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First report on induced breeding of captively matured peninsular carp *Labeo kontius* (Jerdon 1839)

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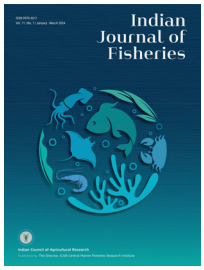

Abstract

The peninsular carp *Labeo kontius* (Jerdon 1839), endemic to the Western Ghats was captively matured and induced bred for the first time during the present study. Parameters like relative fecundity, fertilisation rate and hatching rates were estimated during the breeding trials in addition to analyses of prevailing water quality conditions. The absolute fecundity and gonado-somatic index (GSI) of the fish were estimated separately by gravimetric methods. Microscopic images of oocyte and larvae at different days post-hatching were also recorded. The results of the batch spawning trials conducted during 2021, 2022 and 2025 showed that the relative fecundity ranged from 19,521 to 3,30,902 eggs per kg body weight of the female brood fish. Fecundity of the brood fish ranged between 2,09,345 and 3,26,247 eggs per kg body weight while fertilisation rate and hatching rate in the individual spawning ranged between 31.30 to 56.03 and 81.80 to 97.77%, respectively. The absolute fecundity varied from 57,479 to 1,42,740 mostly depending on the size of the fish. The larval development was characterised by distinct morphological changes. By day 3, the larvae had developed a distinct mouth opening which was measurable under a microscope. By Day 4, the yolk sac was almost completely absorbed and by day 5, the stomach was clearly visible with ingested algae. By day 20, the body was almost completely covered with pigment. The present study showed that *L. kontius* can be successfully induced bred once in a year in carp hatchery systems, particularly during the onset of monsoon between May and July.

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Introduction

The three major peninsular rivers of India, the Godavari, Krishna and Cauvery, support a diverse and distinctive assemblage of indigenous fish species. However, these species are increasingly threatened by pollution, indiscriminate fishing, reservoir construction, degradation of breeding grounds and deterioration of aquatic habitats (Kowtal, 1994). Indiscriminate stocking of Indian major carps (IMCs) has contributed to the loss of species diversity in reservoirs and tanks. Prior to introduction of various major carps from North India, Peninsular India once harboured valuable fishery resources in the form of the barbs and minor carps many of which are indigenous to the Cauvery and Krishna rivers and their tributaries (Chandrashekaraiah *et al*., 2000).

The peninsular carp *Labeo kontius* (Jerdon 1839), commonly called the pig mouth carp or Cauvery carp, is endemic to Western Ghats and is recorded from rivers Cauvery, Bhavani and Moyar and its tributaries in the states of Karnataka, Tamil Nadu and Kerala. *L. kontius* was once a valuable component of capture fisheries in the Cauvery River system, but their numbers have declined drastically in recent years. This fish, which can be domesticated for pond culture, will be a welcome addition to aquaculture basket of our country. Pig mouth carp is a plankton feeder and reported to attain a maximum size of 61 cm. Under its natural riverine habitat, *L. kontius* is observed to breed once a year during the monsoon season in June-August. The characteristic dorsal profile distinguishes *L. kontius* from related species in the river Cauvery. The snout is very conspicuous and thick; mouth appears to be somewhat sub-terminal

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and the lower lip is finely fringed at the margin. The body is more cylindrical than in *L. fimbriatus*, from which it is easily distinguished by the short dorsal fin, conspicuous snout and the characteristic dorsal profile (Alikunhi and Rao, 1951). This species is reported to be a predominantly herbivorous (Alikunhi and Rao, 1951). Limited information is available on the breeding and larval rearing of *L. kontius*. Therefore, the present study was undertaken to evaluate its breeding performance. based on induced breeding trials conducted during 2021, 2022 and 2025.

Materials and methods

Collection of fish

Fish fingerlings were collected from the stony stretches of Cauvery River at Hogenakkal, Tamil Nadu using cast net on 28 January 2020 when the river flow was low. The collection protocol followed that described in an earlier report on the collection of wild peninsular fishes for broodstock development (Sridhar *et al*., 2014). The collected fish were conditioned for around 12-36 h in hapas installed in cement cisterns at the State Government Farm, Hogenakkal and then transported to the Regional Research Centre of ICAR-Central Institute of Freshwater Aquaculture, at Hesaraghatta, in oxygenated plastic bags. On arrival the fish were acclimatised to farm conditions in soil-based cement cisterns following appropriate disinfection procedures to minimise mortality during acclimatisation. After three months of rearing, the fish were transferred to ponds and fed a floating feed containing 30% crude protein, to satiation.

Broodstock management

For captive breeding, broodstock was raised in earthen ponds of 0.01 ha area. The ponds were manured with cow dung @ 3 t ha^{-1}. Selected fish were stocked in these ponds @ 4000 nos. ha^{-1}. The fish were given a fishmeal-based pellet feed with 35% crude protein in feeding trays, at 5% of body weight which was adjusted to satiation in due course. The health of stocked fish was monitored by regular checks and the pond water quality was managed appropriately (APHA, 2005). A total alkalinity of 200-300 ppm, DO 5-8 ppm, temperature of 23-27°C and pH 7-8.5 were recorded in the broodstock pond.

Selection of brooders

Pond cultured *L. kontius* attained first maturity during the month of June at around one and half years of age. It was observed that this species has a very short breeding season, with the peak in June month following rain. During breeding season, female fishes exhibited white and swollen belly and pinkish vent, while males had flat belly (Fig. 1). Further, males oozed milt on slight application of pressure near the vent.

Breeding trials

Breeding trials were conducted in the first week of June, using mature fish from the pond. The male (above 150 g) and female fishes (above 200 g) exhibiting signs of maturity were caught from

(a)

(b)

Fig. 1. (a) Female and (b) male brooders of *L. kontius*

the broodstock pond and brought to the FRP carp hatchery unit. They were transferred to a clean cotton hapa inside the breeding pool and conditioned under overhead shower for 30 min to 1 h. The female fish were injected with Ovatide at 0.5 ml kg^{-1} body weight, while males were given a dosage of 0.3 ml kg^{-1}, below the dorsal fin and above the lateral line. Hormone administered brooders were released to the breeding pool at a male: female ratio of 1: 1 for 2 trials and 2: 1 for another two during the trials conducted during 2021 and 2022. However, for the breeding trials conducted during 2025, the ratio was maintained at 2:1 considering the better spawning response. The fish were allowed to remain in the breeding pool with water circulation and overhead shower running throughout. Spawning occurs at 12-15 h post-hormone administration. The fertilised eggs immediately underwent a remarkable swelling and increased in size by approximately three times that of ripe ovarian egg. The spent brooders were removed, disinfected with a solution of potassium permanganate and transferred back to the ponds.

Incubation

The fertilised eggs were transferred to the hatching pool with continuous water circulation, keeping the eggs in a state of buoyancy all the time. Hatching occurred within 20-24 h of incubation and the spawn that hatched out were transparent, with conspicuous yolk mass and distinct head with transparent eyes.

Rearing of hatchlings

On 4th day, the yolk sac absorbed spawn were transferred from the hatching pool to a pre-manured soil based nursery tank (4 x 6 m^2 cement cistern) at 2,000 nos. m^{-2}. Phased manuring schedule with

a combination of 750 kg groundnut oil cake, 200 kg cow dung and 50 kg single super phosphate per hectare was carried out for maintaining desired plankton population (Jena *et al*., 2009). As basal dose, half of the above amount was made into a thick paste and spread throughout the tank 2-3 days prior to stocking. The rest was applied in 2-3 split doses depending on the plankton level of the pond. In the nursery tank, aquatic insect control was done by application of soap-oil emulsion (18 kg soap+56 kg oil per ha) a day before transferring the spawn. The dead and floating insects, if any, were removed by netting before spawn transfer. The water quality parameters in the rearing tanks remained within the following ranges: Total alkalinity 200–300 ppm, dissolved oxygen (DO) 5–8 ppm, temperature 23–26°C, and pH 8.0–8.9, which were found to be suitable for spawn rearing. The spawn were fed daily with a 1:1 mixture of rice bran and groundnut cake in powdered form @ 600 g lakh^{-1} for the first 10 days, 1,200 g lakh^{-1} for the next 10 days and 2,400 g lakh^{-1} for the last 10 days in 2 instalments during morning and evening. The fry (10-12 mg and 1.5-2.0 cm) were harvested after 30 days using fine meshed net (1.5 mm dia) with a survival ranging from 42 to 56%. These were further reared to fingerling size using a 35% crude protein sinking diet prepared at the Centre (Barlaya *et al*., 2021).

Reproductive biology

Three separate breeding trials with single female and two males were also conducted to get relative fecundity, fertilisation rate and hatching rates for individual fish. Relative fecundity was calculated based on the number of eggs obtained per kg body weight of female fish. Total number of eggs released, number of unfertilised eggs, number of hatchlings (spawn) that hatched out from each brooder were also estimated. All these estimations were done based on the number of eggs per spawn counted from unit volume of randomly collected egg per spawn samples in triplicates. After 6 h, the eggs were placed in a petridish and observed under a stereo zoom microscope. To estimate fertilisation rate, fertilised eggs (transparent eggs) and unfertilised eggs (opaque eggs) were counted in 10 ml volume. The fertilisation rate was determined using the following formula:

$$\text{Fertilisation rate (\%)} = \frac{\text{No.of fertilised eggs}}{\text{Total number of eggs}} \times 100$$

Though hatching occurred within 20-24 h of fertilisation, the hatching rate was estimated on 4th day when the yolk sac was absorbed and spawn could be lifted from the hatchery tanks. The spawn were collected in a petridish and counted by visual observation using a magnifying glass. The hatching rate was determined using the following formula:

$$\text{Hatching rate (\%)} = \frac{\text{No.of hatchlings}}{\text{Total no.of fertilised eggs}} \times 100$$

The yolk sac absorption was observed microscopically that took place after 70±2 h of hatching. The parameters like gonadosomatic index (GSI), absolute fecundity, ovary size, mouth size on the day of mouth differentiation/opening were determined using five ready to spawn females as given below. The total body length and weight of the fishes were recorded after which the fish was euthanised, ovaries were dissected out and weighed using an electronic balance of 0.001 g. accuracy.

The gonadosomatic index (GSI) was estimated using the following formula (Parameswaran *et al*., 1974):

$$\text{GSI (\%)} = \frac{\text{Weight of the ovary}}{\text{Total weight of the fish}} \times 100$$

The absolute fecundity of the fish was estimated by gravimetric method. The sub samples obtained from the ovaries were weighed and immersed separately in Gilson's fluid (Simpson, 1951) for the release of oocytes from the clusters. The number of eggs was counted and fecundity calculated using the following formula (Lagler, 1956):

$$\text{Absolute fecundity} = ni \times \frac{\text{Weight of the ovary}}{\text{Weight of sub sample}}$$

where ni = No. of eggs in the sub sample.

Oocyte size and mouth size of hatchlings were measured by mounting the samples on a glass slide and observation under an upright compound microscope (Zeis Primostar 3). The lengths of 3, 4 and 5 day old hatchlings, representing the stages with yolk, nearly absorbed yolk and algae in the stomach were measured using a stereo zoom microscope (N&M, MS-100).

Results

The results of the batch spawning trials conducted during 2021, 2022 and 2025 are given in Table 1 and 2. It was observed that the relative fecundity ranged from 19,521 to 3,30,902 eggs per kg body weight of the female brood fish. The fertilisation rate and hatching rate ranged between 43 to 65 and 51.71 to 90.37%, respectively. Table 3 gives the relative fecundity, fertilisation rate and hatching rates of the fish bred individually. The fecundity ranged between 2,09,345 and 3,26,247 eggs per kg body weight of the female brood fish. The fertilisation rate and hatching rate in the individual spawning ranged between 31.30 to 56.03 and 81.80 to 97.77%, respectively. The absolute fecundity and gonado-somatic index are tabulated in Table 4. The absolute fecundity varied from 57,479 to 1,42,740 mostly depending on the size of the fish (240-373 g). Fertilised eggs collected from breeding pool for transfer to the hatching pool

Table 1. Breeding performance of *L. kontius* in batch spawning conducted during 2021 and 2022

Trial	Date	No. and total weight (g) of males	No. and total weight (g) of females	Relative fecundity	M:F ratio (by No.)
1	21.06.2021	4 (877 g)	4 (1307 g)	19,521	1:1
2	22.06.2021	4 (1542 g)	4 (1277 g)	27,897	1:1
3	12.07.2021	4 (908 g)	2 (490 g)	1,21,173	2:1
4	27.06.2022	2 (455 g)	1 (328 g)	2,17,225	2:1

Table 2. Breeding performance of *L. kontius* in batch spawning conducted during 2025

Trial	No. and total weight (g) of males	No. and total weight (g) of females	Relative fecundity	Fertilisation rate (%)	Hatching rate (%)
1	20 (3000 g)	10 (1940 g)	2,97,987	43.00	74.42
2	20 (3010 g)	10 (1850 g)	3,30,902	62.00	90.37
3	14 (2452)	7 (2324)	1,28,012	65.00	51.71

were transparent (Fig. 2). The embryonic developmental stages within the eggs, including the comma stage before hatching were clearly visible. Microscopic images of the ovarian eggs and larvae at day 3, 4 and 5 days post-hatching, showing mouth measurement, near complete yolk absorption and ingested algae in the stomach, respectively are presented in Fig. 3.

The larvae developed distinct mouth opening by day 3, which was measurable under the microscope. By day 4, yolk was almost completely absorbed on day 4 while the stomach with ingested algae was clearly visible by day 5. At 20 days post-hatching, the fry were almost completely pigmented. The microscopic measurements recorded were as follows: ova diameter ranged between 500 to 624 µm, mouth opening on day 3 was 242 µm and larval total length was 5.10, 6.37, and 8.15 mm on days 3, 4 and 5, respectively.

Table 3. Breeding performance of *L. kontius* bred individually during 2025

Trial	No. and weight (g) of males	No. and weight (g) of females	Relative fecundity	Fertilisation rate (%)	Hatching rate (%)
1	2 (453)	1 (370)	2,58,152	31.30	81.80
2	2 (455)	1 (352)	2,09,345	39.12	97.77
3	2 (377)	1 (270)	3,26,247	56.03	88.82

Table 4. Absolute fecundity and gonado-somatic index of female *L. kontius* estimated in 2025

Weight of females (g)	Weight of ovary (g)	Absolute fecundity (No. of eggs in the female)	Gonado somatic index (%)
240	45.19	57,479	18.06
249	44.98	72,035	18.83
293	60.51	1,20,437	20.65
337	71.76	1,18,537	21.29
373	83.09	1,42,740	22.28

Discussion

Closing the life cycle is one of the most important requirements for introduction of a new species for farming. In this regard, our efforts were to close the life cycle of *L. kontius*, to introduce a new species for farming and to make the seeds available to strengthen the stock in nature. The species spawns once a year in rivers, reservoirs, bundhs and nallahs like *Labeo bata,* another freshwater minor carp species. Its spawning season coincide with early part of monsoon season and successful attempts were made during the months of May to July from 2021. Water temperature ranged from 26.0 to 28.8°C during successful seed production, which falls within the suitable range for most small indigenous fishes (Islam and Chowdhury, 1976). *L. kontius* appeared to have similar temperature requirements as Indian major carps. The females attained higher weight than the males which is in agreement with the earlier reports (Manojkumar and Kurup, 2010). According to Bhuiyan *et al.* (2007), induced breeding, also known as the hypophysation, is a technique by which a fish that do not readily breed under captive or stagnant water conditions are stimulated to breed by injecting synthetic hormones. In freshwater fish, spawning induction is usually performed

Fig. 2. Fertilised eggs and eggs showing larval development of *L. kontius* just before hatching.

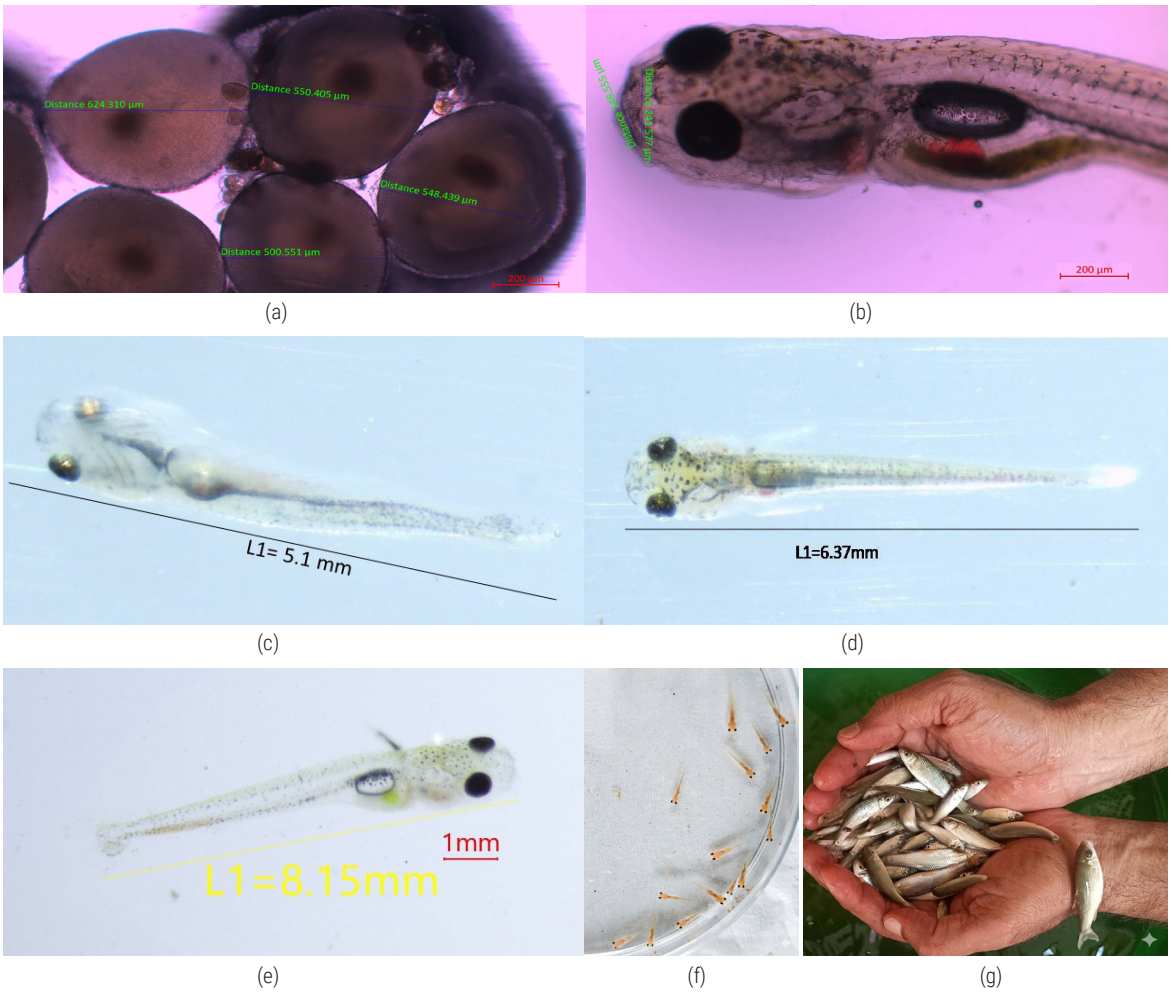

Fig. 3. Microscopic view of *L. kontius* at different developmental stages. (a) Oocyte; (b) Day 3 larva showing mouth measurement; (c) Day 3 larva showing total length; (d) Day 4 larva with the yolk almost completely absorbed; (e) Day 5 larva with ingested algae in the stomach; (f) 20 days old fry; (g) Fingerling

using the hypophysation technique (Arantes *et al*., 2013). The doses of Ovatide for induction of spawning of *L. kontius* used in the present study was 0.5 and 0.3 ml kg^{-1} for female and male fishes respectively. This dose is similar to that used in breeding of IMCs and *L. calbasu* (Peter *et al*., 1988).

The lower relative fecundity observed during the 1st two trials with male: female ratio of 1:1 indicates the need for a higher number of males for successful spawning. The relative fecundity with ideal (2:1) male: female ratio (Basavaraja *et al*., 2007; Verma *et al*., 2016: Kusmiatun *et al*., 2024) for *L. kontius* ranged from 1.21 to 3.30 lakh eggs in the batch breeding trials, and from 2.09 lakhs to 3.26 lakhs in the individual female breeding. These values are slightly less (3.50 lakh to 5.01 lakh) than the value reported for *L. calbasu* (Chakraborty and Tabasum, 2024). According to Rajanna *et al*. (2021) the fecundity of *Labeo fimbriatus* ranged between 63,897 and 5,10,824. According to Bhatnagar (1964), the fecundity ranged between 2,12,000 and 5,76,251 eggs per kg weight of *L. bata*. Bhagawati *et al*. (2023) recorded a fecundity of 2.75 lakh per kg for female of another minor carp *Cirrhinus reba*. The range observed for *L. kontius* is comparable with the fecundity of other minor carps.

The fertilisation rate for *L. kontius* ranged from 31 to 65% in the present breeding trials. Pandey *et al*. (1998) and Keshavanath *et al*. (2006) reported a fertilisation rate of 70-80% and 60-99% for *Tor khudree*. Earlier studies indicated that Indian major carps have fertilisation rates ranging from 70-96% (Basavaraja *et al*., 2007; More *et al*., 2010). The maximum fertilisation rate for calbasu was reported as 98.40±0.88% (Chakraborty and Tabasum, 2024). Hatching of *L. kontius* took place 20 to 24 h following fertilisation at water temperature of 24.0 to 26.8°C. Alikunhi and Rao (1951) reported that it took 20 h of incubation to hatch fertilised eggs of *L. kontius* collected from river, when the temperature of water ranged from 22 to 23°C. Bhagawati *et al*. (2023) reported 24 h for hatching of a medium carp *C. reba* at a water temperature of 24-25 °C. Incubation period for eggs of Indian major carps varies from 14 to 18 h (Chakrabarty and Murty, 1972). Hatching of *L. calbasu* took place 16 to 18 h following fertilisation at a temperature of 26.5 to 28.5°C. Mojer (2025) reported that following artificial fertilisation, the incubation period for common carp observed was 38 h, at a temperature range between 25 and 27°C. The rate of development of embryos varies according to the water temperature (Basavaraju and Varghese, 1981; Blaxter, 1992). The hatching rate for *L. kontius*

ranged from 52 to 98% in the breeding trials, being comparable with the figures reported for other major and minor carps. More *et al*. (2010) and Saud *et al*. (2013) recorded hatching percentages ranging from 80-92% with Indian major carps. The maximum hatching rate for calbasu was 88.03±1.44% (Chakraborty and Tabasum, 2024). Mojer (2015) reported a hatching rate of 85%, in artificial fertilisation of common carp.

GSI provides information on fish reproduction and is a crucial factor in assessing ovarian maturity. The gonado-somatic index of *L. kontius* ranged from 18-22%, which is comparable with that reported for *L. calbasu:* 18.8-20.7% as reported by Shailja and Saxena (2012); 19.34 to 22.82% according to Chakraborty and Tabasum (2024). Mishra and Saxena (2012) also found that the ovarian weight was almost 20% of the body weight of full mature *L. calbasu*. According to Bhatnagar (1964), the GSI in *L. bata* ranged between 13.02 to 24.60. Sridhar *et al*. (2014) recorded maximum GSI of 12.51 in *H. pulchellus*, another peninsular carp native of Tunga River. Alikunhi (1966) recorded a GSI of 18 to 24.20 in common carp. Shukla and Patel (2024) recorded a higher GSI of 34.55, 35.21 and 29.10, respectively, for the Indian major carps, *Labeo catla*, *Labeo rohita* and *Cirrhinus mrigala*. The GSI exhibited by *L. kontius* varied depending upon the weight of the fish and ovary. These observations were similar to the results obtained in grass carp *Ctenopharyngodon idella* (Alikunhi *et al*., 1963); *L. catla* (Natarajan and Jhingran, 1963); *L. rohita* (Khan and Jhingran, 1975) and *H. pulchellus* (Sridhar *et al*., 2014).

The absolute fecundity of *L. bata* varied from 37,945 to 69,786 eggs in mature specimens of 150 to 300 mm total length (Nanda *et al*., 2002). Fecundity of *Labeo gonius* measuring 220-496 mm was found to range from 18,697 to 2,03,233 (Chowdhary and Shahid, 2018). In the present study, it ranged between 57,479 and 1,42,740 for fish weighing between 240 g and 373 g. Generally, it has been found that the number of eggs increased with the size of fish and gonad weight. Normando *et al.* (2009) suggested that variation in fecundity was primarily a reflection of variation in the size of fish at maturity. Narahara *et al*. (1989) and Stequert *et al*. (2003) registered a high correlation between fecundity and gonad weight. However, according to Lagler (1956), the number of eggs produced by a female depends on many factors like size, age, condition and the nature of the sample. The larval yolk sac of *L. kontius* was almost completely absorbed by day 4 post-hatch. Other authors also observed that the yolk sac was completely absorbed in catla, rohu, mrigal and their hybrids on day 4 post- hatching (Chakrabarty and Murty, 1972; Konda Reddy, 1977; Basavaraju and Varghese, 1981). However, Mojer (2015) reported complete absorption of the yolk sac within three days after hatching. The growth and survival of kontius fry during nursery rearing were moderate. The growth obtained were comparable with that obtained for *T. khudree* (Basavaraja *et al*., 2002), *Puntius sarana* (Chakraborty *et al*., 2003) and *L calbasu* (Chakraborty and Tabasum, 2024).

The diameter of the oocytes collected from ovary of *L. kontius* varied between 500 to 624 µm. Oocyte diameter of Javaen Barb ranged between 290 and 300 µm (Hasan *et al*., 2015), while that of common carp (*Cyprinus carpio*) between 400 and 1500 µm (Tempero *et al*., 2006). Kumar *et al*. (2021) reported oocyte diameter of 851 to 950 µm in brackishwater catfish, *Mystus gulio* indicating species specific differences. Ova diameter of *C. carpio, L. rohita, C. catla* and *C. mrigala* immediately after spawning were observed to be 1–1.5, 1–1.1, 2–3.2, 1–1.5 mm (Singh *et al*., 2006). Basavaraju and Varghese (1981) recorded a length of 5.77 to 6.55 mm for larvae of rohu-mrigal hybrid in 3 to 5 days old hatchlings while the length of same age group larvae of *L. kontius* ranged between 5.1 to 8.15 mm. They also observed well developed mouth on day 3 post-hatching similar to our observation.

Reddy and Varghese (1983) reported that the intestines of 2 days old larvae of catla x rohu hybrid contained algae and cladocerans, indicating that feeding had commenced by the second day itself, while the yolk sac was still present. Similarly, the microscopic image of the 5 day old *L. kontius* larva in the present study showed ingested algae in the stomach. Fry of *L. kontius* were also observed to feed near the bottom and browse on walls of the aquaria and cement cisterns. This feeding behaviour was further confirmed during fingerling rearing in tanks containing suspended bundles of sugarcane bagasse. These observations indicate the potential suitability of the species for periphyton based aquaculture. Alikunhi and Rao (1951) reported that post-larvae and early fingerlings of *L. kontius* fed voraciously on zooplankton including rotifers, cladocerans and copepods. They also observed that, when available, the fish consumed substantial quantities of phytoplankton, including *Microcystis*.

The present study demonstrated that *L. kontius* can be successfully induced to breed once annually, in carp hatchery systems during the onset of monsoon season between May and July. The development of an induced breeding protocol for *L. kontius* represents an important step towards introduction of this indigenous peninsular carp species into the aquaculture sector of the country. However, further research is required before its introduction into commercial aquaculture. In particular, growth and compatibility studies under farming conditions, including polyculture with other carps, are needed to evaluate its growth performance and suitability for integration into existing culture systems.

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