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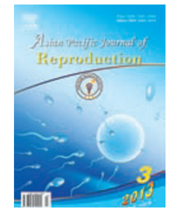

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Impact of seasonal variation and feeding on reproductive behavior of fresh water spiny eel *Mastacembelus armatus* from Cauvery River

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ABSTRACT

Objective: To analyze the effect of seasonal variation and nutritional factors over the fecundity, gonado somatic index (GSI) and sperm motility of fresh water spiny eel *Mastacembelus armatus (M. armatus)* under artificial cave fitted tanks in laboratory condition. **Methods:** Forty pairs of *M. armatus* were collected from River Cauvery and are acclimated under lab condition. The fishes were fed with three different feeds like Fresh water prawns, earthworms and fish larvae for 60 days. Fecundity, sperm motility, Length weight relationship and GSI were analysed using standard procedures. **Results:** The fecundity rate was increased when body weight and gonad weight increased. The lograthemic relationship of the fecundity–total length and fecundity–body weight were found to be more correlated than the fecundity–gonad weight relationship. Maximum GSI was recorded in both male and female fishes during the breeding season (June–October). The condition factor (K) was maximum at the non breeding seasons and reduced in peak breeding season of *M. armatus*. In male fishes the sperm motility was recorded maximum (70%–85%) in the breeding season and regressed gradually to 0–15%. Among the feeding groups earthworm fed group showed higher body weight and fecundity rate than the control group which was statistically significant at P <0.05 level. **Conclusion:** The outcome of the present study shows the seasonal variation and feeding increase the reproductive performance. It can be effectively used for the healthy brooder selection, captive breeding and conservation of *M. armatus*.

1. Introduction

Mastacembalus armatus (M. armatus), species of freshwater Spiny eel have great economic value especially in India. Mastacembelidae or spiny eels are elongate, eel like, medium sized to large acanthomorph teleosts that occur in tropical Africa and Middle East Asia [1]. The wild population has steadily declined mainly due to the loss of habitat, introduction of alien species, diseases, pollution, siltation, poisoning, dynamite and other destructive fishing [2]. Fecundity is one of the most important biological aspects of a fish species. This must be known to assess the productive potential and to evaluate the commercial potentialities of a fish stock [3] and they are in contrast with the published data concerning the different aspects of wild fish reproduction [4–6]. For efficient fish culture and effective management practices it is prime important to know the fecundity of fish [7].

Studies on reproduction, including the assessment of size at maturity, fecundity, duration of reproductive season, daily spawning behavior and spawning fraction, permit quantification of the reproductive capacity of individual fish have reported by Maurua *et al.* [8]. The condition factor is affected by food availability, physical factors and the physiology of fish, including its gonad maturity stage. Food availability is further dependent on environmental conditions and population density [9]. Extensive works have been carried out on food and feeding habit, cytological, redescription, morphometry and length–weight relationship of the mastacembelid fishes in India and abroad in last few decades. Froese and Binohlam [10], Serajuddin and Ali [11], Ahirrao [12], Emmanuel and Melanie [13] and Cakmak and Alp [14] have reported the studies on GSI of fishes. Gonado Somatic

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Index has been used as an indicator of reproductive activity of *Namibian sardine* [15]. Knowledge of the reproductive responses of fish to specific environmental cue offers means by which the timing of spawning can be adjusted to produce and provide fry and fingerlings on demand [16]. Studies on reproduction, including the assessment of size at maturity, fecundity, duration of reproductive season, daily spawning behavior and spawning fraction, permit quantification of the reproductive capacity of individual fishes [8]. Narejo *et al*. [17] studied the ova diameter, Gonado Somatic Index (GSI), and fecundity of *M. armatus* in Bangladesh.

A serious shortage of some basic scientific information on the biology, culture techniques especially fecundity of the spiny eel [18]. The present investigation was aimed to study the reproductive biology based on Fecundity, Ova diameter, Gonadosomatic index, Condition factor, Sperm motility and Reproductive nutrition of *M. armatus* from the wild freshwater spiny eel of Cauvery River Erode, Salem and Namakkal District area of Tamil Nadu, India.

2. Materials and methods

2.1. Fish collection

The fish *M. armatus* was collected from Cauvery River bank (January 2009 to December 2010) by using special Grass Bait and Nets without disturbance. The fishes were acclimatized to four artificial cave fitted tanks. *M. armatus* (40 Male and 40 Female) brooders were selected based on the external morphology and ovarian biopsy. Earthworm collected from Tamilnadu Agriculture University, Coimbatore in Tamilnadu, Trash fish Tilapia and *Macrobrachium nobilii* collected from Cauvery River at Bhavani, Erode District, Tamilnadu, India. During the experiment animals were fed daily with *Macrobrachium nobilii*, earthworm and fish larvae for 60 days.

2.2. Reproductive performance

The body weight of each fish was recorded and the testes and ovary were removed and weighted . The gonad samples were preserved in 4% (or) 10% formaldehyde solution. The weight of the fishes was monitored for every 10 days interval. At the end of the experimental period ABW, ABL, fecundity, sperm motility, and GSI of both control and experimental fishes were recorded.

2.3. Fecundity estimation

Fecundity was estimated on the basis of total weight of the ovaries. The fecundity of the fish was obtained by using the formula given by Le Cren [19].

$$F= \frac{N \times \text{gonad weight}}{\text{Sample weight}}$$

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

2.4. Ova and GSI measurement

The ova diameter was measured under microscope fitted with ocular micrometer according to method given by Le Cren [19]. The Gonado–Somatic Index was calculated for each male and female fishes separately by the following formula: Weight of the Gonad

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

2.5. Length and weight relationship

The length–weight relationship (LWR) of Spiny eel was estimated by using the equation:

$W= aL^b$

where, W= weight (g), L= total length (cm), a = constant, b= growth exponent. A logarithmic transformation was used to make the relationship linear log W=log a + log b L. The values of the compiled growth exponent were used for the calculation of condition factor [20].

$$K= \frac{100\ W}{L^b} 100\ W$$

Where, K= condition factor, W= total body weight (g), L= total length (cm), b= growth exponent.

2.6. Sperm motility

Sperm motility was analysed followed the procedure of Alavi [21].

2.7. Statistical analysis

Body length, weight and gonads weight measured by linear LogrAll Statistical values were performed using one–way ANOVA and a comparison of the mean values was done using Duncan's multiple range tests at 0.05% level of significance using the software program SPSS (Version 14.0) for Windows was used for the analysis.

3. Results

The fecundity of 20 specimens of mature female and male of *M. armatus* every month from January 2009 to December 2010 was presented in the Table 1 & 2. The length of mature fish were ranged from 21.2 cm to 57.9 cm with a mean weight of 120.89 to 412.02 g. The number of ova ranged from 942 to 18726 and an average of 790.01 ova per gram of ovary was recorded. Maximum fecundity was recorded from a fish measuring 47.2 cm and the minimum 27.5 cm in length. During the present investigation the fecundity rate increased with increased total body weight and gonad weight of the fish. The fecundity–total length shows curvilinear relationship, while gonad weight and body weight shows linear relationship with fecundity. The equations of regression co–efficient between total length (TL), body weight (BW) and gonad weight (GW) versus fecundity (F) were given below. All these relationships have been shown graphically in Figure 1–3.

Table 1

Month–wise changes in length, weight, gonad weight, ova diameter, GSI and fecundity of female fish of *M. armatus*.

Sr.No	Months	No. of Females	Length of fish (mm)	Weight of fish (g)	Gonad weight of female (g)	No. of ova	Ova diameter (mm)	Condition Factor	Mean % GSI	Fecundity %
1	January–2009	20	275	125.06	2.74	942	0.93	0.000 60	2.190	20.64
2	February–2009	20	290	128.30	2.97	2 498	0.90	0.000 52	2.314	57.82
3	March–2009	20	306	166.82	4.56	3 764	0.98	0.000 58	2.733	75.55
4	April–2009	20	276	196.09	7.52	4 300	1.02	0.00093	3.834	164.90
5	May–2009	20	408	207.51	9.84	9 234	1.28	0.000 30	4.741	437.87
6	June–2009	20	490	240.96	11.54	13 865	1.93	0.000 20	4.789	664.01
7	July–2009	20	348	246.42	14.14	15 441	2.16	0.000 58	5.738	885.37
8	August–2009	20	465	346.35	19.42	16 094	2.22	0.000 34	5.612	902.32
9	September–2009	20	472	408.29	24.87	18 726	2.47	0.000 38	6.091	1140.64
10	October–2009	20	460	402.17	21.65	16 389	2.32	0.000 41	5.383	882.26
11	November–2009	20	540	376.09	19.32	14 831	2.29	0.000 23	5.137	761.87
12	December–2009	20	325	220.21	10.76	7 843	1.02	0.000 64	4.886	382.22
13	January–2010	20	328	184.85	4.28	1 657	0.82	0.000 52	2.135	38.37
14	February–2010	20	300	146.17	4.56	2 117	0.73	0.000 54	3.119	66.04
15	March–2010	20	286	135.41	3.87	1 054	0.85	0.000 57	2.857	115.86
16	April–2010	20	447	120.89	5.31	3 737	0.97	0.000 13	4.393	164.14
17	May–2010	20	428	127.34	6.65	10 690	1.05	0.000 16	5.222	558.25
18	June–2010	20	579	244.21	12.86	13 542	1.20	0.000 12	5.266	713.12
19	July–2010	20	541	292.12	16.32	16 865	2.21	0.000 18	5.586	942.20
20	August–2010	20	438	398.24	22.76	16 962	2.35	0.000 47	5.715	969.40
21	September–2010	20	421	412.02	25.66	18 230	2.50	0.000 55	6.227	1135.33
22	October–2010	20	387	396.29	23.12	12 877	2.42	0.000 68	5.834	751.25
23	November–2010	20	346	364.37	16.49	10 765	2.23	0.000 87	4.525	487.18
24	December–2010	20	298	123.41	9.76	6 345	1.21	0.000 46	3.046	422.71

Log F = 0.022 +2.659 × Log L (Fecundity – Total length) (r = 0.064)

Log F = 2.860 –1.8537 × Log BW (Fecundity – Body weight) (r = 0.691) and reduced

Log F = 45.65648 –41.7463× Log GW (Fecundity – Gonad weight) (r = 0.852),

Respectively, where F=total number of eggs in an individual, L = total length (mm).

BW = Body weight (g) and GW = gonad weight (g).

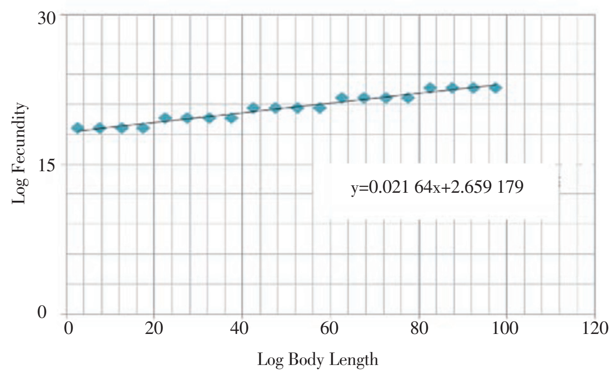

Figure 1. Logarithmic relationship between fecundity and body length of female spiny eel *M. armatus* (2 years).

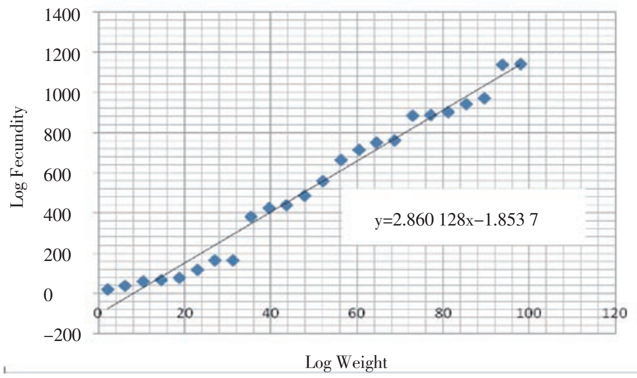

Figure 2. Logarithmic relationship between fecundity and body weight of female spiny eel *M. armatus* (2 years).

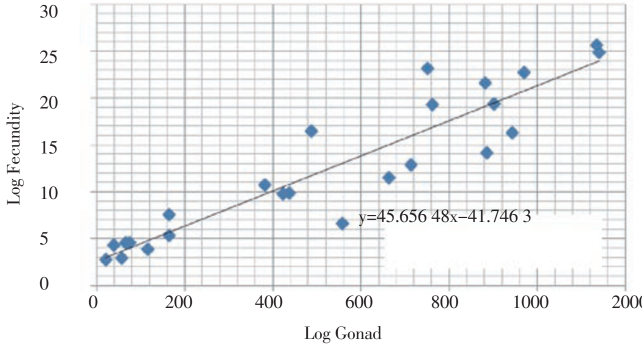

Figure 3. Logarithmic relationship between fecundity and gonad weight of female spiny eel *M. armatus* (2 years).

Maximum ova diameter was recorded during July to November (2.16 to 2.50 mm) and minimum in January to April (0.82 to 0.98 mm). GSI values ranged from 0.562% to 1.746% in males and 2.315% to 6.227% in females respectively. Maximum GSI was recorded in September of both years (GSI–male=1.746% and 1.726%; GSI– female= 6.091% and 6.227%). After extrusion of ripe gonads, the gonads were in size and weight from December to June as indicated by the decline of GSI. During the experimental period a sudden decreases in gonad weight from 6% to 2% in females and 2 to 0.6% in males respectively.

There is a positive relationship between Average Body Weight (ABW) and Average Body Length (ABL) based on correlation coefficient. When the weight and growth increases the condition factor decreased. The maximum condition factor was observed in April month of both year (2009 and 2010) 0.00096 and 0.00097 and the least factor was observed in the month of June 2009 (0.00012) and 0.00020 during 2010. The condition factor was relatively depends upon food availability and ecological parameters.

The sperm motility analysis of the present investigation reveals maximum motility (70%–80%) during peak spawning season September to November and minimum (0–15%) in January to March (Table 2). The influences of feed on gonadal and fecundity changes for *M. armatus* during the 60 days of experimental period were given in the Table 3 and Figure 4–6. The ABW and ABL of all experimental fishes were higher than the control. The increased body weight and length were recorded between 30th to 60th days of our experimental period. Highest body weight and length was recorded in earthworm fed group (28.800 ± 0.905 cm and 270.65±6.95 g) and least in the Control (27.300±0.158 cm and 242.49 ± 7.11 g). Statistically these values are significant at $P<0.05$ level.

Table 2

Month–wise changes in length, weight, gonad weight, GSI, and sperm motility of male fish of *M. armatus*.

Sr. No	Months	No. of males	Length of fish (mm)	Weight of fish (g)	Gonad weight(g)	Mean % GSI	Sperm motility (%)
1	January–2009	20	234	146.03	1.02	0.698	0–5
2	February–2009	20	264	154.76	1.76	1.137	6–9
3	March–2009	20	296	176.15	2.21	1.254	10–12
4	April–2009	20	312	187.96	2.43	1.292	13–15
5	May–2009	20	322	194.25	2.74	1.411	16–19
6	June–2009	20	348	261.73	4.17	1.593	20–30
7	July–2009	20	412	300.61	5.03	1.673	30–38
8	August–2009	20	509	325.36	5.50	1.690	40–50
9	September–2009	20	534	398.52	6.96	1.746	70–80
10	October–2009	20	476	380.30	5.84	1.535	60–70
11	November–2009	20	439	362.32	3.80	1.049	50–60
12	December–2009	20	356	324.43	1.98	0.610	40–50
13	January–2010	20	243	245.53	1.32	0.562	0–5
14	February–2010	20	273	234.60	1.69	0.688	6–8
15	March–2010	20	287	223.05	2.12	0.950	9–13
16	April–2010	20	345	260.89	2.63	1.008	15–19
17	May–2010	20	412	258.47	3.68	1.423	21–29
18	June–2010	20	587	260.27	3.72	1.429	30–40
19	July–2010	20	523	263.42	4.24	1.609	41–49
20	August–2010	20	441	306.56	5.15	1.679	50–65
21	September–2010	20	404	396.27	6.84	1.726	70–85
22	October–2010	20	362	326.23	5.43	1.664	65–70
23	November–2010	20	323	309.10	4.02	1.301	31–40
24	December–2010	20	212	296.32	2.32	0.782	15–20

Table 3

Influence of nutrition in growth and gonadal development of *M. armatus*.

Nutrition	0 day		15th day		30th day		45th day		60th day	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
Control	257.00±6.60[a]	235.20±1.87[b]	262.00±3.10[b]	236.60±0.670[b]	264.00±3.08[b]	239.50±1.58[c]	269.00±7.615[b]	240.20±3.72[c]	273.00±1.58[c]	242.40±7.11[c]
E. worm	253.00±1.73[b]	230.70±1.82[c]	260.00±2.54[b]	237.50±1.42[b]	268.00±5.70[a]	247.20±3.13[b]	279.00±14.30[a]	258.00±12.92[a]	288.00±9.05[a]	270.60±6.95[a]
M. nobilii	260.00±7.62[a]	243.50±1.93[a]	264.80±7.19[a]	245.60±13.65[a]	269.00±7.61[a]	251.20±1.49[a]	273.00±6.70[b]	256.60±1.27[a]	278.00±4.72[b]	261.80±1.73[b]
T. larvae	254.00±3.16[b]	230.40±1.01[c]	265.00±7.21[a]	234.90±2.90[c]	269.00±14.42[a]	243.50±2.55[b]	272.00±5.83[b]	252.40±7.29[b]	276.00±6.00[b]	257.80±1.50[b]

*Mean± SD (n=5) , Mean values within the same row sharing the same superscript are not significant different ($P>0.05$).

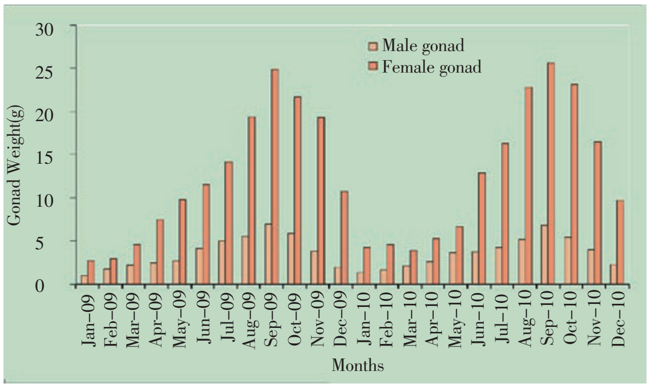

Figure 4. Relationship between fecundity and gonad weight of female spiny eel *M. armatus* (2 years).

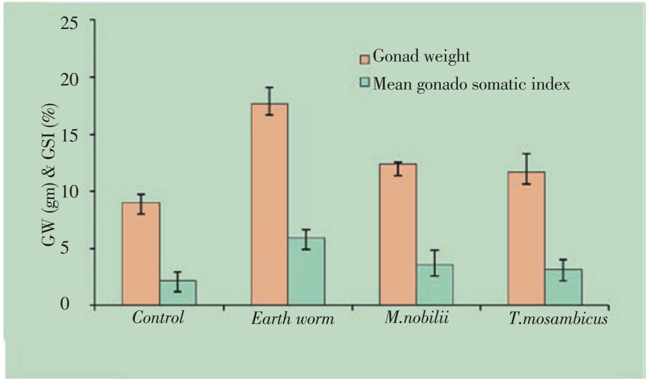

Figure 5. Influence of live feed nutrition in Gonad weight and GSI of *M. armatus*.

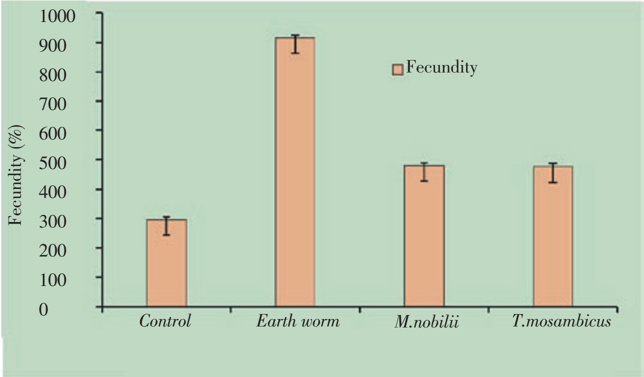

Figure 6. Influence of live feed nutrition in fecundity of *M. armatus*.

4. Discussion

Estimation of fecundity of fish is a prerequisite in successful breeding programme as fecundity of a species is an indicator of reproductive potential of the species. Bagenal and Braum [22] had reported that fecundity in fish species characteristically varied among individuals of the same size and age. The change in the fecundity estimation could be due to different environmental conditions in which the two populations live. The fecundity also varied with the seasons, climatic conditions and environmental habitat, nutritional status and genetic potential [23]. The fecundity of fish increases with increasing length, and in some species at a greater rate than body-weight, so that in older, larger fish the reproductive strain may impose a limit to increasing egg production [24]. It may be noted from the above equations as well as from the Figs 1, 2 and 3 that the logarithmic relationship of the fecundity-total length and fecundity-body weight were found to be more correlated than the fecundity-gonad weight relationship. The results of the present study was coincides with the results of Azadi *et al.* [25] American eel (Anguilla rostrata), Das *et al.* [3] in Heteropneustes fossilis, Usman *et al.* [26] in Plotosus canius, Kabir *et al.* [24] in Gudusia chapra, Rahman *et al.* [18] in *Mastacembelus armatus*.

Narejo *et al.* [17] and Rahman *et al.* [18] have observed that *M. armatus* has only one breeding season during May to July with a peak in July and the maximum size of the mature ova was 1.00 mm progressively increasing in the ova diameter during December to July. Similar findings were also reported by Nabi and Hussain [27] in Spiny eel, Macrognathus aculeatus and Narejo et al. [17] in *Mastacembelus armatus*. In the present study period we recorded an average egg count from 942 to 18726 with a mean ova diameter of 0.9 to 2.47mm.

GSI is used as a biomarker for exposure of aquatic wild life to environmental estrogens, since a correlation has been established in male fish between inhibition of testicular growth and the potency of estrogenic compounds [28]. The GSI during the present investigations showed one peak during breeding season (September) 2.47 and 1.746 % for females and males respectively. Abdullah *et al.* [29] correlated the GSI with increased protein and lipids in both before breeding and breeding season of fishes. Maximum GSI values correspond with the spawning season of fish. Barnabe[30] reported that high GSI of sea bass were found at the peak of the it's spawning season.

A number of factors (e.g. sex, seasons, environmental conditions, stress, and food availability) also affect the condition of fish. The value of K may vary when average weight of the fish is not increasing in direct proportion to the cube of its length [31]. In the present study conditions factor (K) appear to increase with increasing length or weight of the fish. As for the condition factor of *M. armatus*, K varies about 0.00093 (highest) in April 2009 and lowest value was found in June 2010 (0.00012). Its suggest that in September the species starts the reproductive period. On the other hand, in April, with K at the highest level, individuals had already recovered. These data coincide with those of Vazzoler[32] and Lizama *et al.* 2002 [33].

The percentage of sperm motility also changed, which can be related to the motility of semen dependent on spawning season and environmental condition. Maximum sperm motility was observed in the month of September (70%-85%). Many other factors contributing to individual variation in sperm quality have been reported Rurangwa *et al.*[34], and these factors are genetic variability among fish, rearing conditions, brood stress, sperm collection methods, and storage of milt and sperm activation conditions. The seasonal variation of gamete quality also influences motility and fertilization success [35, 36]. A decrease in sperm concentration towards the end of spermiation period has been reported in many teleosts such as turbot [37], sea bass [38], and cod [39].

The spiny eel is a zooplankton feeder when young and turns to insectivorous habit in later stages. The adult feeds on earthworms, insects, micro crustaceans, and larvae of other aquatic invertebrates Abujam and Biswas, 2010 [40]. Among this Earth worm fed group of eels have high growth rate and fecundity were compared with control was statistically significant at level.

Sexual maturation entails several processes including gonadogenesis (the development of gonadal tissue), gametogenesis (the production of oocytes or spermatocytes) and in females, primary and secondary vitellogenesis (the endogenous and exogenous production of egg yolk proteins). Growth increases until the fish reaches sexual maturity, at which time the rate of growth starts to slow down. The growth rate of fish is controlled by food intake and environmental conditions Jobling *et al* [41].

Relationships between fecundity and nutrition are not as apparent as with stimulation because there is too much variation. The present study support to gonadal development and suitable spawning season were determined the reproductive performance of *M. armatus* by using artificial propagations and wild stock conservatory movement.

Conflict of interest statement

We declare that we have no conflict of interest statement.

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References

[1] Berra T. Freshwater fish distribution. San Diego: Academic Press; 2000, p. 604.

[2] CAMP. Conservation assessment and management plan for freshwater fishes of India. Workshop report. Zoo Outreach Organization, Coimbatore/CBSG and NBFGR, Lucknow, India; 1998, p. 1 -158.

[3] Das M, Dewan S, Debnath SC. Studies on fecundity of *Heteropneustes fossilis* (Bloch) in a mini pond of Bangladesh Agricultural University, Mymensingh. *Bangladesh J Agricul Sci* 1989; **16**(1): 1-6.

[4] Benzer SS, Gul A, Yilmaz M. Breeding properties of *Tinca tinca* (L., 1758) living in Hirfanlı Dam Lake (Kırşehir, Turkey). *EU J Fish Aquat Sci* 2007; **24:** 127-129.

[5] Kucharczyk D, Kujawa R, Mamcarz A, Targońska K, Krejszeff S, Wyszomirska E. Artificial spawning of common tench (*Tinca tinca* L.) collected from wildpopulations. *Pol J Nat Sci* 2007; **22:** 37-45.

[6] Targonska K, Perkowsk T, Zarski D, Krejszeff S, Mamcarz A, Kujawa R, et al. Method of evaluation of wild common tench, *Tinca tinca* (L.), female suitability for artificial reproduction during the spawning season Italian *J Animal Sci* 2012; **11:** 30, 164-168.

[7] Mian AM, Dewan S. Studies on the fecundity of *Sarotherodon nilotica* (Linnaeus) in a fishpond. *Bangladesh J Zool* 1984; **12:** 99-103.

[8] Maurua H, Kraus G, Saborido Rey F, Witthames AR, Thorsen P, Junquera V. Procedures to estimate fecundity of marine fish species in relation to their reproductive strategy. *J Northw Atl Fish Sci* 2003; **33:** 33-54.

[9] Parrish RH, Mallicoate DL. Variation in the condition factors of California pelagic fishes and associated environmental factors. *Fish Oceanogr* 1995; **4**(2): 171-190.

[10] Froese R, Binohlan C. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruitin fishes, with a simple method to evaluate length frequency data. *J fish Biol* 2000; **56:**758-773.

[11] Serajuddin M, Ali R. Food and feeding habits of striped spiny eel, *Macrognathus pancalus* (Ham.). *Ind J Fish* 2005; **52:** 81-86.

[12] Ahirrao SD. Length-weight relationship of fresh water spiny eel *Mastacembelus armatus* (Lacepede) from Marathwada region. *Ecol Environ Cons* 2008; **14:** 71-72.

[13] Emmanuel JV, Melanie LJS. Mastacembelus simbi, a new dwarf spiny eel (Synbranchiformes: Mastacembelidae) from the lower Congo river. *Ichthyol Explor Freshwater* 2009; **20:** 213-22.

[14] Cakmak E, Alp A. Morphological differences among the Mesopotamian spiny eel, Mastacembelus mastacembelus (Banks and Solander, 1794), Populations. *Tur J Fish Aquatic Sci* 2010; **10:** 87-92.

[15] Matthews JP. The pilchard of South West Africa (*Sardinops ocellata*). Sexual development. Condition factor and reproduction, 1957 -1960. *Investl Rep Mar Res Lab S W Afr* 1964; **10:** 96.

[16] Kamanga LJ, Kaunda E, Mtimuni JP, Maluwa A, Mfitilodze WM. Effect of temperature on gonadosomatic index (GSI) of *Oreochromis karongae* (Trewavas). *Aqua Fish Technical Report* 2002; **1:** 21-24.

[17] Narejo NT, Rahmatullah SM, Mamnur Rashid M. Studies on the reproductive biology of freshwater spiny eel, *Mastacembalus armatus* (Lacepede) reared in the cemented cisterns of Bangladesh Agricultural University, Mymensingh, Bangladesh. *Pakistan J Biol Sci* 2002; **5** (7): 809-811.

[18] Rahman MM, Ahmed GU, Rahmatullah SM. Fecundity of wild freshwater spiny eel Ma*stacembelus armatus* (Lacepede) from Mymensingh Region of Bangladesh. *Asian Fish Sci* 2006; **19:** 51-59.

[19] LeCren ED. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J Ani Ecol* 1951; **20:** 201-219.

[20] Knights B. Body dimensions of farmed eels (*Anguilla anguilla* L.) in relation to condition factor grading sex and feeding. *Aquacult Eng* 1982; **1:** 297-310.

[21] Alavi SMH, Rodina M, Viveiros ATM, Cosson J, Gela D, Boryshpolets S, et al. Effects of osmolality on sperm morphology, motility and flagellar wave parameters in Northern pike (*Esox lucius* L.). *Theriogenology* 2010; **72:** 32-43.

[22] Bagenal TB, Braum V. Eggs and early life history. In: Ricker WE. (ed.) *Methods for assessment of fish production in freshwaters*. Oxford: Blackwell; 1978,p. 165-20.

[23] Bromage N, Jones J, Randal C, Thrush M, Davies B, Springate J, et al. Brood stock management, fecundity, egg quality and the timing of egg production in the rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 1992; **100:**141-166.

[24] Kabir AK, Hossain MA, Rahmatullah SM, Dewan S, Islam MS. Studies on the gonadosomatic index and fecundity of chapila (*Gudusia chapra* Ham.). *Bangladesh J Fish Res* 1998; **2**(2): 195-200.

[25] Azadi MA, Siffique MS. Fecundity of cat fish *Heteropneusts fossilis* (Bloach). *Bangladesh J Zool* 1986; **14:** 33-39.

[26] Usman BJ, Amin SMN, Arsad A, Aminur Rahman M. Fecundity and egg size of grey-eel cat fish *Plotosus canius* (Hamilton, 1822) from the Coastal waters of Kampong Telok, Negeri Sembilan Penisular Malaysia. *Asian J Anim Vet Adv* 2012; **8:** 348-354.

[27] Nabi MR, Hussain MA. Reproductive biology of the freshwater spiny eel, *Macrognathus aculeatus* (Bloch). *Bangladesh J Zool* 1996; **24** (2): 115-120.

[28] Gimeno SH, Komen PWM, Venderbosch Bowmer T. Disruption of sexual differentiation in genetic male common carp (*Cyprinus carpio*) exposed to an alkylphenol during different life stages. *Environ Sci Technol* 1997; **31**(10): 2884-2890.

[29] Abdullah S, Lohar PS. Biochemical composition and gonadosomatic

index of three major carps in Hatnoor reservoir, Maharashtra, India. *J Ecobiotechnol* 2011; **3**(6): 1–4.

[30]Barnabe G. Biological basis of fish culture. In: Barnab G, Horwood E.(eds). *Aquaculture: Biology and ecology of' cultured species*. New York: RC press; 1994, p. 227–372.

[31]Abbas G. Length–weight and condition factor relationship of Anchovy, (*Coilia dussumieria*) and Mullet (*Liza carinata*) from Bhanbhore backwaters along Sindh coast (Pakistan: Northern Arabian Sea). *Pakistan J Zool* 2000; **32:** 65–72.

[32]Vazzoler AEA, De M. *Biologia da reproduçaode peixes teleosteos: teoria e pratica*. Maringa: Eduem SBI; 1996, p. 169.

[33]Lizama M, De Los AP, Ambrosio AM. Condition factor in nine species of fish of the chracidae family in Uppar Prrana River floodplain, Brazil. *J Biol* 2002; **62**(1): 113–124.

[34]Rurangwa E, Kime DE, Ollevier F, Nash JP. The measurement of sperm motility and factors affecting sperm quality in cultured fish. *Aquaculture* 2004; **234:** 1–28.

[35]Lubzens E, Daube N, Pekarsky I, Magnus Y, Cohen A, Yusefovich F, et al. Carp (*Cyprinus carpio* L.) Spermatozoa cryobanks strategies in research and application. *Aquaculture* 1997; **155:** 13–30.

[36]Linhart O, Rodina M, Cosson J. Cryopreservation of sperm in common carp: sperm motility and hatching success of embryos. *Cryobiology* 2000; **41:** 241–250.

[37]Suquet M, Dreanno C, Dorange G, Normant Y, Quemener L, Gaignon JL, et al. The ageing phenomenon of turbot, *Scophthalmus maximus*, spermatozoa: effects on morphology, motility and concentration, intracellular ATP content, fertilization and storage capacities. *J Fish Biol* 1998; **32:** 31– 41.

[38]Dreanno C, Cosson J, Suquet M, Dorange G, Fauvel C, Cibert C, et al. movement of sea bass (*Dicentrarchus labrax*) spermatozoa. *J Reprod & Fert* 1999; **116:** 113–125.

[39]Rouxel C, Suquet M, Cosson J, Severe A, Quemener L, Fauvel C. Changes in Atlantic cod (*Gadus morhua* L.) sperm quality during the spawning season. *Aquac Res* 2008; **39:** 434– 440.

[40]Abujam S, Biswas P. Notes on the biology and rearing feasibity of Spiny Eel. *Sibcoltejo* 2010; **5:** 87–91.

[41]Jobling M. Bioenergetics: feed intake and energy partitioning. *Fish Ecophysiol* 1993; **1:** 44.

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