight in the calculation of index. It was observed highest in June of both the sexes (1.27±0.158 for male and 1.838 ±0.207 for female) and minimum in the month of October (0.775±0.064 for male and 0.74±0.24 for female). (Table 3)

3.7 Size at first maturity

Percentage occurrence of mature fish in different length groups is presented in Table 4 (Males) and Table 5 (Females). All male fishes were immature in a length group of 95-105 mm and all the females were immature in the size group of 95-115 mm. The percentage of mature females increased up to the length group of 155-165 mm and that of mature males up to 145-155 mm length group when hundred per cent maturity was observed. The size at first maturity was

determined to be 123 mm for males and 131 mm for females. This indicated that the males mature a bit earlier than the females.

Table 3: Monthly average values of Dobriyal index (DI) for *P. sulcatus* (Mc clelland) during January, 2000-December 2001.

Months	DI(male)	DI(female)
Jan	0.855± 0.049	1.022 ± 0.106
Feb	0.991 ±0.152	1.04 ± 0.230
Mar	1.042 ±0.079	1.145 ± 0.106
Apr	1.21 ±0.212	1.14± 0.34
May	1.25± 0.08	1.54 ± 0.282
Jun	1.272± 0.159	1.84 ± 0.207
Jul	1.026 ± 0.0821	1.656 ± 0.237
Aug	0.833 ±0.156	0.939 ±0.285
Sep	0.78 ±0.04	0.754 ± 0.394
Oct	0.775± 0.064	0.74 ±0.24
Nov	0.9 ±0.546	0.78 ± 0.12
Dec	0.965± 0.142	0.95 ± 0.106

3.8 Frequency and season of spawning: The data pertaining to the occurrence of fishes at different stages of maturity are presented in Fig 3. Fish of advance maturity (Stage VI) were observed during June-August and the spent fish during July-August. Only one spent fish was observed in the month of September. On the basis of above observations it can be inferred that the spawning in *Pseudecheneis sulcatus* takes place during July-August.

4. Discussion

Spawning behaviour in fish has been studied by Clark (1934) [2] and Hickling and Rutenberg (1936) [12] based on the size distribution of intra-ovarian eggs in different fishes. According to Jhingran (1982) [14], the majority of teleost fishes all over the world are seasonal breeder and in the Indian subcontinent a vast majority of freshwater fishes breed during monsoon season. Present study indicates that *Pseudecheneis sulcatus* also spawns during monsoon season for a limited period of July-August. Clark (1934) [2] was of the opinion that if only one batch is

Table 4: Percentage occurrence of mature (males) of *P.Sulcatus* during pre-spawning and spawning season (June-September) in various size groups during January, 2000 to December, 2001

Size groups (mm)	Mid Points	No. of mature fish	Percentage of mature fish	No. of fish examined
95-105	100	0	0	2
105-115	110	2	25	8
115-125	120	5	41.6	12
125-135	130	10	83.3	12
135-145	140	9	90	10
145-155	150	3	100	3
155-165	160	3	100	3
165-175	170	3	100	3

Table 5: percentage occurrence of mature (Females) of *P. sulcatus* during pre-spawning and spawning season (June-September) in various size groups during January, 2000 to December, 2001

Size groups (mm)	Mid points	No. Mature of fish	Percentage of mature fish	No. of fish examined
95-105	100	0	0	0
105-115	110	0	0	0
115-125	120	3	42.9	7
125-135	130	9	64.3	14
135-145	140	8	74.7	11
145-155	150	8	80	10
155-165	160	2	100	2
165-175	170	1	100	1
175-185	180	1	100	1
185-195	190	0	-	0
195-205	200	1	100	1

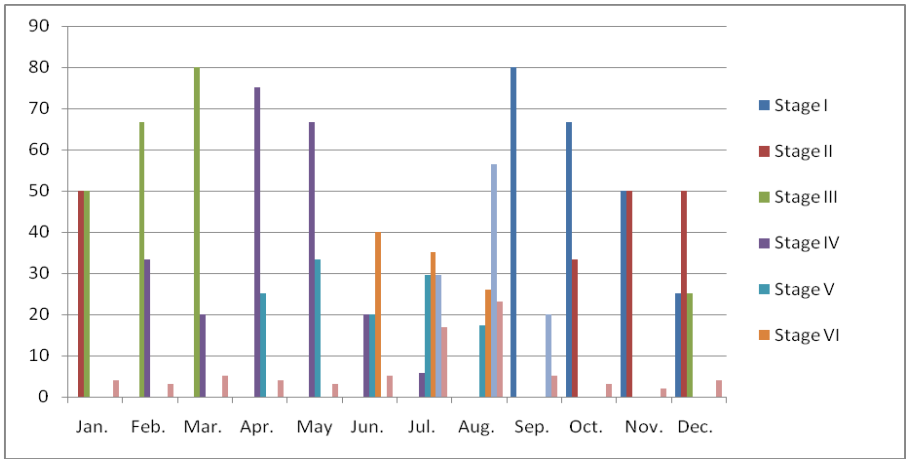

Fig 3: Percentage occurrence of fish of different maturity stages during January, 2000 to December, 2001..

spawned, the ratio between the numbers of eggs in mature group should remain constant. On the other hand, if more than one batch is spawned, the ratio gradually decreases. James & Baragi (1980) [13] opined that the ovary in itself is an indicator of season and frequency of spawning.

The gonado- somatic index has been employed by various workers to indicate the maturity and periodicity of spawning. The maximum GSI values for both the sexes of *Pseudecheneis sulcatus* were noted in the month of July. The possible reason for this might be that this fish is rare in catch round the year excepting July-August when its catch is good. Dobriyal index gave an indication of Spawning in July itself with indicating a sudden fall in value. The percent occurrence of fish maturity round the year is also an indication of frequency and season of spawning. Several workers have used this method (Sobhana and Nair, 1974; Vasudevappa and James, 1980; Thakre and Bapat, 1981; Dobriyal and Singh, 1984, 89a, 89b, Negi and Dobriyal, 1997) [19, 13, 20, 6, 7, 15]. The 50% level in maturity which has been taken to represent the mean length at which maturity was obtained, were 123 mm

and 131 mm for male and female fish respectively. The spawning season of a fish can be predicted from (i) the occurrence of mature fish, (ii) the recruitment of juveniles, (iii) the regression coefficient 'b', (iv) observations of the spent fish, (v) analysis of GSI and DI, etc. On the basis of observations made on occurrence of mature and spent fish and the GSI and DI, it is concluded that the fish spawns during July-August.

Studies on the ecology of spawning niches have been made by Singh *et al*. (1985) [17], Dobriyal and Singh (1987) [5], Dobriyal *et al*. (2000) [10] and Singh *et al*. (2012) [18]. According to Singh *et al*. (1985) [17] in *Glyptothorax pectinopterus*, the spawning takes place in rising water which becomes more turbid, and the spawned eggs are less conspicuous to the predators. Dobriyal and Singh (1989b) [7] indicated that a minor carp *Puntius chillinoides* preferred shallow pockets of lateral waters supporting a veritable carpet of filamentous algae and entomofauna, moderate conditions of water temperature and dissolved oxygen, low velocity and less gradient. According to Dobriyal *et al*. (2000) [10] *Barilius barna* spawns in the side waters of the stream khandagad, a tributary of the Alaknanda river system. They lay their eggs in protected turbid shallow waters under stones. *P. sulcatus* also spawns in the flooded riverine conditions during monsoon season. But due to rarity of fish in catch and also the non-availability of its fingerlings, its spawning grounds could not be located. However the experienced fishermen opined that this fish spawns in the flooded river but perhaps their young ones migrate to the side tributaries and are not available in big rivers.

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