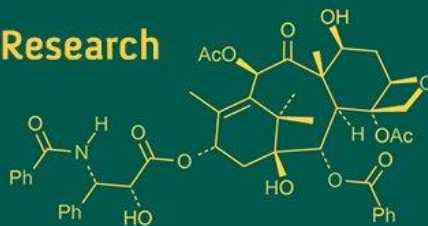
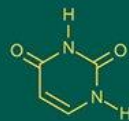
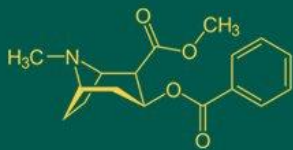


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(9): 188-192
www.biochemjournal.com
 Received: 08-06-2026
 Accepted: 09-07-2026

Nityanand Pandey
 ICAR-Central Institute for
 Coldwater Fisheries Research,
 Bhimtal, Uttarakhand, India

S Ali
 ICAR-Central Institute for
 Coldwater Fisheries Research,
 Bhimtal, Uttarakhand, India

Santosh Kumar
 ICAR-Central Institute for
 Coldwater Fisheries Research,
 Bhimtal, Uttarakhand, India.

Corresponding Author:
Nityanand Pandey
 ICAR-Central Institute for
 Coldwater Fisheries Research,
 Bhimtal, Uttarakhand, India

Gonadal maturity and captive breeding of Indian Trout, *Raiamas bola* (Hamilton, 1822)

Nityanand Pandey, S Ali and Santosh Kumar

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9c.9914>

Abstract

An attempt was made to assess the Gonadosomatic Index (GSI), spawning season, fecundity and captive breeding of *Raiamas bola*, which is an indigenous fish species belongs to family cyprinidae and subfamily Rasborinae (Danioninae) having food and ornamental value, and is distributed in mid and high altitudes of Indian Himalayan region. The wild stock of this species was collected from Kosi and Ramnagar streams of Uttarakhand, which was found in poor and stressful condition with 'b' value as 2.39 and condition factor (K) as 0.60. It was observed that fish spawn once in a year during the month of July with maximum GSI value as 13.12 ± 1.22 in females, while males reflected one-month advanced maturity during the month of June. Successful induced breeding with synthetic hormone, Ovate was achieved with one preparatory dose @ 0.1 ml/kg body weight to females in the pre-spawning phase during the month of May and successful spawning in the month of July with induced hormone @ 0.5 ml/kg body weight in females, and 0.3 ml/kg body weight in males. Spawning was achieved after 15-18 hours latency period by dry stripping method with absolute fecundity as 36548 per kg body weight, 62% of fertilization rate and 73% spawn survival at the water temperature of 20-23 °C. The present findings highlight the reproductive potential of *R. bola* in coldwater conditions, which enable the captive breeding and seed production of this species for conservation and aquaculture purposes.

Keywords: *Raiamas bola*, indigenous fish, Gonadosomatic Index (GSI), captive breeding, ornamental value, conservation

Introduction

Raiamas bola (Hamilton, 1822) is an important food and game fish (Talwar and Jhingran, 1991) [28] commonly known as 'Indian trout' or 'trout barb' belongs to family cyprinidae and subfamily Rasborinae (Danioninae). The species inhabits rapid clear rivers and rocky hill streams in the Himalayan and sub-Himalayan regions of India (such as Assam, West Bengal, Bihar, Uttar Pradesh, and Uttarakhand), extending into Nepal, Bangladesh, and Myanmar. The population of this species seems affected by destructive fishing practices and habitat deterioration. Its wide mouth and stream lined body is well suited for a predacious life and is a voracious feeder (Chaudhary and Vishwanath, 2010) [4]. It is characterized by greenish grey colour separated from silvery sides by longitudinal golden stripe. It reaches a maximum size of 30 cm in length (Talwar and Jhingran, 1991) [28]. As per IUCN, the species has been categorized under 'Least Concern' but the population of this species is declining due to destructive fishing methods, and it was emphasized that detailed research into distribution, biology, population, habitat trends, threats and impacts are needed. Being a potential food and game fish the study on its breeding biology and developing its captive breeding is essentially required for the seed production to enable the rehabilitation and conservation of the species. This species was introduced into Walwham and Lonavla lakes (Poona District), which was documented by F. Evans in his short publication "*Fishing in Lonavla*" for the Journal of the Bombay Natural History Society during the year 1926. The fish breeds during early monsoon season (June) in heavily inundated areas. It breeds approximately after attaining three years of age. The fish exhibits sexual dimorphism. The males have got rough scales on the sides of the body particularly in the posterior half during spawning season and attain a bright colour. It attains maturity approximately at an age of 3 years. The fish breeds during early monsoon season (June) in quiet inundated area. Indian trout is a very good game fish and is taken with the fly or small spinning bait. The fish generally inhabits the localities

dominated by mahseer, where they seem to be killed along with mahseer by the unscrupulous fishermen adopting illegal means. Among the barilines, *Barilius bendelisis* and *B. tileo* are quite common in the catches but *R. bola* is rarely seen. Also the fish is fast disappearing from many of the drainages where it occurred naturally or was transplanted. Hence, it is feared that if suitable conservation measures are not adopted, this endangered species may be lost. As is evident from its introduction in the Walwham and Lonavala lakes where the species had bred initially, Indian trout can be easily propagated on those lines adopted for mahseer and introduced in those areas for sports and game where mahseer are not common.

Fish reproduction is a periodic phenomenon and is controlled by environmental (exogenous) as well as internal (endogenous) regulatory mechanisms. The act of breeding occurs under optimal environmental conditions that are favorable to the survival of the young ones. Environmental stimuli are detected by sensory organs, relayed to the brain that triggers endogenous mechanisms into action. An endogenous mechanism is mediated through a cascade of various neurotransmitters and hormones secreted by tissues of a brain-hypothalamus-pituitary-gonadal axis. Fish in captivity may not always reproduce at the most favorable time. In this situation, hormones play a critical role in the reproductive processes. Hormone-induced spawning techniques influence this sequential mechanism at several steps, either by promoting or inhibiting the process. Induced reproduction in fish includes two main strategies. The first is the manipulation of the cultural environment to mimic important characteristics of the natural spawning environment of that fish. The second strategy is the administration of one or more naturally occurring reproductive hormones or their synthetic analogs in brood fish through injection or dietary methods. Exogenous hormones such as pituitary gland extracts and others are commonly injected to mature brooders to induce breeding (Yaron, 2009) [98]. In India, a breeding technique of cold-water fish species, with or without hormone injection has been developed for *T. khudree*, *T. putitora*, *T. tor*, and hybrid mahseer (Ogale and Kulkarni, 1987; Sangma and Basavaraja, 2010) [14, 22], *Schizothorax richardsonii* (Joshi et al. 2026) [10], *Barilius bendelisis* (Rawat et al. 2026) [21], *Labeo gonius* (Siddiqui et al. 2021) [27] and Garra gotyla (Patiyal et al. 2020) [18]. Attempts have been made to breed Golden mahseer in the Kumaun region (Shyam Sunder., 1993; Ogale, 1997). Breeding of *Labeo dyocheilus* (Pandey et al., 2012; Sarkar et al., 2001) [16, 23] and *Bangana dero* (Pandey et al., 2017) has been achieved using synthetic inducing hormone in cold-water conditions under captivity. Captive breeding of *Channa aurantimaculata* in Assam was also reported by Gogoi (2015) [8]. In recent years, induced breeding for qualitative and quantitative improvement of fish has been widely recognized as a popular technique for significant expansion of reproductive processes of domestic fishes (Dhawan and Kaur, 2004) [7]. Hence, the present study was undertaken to develop the induced breeding protocol and to assess the Gonadosomatic Index (GSI) and Fecundity of *Riaimas bola* in captivity and under coldwater conditions.

Materials and Methods

The field study was conducted at Central Institute for Coldwater Fisheries Research, Bhimtal (29° 21'N and 79°

34'E, Altitude 1370 msl) Uttarakhand, India during the year 2018, and further rearing of the produced seed was done in captivity up to the year 2024. Male and female (n=80) brooders of *Riaimas bola* were collected from the Kosi and Ramganga stream in Uttarakhand and kept in the ponds. For knowing well-being of the fish, all collected fishes were measured for length and weight, which indicated positive correlation between length and weight. The slope value (b) was obtained by the least square linear regression from the log transformed equation $\text{Log } W = \text{Log } a + b \text{ Log } L$. The correlation (r^2) that is the degree of association between the length and weight was computed from the linear regression analysis $R = r^2$. All the statistical analysis was done in SPSS Ver. 19.

For breeding trials, selected healthy fishes were disinfected and reared for one year in the cemented tank under cold-water condition (5-23.0°C) and fed daily with conventional carp feed (protein level 24%) at 3% of their body weight. Fishes were dissected and gonad was taken out individually from male and female and weighed on a single pan electronic balance. GSI of female was calculated by using following formula.

$$GSI = \frac{\text{Weight of gonad (g)}}{\text{Total body weight (g)}} \times 100$$

The brooders were selected based on their external characteristics such as females were selected on the basis of bulging abdomen, soft ventral abdominal region, smooth pectoral fin with reddish color and oozing of eggs with gentle pressure on the abdomen while males were selected on the basis of milt oozing with gentle pressure on the abdomen. The experiment was conducted with collected stock of brooders, varying the size of 68-140 g in female and 60-120 g in males. The age of the collected stock was not known, and it was not possible to determine the age by very small scales of this species. A preparatory dose of inducing agent ovatide was given in the pre spawning phase during the month of May @ 0.1 ml/kg only to females. The treated and selected brooders were injected intramuscularly with Ovatide @ 0.3, 0.5, 0.7 ml/kg body weight in females and 0.1, 0.2 and 0.3 ml/kg body weight in males during the month of July. The induced specimens were kept together for spawning by stripping. After latency period of 15 hours, the eggs from the females were stripped applying dry stripping method and mixed with the milt from the mature males. The eggs were incubated in flow through system with an average water flow of 2 L/minute. Hatching occurred after six days at average water temperature of 18 - 22 °C and hatchling were kept in the hatching tray for four days until yolk sac was fully absorbed. A total of 40 females were stripped in different 5 breeding trials on different dates. Absolute fecundity of each female was determined by random sampling of eggs in 10 ml graduated measuring tube immediately after spawning. The total number of eggs in 10 ml were counted and multiplied with total volume of eggs released. The fertilization rate was determined by randomly taking a sample of 100 eggs in three replicates from the total eggs in a Petri-dish. Fertilized eggs having intact nucleus were only considered for calculating percentage of fertilization. The fertilization rate and hatching rate were calculated as follow

Table 1: The water quality parameters of brood stock pond and breeding pond were analyzed as per APHA (1998)

Parameter	Formula
Fecundity	No. of stripped egg / Weight of ovulated fish
Fertilization rate (%)	No. of fertilized eggs / Total No. of eggs in a batch $\times 100$
Hatching rate (%)	No. of eggs hatched / Total No. of fertilized eggs in a batch $\times 100$
Survival rate (%)	Total number of survival larvae until day 7 / Total No. of larvae counted at day 1 $\times 100$

The water quality parameters of brood stock pond and breeding pond were analyzed as per APHA (1998) (Table-1). Statistical analysis of the data was done by one way Analysis of Variance (ANOVA) to determine differences between the means taking at 1% ($P < 0.01$) or 5% ($P < 0.05$) significance levels. The produced seed was reared in the captive condition for the further study and gonadal maturity, and size of the captive reared fish was observed at the age of 3 and 6 years.

Results

The Length-weight relationship showed that the wild stock is under severe stress, and the species follow non-isometric growth pattern ($b \neq 3$). The 'b' value obtained is 2.39 which is less than 3.0, the ideal value considered for isometric growth pattern. The mean condition factor (K) calculated for the wild stock is 0.60 ± 0.11 which is much less than unity ($K=1$). This indicated the poor well-being of the wild stock of this species in the stream. However, more seasonal data are

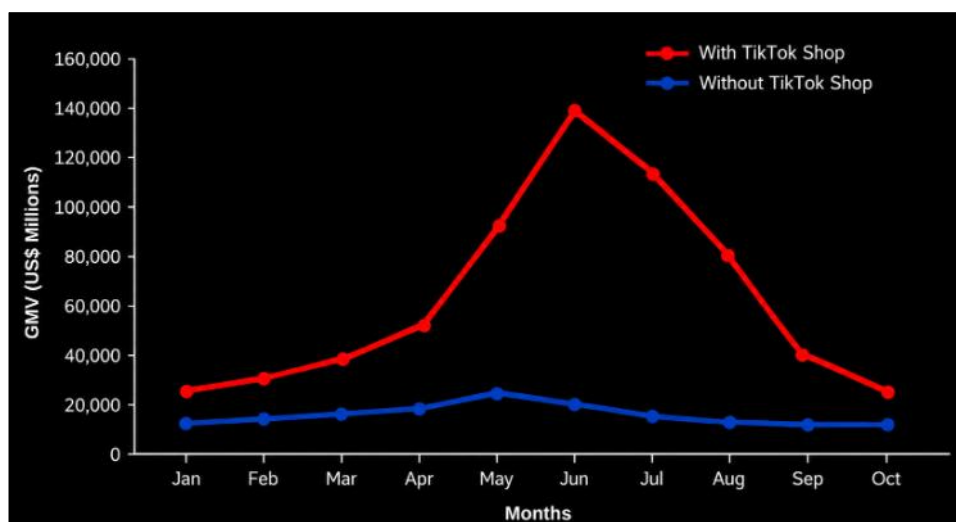
required for ascertaining these facts. The collected wild brooders having the body weight as 60-140 g showed full maturity with eggs release and oozing milt during second week of June in males and in the month of July in females under captive condition at the water temperature in the range of 18-23 °C. Gonadosomatic index (GSI) increased gradually from April to July and decreased in the month of August in females under captive condition. GSI ranged from 3.24 ± 0.12 to 13.12 ± 1.22 during different maturity stages (Fig 1). During spawning season, females showed soft and bulged belly with swollen light reddish vent. Sexual dimorphism is visible only during the breeding season (June to July). It was difficult to distinguish males and females based on the morphological characters except the breeding season.

Ovarian development

1. Resting phase (November-April)
2. Preparatory phase (May)
3. Pre-spawning phase (June- July)
4. Spawning phase (July-August)
5. Post-spawning/regression phase (September-October)

Testicular development

1. Resting phase (November-February)
2. Preparatory phase (March- April)
3. Pre-spawning phase (May-June)
4. Spawning phase (June-August)
5. Post-spawning/regression phase (August-September)

**Fig 1:** Seasonal variation in Gonadosomatic index of males and females *Raiamas bola*

Pattern of gonadal development and observed GSI showed the desynchronized situation in males and females as males attained testicular maturity one month advanced (during June). Induced breeding trials were conducted during the month of July. Healthy and bigger sized brooders were selected for the stripping of the eggs. The average length of the females was 22.13 ± 6.54 cm and average weight was 112.15 ± 2.68 g. However, male stock showed milt oozing even during the month of May with the average length and weight of 18.46 ± 8.47 cm and 91.37 ± 9.21 g, respectively. A preparatory dose of inducing agent, Ovotide was given @ 0.1 ml/kg only to females, intra-peritoneal in a single dose during the month of May to enable the spawning. The treated group showed maturity in 58% females, while only 12% females were mature in the group of without preparatory dose in

captive condition. Further, mature brooders were injected intramuscularly with Ovotide @ 0.3, 0.5, 0.7 ml/kg body weight in females and 0.1, 0.2 and 0.3 ml/kg body weight in males. Spawning in females was not observed with low dose of the inducing hormone, 0.3 ml/kg body weight. The optimum dose of the hormone for females was 0.5 ml/kg and for males, it was 0.3 ml/kg with latency period of 15-18 hours.

The fecundity of the species was estimated in the range of 30,000-42,000 (average-36548) per kg body weight. An average of 62% of fertilization rate of eggs was obtained with 73% spawn survival. A positive correlation was observed with bodyweight of the brooders for fecundity, fertilization rate, and hatching rate. Females having bodyweight more than 100 g showed better breeding performance than the

smaller sized females. During the summer season, brood stock showed bacterial infection in captive condition, might be due to increasing temperature. The fertilization rate and

spawn survival was in lower side at lower temperature (Table 1).

Table 1: Spawning performance of R. Bola in relation to body weight, water temperature and hormone dose

Average weight of female (g)	Average weight of male (g)	Dose of Ovotide (ml/kg)		Spawning/ fecundity/kg body weight	Fertilization rate (%)	Hatching rate (%)	Water temperature (°C)
		Female	Male				
98±4.6	83±2.4	0.3	0.1	No spawning	Nil	Nil	20.4
96±3.8	85±2.8	0.5	0.2	Partial spawning	Nil	Nil	19.6
95±2.4	86±3.2	0.5	0.3	30432	54	28	19.4
104±2.8	90±1.3	0.5	0.3	34384	60	68	19.8
102±2.2	89±1.4	0.5	0.3	34898	60	70	22.6
110±2.6	90±1.8	0.5	0.3	36548	62	73	23.0
111±2.2	88±2.2	0.5	0.3	34246	56	68	19.6

The observed water quality parameters showed the cold-water condition having the lower thermal regime (8-23.6 °C) and moderate dissolved oxygen (6.7-7.8mg/L). Significant

seasonal variation was observed during the field experimentation for all the water quality parameters (Table 2).

Table 2: Physico-chemical parameters of brood stock pond and breeding tank

Parameters	Brood stock pond	Breeding pond
Air temperature (°C)	10-23.4	20±3.28
Water temperature (°C)	8-23.6	20±1.12
pH	7.8-8.2	7.6±0.22
Dissolved oxygen (mg/L)	6.7-7.8	7.4±0.20
Free CO2(mg/L)	1.2-2.0	1.0±0.26
Total alkalinity(mg/L)	72.4-76.2	74.2±0.60
Total hardness (mg/L)	80.2-90.5	86.1±0.82

The captive reared stock achieved the gonadal maturity at the age of three years having the average weight of 186±6.8 g, while a maximum of 1.23 kg weight was achieved by the fish after captive rearing of six years.

Discussion

Indian Himalayan region inhibits number of indigenous fish species of ornamental value (Anita *et al.*, 2015) ^[1], sports and food value. In the present study, a single intramuscular injection of synthetic hormone, Ovotide resulted in successful ganadal maturity in females. Our findings matched with the GSI pattern reported by Pandey *et al.* (2012) ^[16] and Gupta *et al.* (2013) ^[9] in *L. dyocheilus*, Siddiqui *et al.* (2021) ^[27] in *Labeo gonius*, Pandey *et al.* (2017) in *Bangana dero*. The greater value of GSI during the month of July in females reflects the ovarian maturity in the fish (Mishra and Saksena, 2012) ^[13] and spawning season, once in a year. GSI can not only predict the breeding season but also indicates the maturity status and periodicity of spawning of a fish. Results showed a sudden decrease in gonad weight from September to January as indicated the decline of GSI after spawning. Results clearly indicate that female fish with greater weight had higher fecundity, fertilization and survival rate, which is in the conformity of the observations of Khan *et al.* (1992) ^[11] and Gupta *et al.* (2013) ^[9]. Similar trend of gonadal maturity and breeding pattern was reported for the snow trout, *S. richardsonii* in cold-water conditions (Ciji *et al.*, 2021; Sharma *et al.*, 2022; Sarma *et al.*, 2024 and Joshi *et al.*, 2026) ^[5, 25, 6, 10]. Fish did not spawn until the water temperature increases during the summer months, reflects that gonadal maturity and spawning is induced by increasing temperature in cold-water condition. Ovulation is regulated by important endogenous hormones like a gonadotropin-releasing hormone and gonadotropin inhibiting factor which are interdependent on each specific hormone or factor for proper

regulation and corresponding signal mediation necessary for ovulation (Peter and Yu, 1997; Peter *et al.*, 1998; Marimuthu *et al.*, 2009), ^[19, 20, 12]. In present study, Ovotide, a synthetic inducing hormone was found to be effective for ovulation and spawning, which was also reported to induce several other species such as *Labeo gonius* (Siddiqui *et al.*, 2021) ^[27], *Schizothorax richardsonii* (Joshi *et al.*, 2026) ^[10] and *Cirrhinus mrigala* (Dhawan and Kaur, 2004) ^[7]. Observation indicates the favorable higher thermal regime of cold-water for the better egg incubation and survival, which was also reported by Das *et al.* (2021) for a similar cold-water fish, *Neolissochilus hexagonolepis*. Bisht *et al.* (2014) reported seasonal variation and predominance of pathogenic bacteria during summer season might be a cause of bacterial infection in the growing brood stock.

Conclusion

Raiamas bola is an indigenous fish species of Himalayan region having the sports, ornamental and food value. As per IUCN, the species has been categorized under ‘Least Concern’ and the wild population of this species is fragmented, declining having stressful condition. The present study revealed that captive rearing, induced breeding and seed production of this species is possible under cold-water condition, which would be helpful for biodiversity conservation, rehabilitation and promotion of ornamental fishery and aquaculture of this indigenous species in Himalayan region.

Acknowledgement

The authors are thankful to the Director, Central Institute for Coldwater Fisheries Research (ICAR-CICFR, formerly ICAR-DCFR), Bhimtal for providing the opportunity to carry out this work along with their valuable guidance, useful suggestions, and facilities during the research.

References

- Anita, Khatri A, Dubey MK, Pandey NN. Scope of ornamental fisheries in snow fed rivers of Uttarakhand—overview. *Journal of Applied and Natural Science*. 2015;7(2):1042–1045. doi:10.31018/jans.v7i2.729.
- APHA. Standard methods for the examination of water and wastewater. 15th ed. Washington, DC, USA: American Public Health Association; 1998. p. 1134.
- Bisht A, Singh UP, Pandey NN. Comparative study of seasonal variation in bacterial flora concomitant with farm raised fingerlings of *Cyprinus carpio* at tarai region of Uttarakhand. *Journal of Environmental Biology*. 2014;35(2):363–367.
- Chaudhary S, Vishwanath W. Raimas bola. In: IUCN Red List of Threatened Species. Version 2013.1. 2010. Available from: www.iucnredlist.org
- Ciji A, Sharma P, Rajesh M, Kamala, Sharma A, Dash P, et al. Intra annual changes in reproductive indices of male and female Himalayan snow trout, *Schizothorax richardsonii* (Gray, 1832). *Aquaculture Research*. 2021;52(1):130–141. doi:10.1111/are.14875.
- Dash P, Tandel RS, Pandey NN, Sawant PB, Sarma D, Rawat KD, et al. Effects of rearing temperature on egg incubation, growth, standard metabolic rate, and thermal tolerance of chocolate mahseer, *Neolissochilus hexagonolepis*. *Journal of Thermal Biology*. 2021;98:102942. doi:10.1016/j.jtherbio.2021.102942.
- Dhawan A, Kaur K. Comparative efficacy of ovaprim and ovatide in carp breeding. *Indian Journal of Fisheries*. 2004;51(2):227–228.
- Gogoi N, Hazarika LP, Biswas SP. Studies on the reproductive biology and captive breeding of *Channa aurantimaculata*, an endemic fish from Assam. *Journal of Environmental Biology*. 2015;3:369–374.
- Gupta M, Pandey NN, Tiwari VK, Singh R, Prakash C, Chaturvedi CS. Study of gonadosomatic index and fecundity of pond raised *Labeo dyocheilus* in cold water conditions. *International Journal of Advanced Research*. 2013;1:137–140.
- Joshi R, Sharma P, Gehlot B, Arya M, Pandey H, Bhat J, et al. Captive breeding, fecundity, and early larval development of snow trout (*Schizothorax richardsonii*) in a flow-through hatchery system. *Fishery Technology*. 2026;63(1):78–86. doi:10.56093/ft.v63i1.170005.
- Khan S, Banu N, Isabella B. Studies on some aspects of biology and fecundity of *Mystus tengra* (Hamilton-Buchanan, 1822). *Bangladesh Journal of Zoology*. 1992;20:151–160.
- Marimuthu K, Haniffa MA, Rahman MA. Spawning performance of native threatened spotted snakehead fish, *Channa punctatus* induced with ovatide. *Acta Ichthyologica et Piscatoria*. 2009;39:1–5.
- Mishra S, Saksena DN. Gonadosomatic index and fecundity of an Indian major carp *L. calbasu* in Gohad reservoir. *The Bioscan*. 2012;7(1):43–46.
- Ogale SN, Kulkarni CV. Breeding of pond raised hybrids of mahseer fish *Tor khudree* (Sykes) and *Tor tor* (Ham.). *Journal of the Bombay Natural History Society*. 1987;84(2):332–335.
- Ogale SN. Induced spawning and hatching of golden mahseer, *Tor putitora* (Hamilton) at Lonavala, Pune (Maharashtra) in western ghat. *Fishing Chimes*. 1997;17(1):27–29.
- Pandey NN, Halder RS, Ali S, Kumar P, Patiyl RS, Mahanta PC. Induced spawning of *Labeo dyocheilus* in captivity under cold water condition. *Journal of Inland Fish Society of India*. 2012;43(2):44–48.
- Pandey NN, Gupta M, Singh R, Ali S, Halder RS, Kumar P, et al. Breeding performance of indigenous carp, *Labeo dero* in captivity under cold water condition of Uttarakhand, India. *Journal of Environmental Biology*. 2017;38(5):771–775. doi:10.22438/jeb/38/4/MRN-384.
- Patiyal RS, Mir MI, Pandey NN, Rajesh M, Sarma D, Chandra S. Study on embryonic and larval developmental stages of sucker head *Garra gotyla* (Gray 1830; Teleostei; Cyprinidae). *Zygote*. 2020;28(5):349–359. doi:10.1017/S0967199419000698.
- Peter RE, Yu KL. Neuroendocrine regulation of ovulation in fish: basic and applied aspects. *Reviews in Fish Biology and Fisheries*. 1997;7:173–197.
- Peter RE, Lin HR, Van Der Kraak G. Induced ovulation and spawning of cultured freshwater fish in China: advances in application of GnRH analogues and dopamine antagonists. *Aquaculture*. 1998;74(1):1–10.
- Rawat S, Malik DS, Bahuguna A. Assessment of reproductive potential and spawning patterns of *Barilius bendelisis* (Hamilton, 1807) in tributaries of the Ganga River in the Garhwal Himalayan region. *Indian Journal of Fisheries*. 2026;73(1). doi:10.21077/ijf.2026.73.1.168307-07.
- Sangma KON, Basavaraja N. Induced breeding, embryology and rearing of fry of deccan mahseer, *Tor khudree* (Sykes). *Journal of AquaTropica*. 2010;25(1-2):13–20.
- Sarkar UK, Patiyl RS, Srivastava SM. Successful induced spawning and hatching of hill stream carp, *L. dyocheilus* in Kosi river. *Indian Journal of Fisheries*. 2001;48(4):413–416.
- Sarma D, Arya M, Posti R, Mohan D, Das P, Ganie PA. Snow trout fishes (*Schizothorax* spp.) of the Asiatic region: a review enlightening distribution, diversity, and conservation issues. *Indian Journal of Fisheries*. 2024;71(2):150–164. doi:10.21077/ijf.2024.71.2.124800-20.
- Sharma S, Bisht HCS, Pandey NN, Vishwakarma BK. Herbal feed additives for gonadal maturity and breeding performance of female snowtrout (*Schizothorax richardsonii*) in captive condition. *Asian Pacific Journal of Health Sciences*. 2022;9(1):110–114. doi:10.21276/apjhs.2022.9.1.25.
- Shyam S, Mohan M, Raina HS, Singh R, Halder RS. Culture of golden mahseer, *Tor putitora* (Hamilton) in Kumaon Himalaya. Mass scale production of stocking material. In: *Proceedings of the Third Indian Fisheries Forum*; 1993. p. 45–48.
- Siddiqui U, Pandey NN, Bipin KV, Dinesh M, Preetam K, Kumar S. Artificial breeding, gonadosomatic index (GSI) and fecundity of captive reared *Labeo gonius* in coldwater condition. *International Journal of Zoological Investigations*. 2021;7(2):955–960.
- Talwar PK, Jhingran AG. *Inland fishes of India and adjacent countries*. Vol. 1 and 2. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.; 1991. p. 1097.
- Yaron Z, Bogomolnaya A, Drori S, Biton I, Aizen J, Kulikovskiy Z, et al. Spawning induction in the carp: past experience and future prospects—a review. *The Israeli Journal of Aquaculture-Bamidgeh*. 2009;61(1):5–26.