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Seasonal Ovarian Cycle and Spawning Periodicity of the Ornamental Cyprinid *Rasbora rasbora* in Jammu

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Abstract

The seasonal ovarian cycle of the ornamental cyprinid Rasbora rasbora was assessed from an annual series of monthly morphometric and histological observations from Jammu. The dataset included fish length, body mass, ovary mass, gonadosomatic index (GSI), dominant oocyte stages, oocyte diameter and nuclear diameter. Oocyte development was resolved into six stages: chromatin-nucleolar, perinucleolar, yolk-vesicle, vitellogenic, maturation and ripe-egg stages. GSI increased from 0.84 ± 0.09 in January to 4.94 ± 0.75 in May and 10.08 ± 3.47 in June, reached an annual maximum of 21.84 ± 3.65 in July, and declined to 8.22 ± 6.26 in August and 1.84 ± 0.59 in September. Mean ovary mass and oocyte diameter followed the same seasonal progression, peaking in July at 1.44 ± 0.57 g and 0.982 ± 0.011 mm, respectively. Mature and ripe oocytes dominated in June and July; post-ovulatory and atretic structures accompanied the subsequent decline. The combined evidence indicates a single annual, monsoon-associated spawning period extending from July to mid-September, with greatest spawning activity in August. These observations provide practical timing for broodstock conditioning, captive propagation and conservation-oriented culture of this indigenous ornamental fish.

Keywords: Rasbora rasbora, gonadosomatic index, oogenesis, ovarian histology, monsoon breeder, ornamental fish, Jammu

1 Introduction

Reliable captive propagation of indigenous ornamental fishes depends on knowing when broodfish mature, when ovulation occurs and which ovarian features distinguish resting, developing and spent females. General treatments of fish reproduction identify seasonal gonadal development as a basic requirement for broodstock management [1]. For small cyprinids collected from natural waters, this information is also important for reducing dependence on capture-based supply during the breeding season.

The gonadosomatic index provides a compact measure of seasonal allocation to the gonad. Changes in GSI have therefore been used to identify maturation and spawning in teleosts [2], [3]. Histological evidence is needed alongside GSI because ovarian mass alone does not distinguish developing oocytes from post-ovulatory tissue or atresia. Teleost oogenesis involves coordinated changes in the nucleus, cytoplasm, yolk inclusions and follicular envelopes [4], and regional studies have shown that these changes can be organized into reproducible maturity stages [5].

Rasbora rasbora is a small indigenous cyprinid with ornamental value in Jammu. Earlier work from Jammu documented seasonal changes in its gonads and reported a July GSI maximum [6], but a consolidated monthly account linking GSI, ovary mass, oocyte-stage composition and cellular dimensions is useful for culture planning. The present study describes that annual pattern, defines the six ovarian stages observed in the species and identifies its spawning period from convergent morphometric and histological evidence.

2 Materials and Methodology

2.1 Study material and variables

The analysis draws on a one-year series of monthly observations on female R. rasbora from Jammu, recorded during the author's doctoral research at the Department of Zoology, University of Jammu [13]. Each monthly record comprised total length (cm), body mass (g), ovary mass (g), GSI, the percentage contribution of the most prevalent oocyte stages, mean oocyte diameter (mm) and mean nuclear diameter (mm), expressed as mean ± standard deviation. Because the number of specimens examined each month was not retained in the source record, the analysis is restricted to descriptive monthly comparisons and no inferential tests were applied.

GSI was treated as the percentage ratio of ovary mass to body mass:

$$\mathrm{GSI} = (ovary\ mass / body\ mass) \times 100.$$

The values reported in the monthly archive were retained for analysis. Seasonal interpretation considered GSI together with ovary mass, oocyte diameter and the monthly distribution of developmental stages.

2.2 Histological assessment

Ovarian sections from the same study were evaluated for the organization of the tunica albuginea, germinal epithelium, ovigerous lamellae, developing oocytes, post-ovulatory follicles and atretic oocytes. Oocyte development was assigned to six stages on the basis of nuclear position, distribution of nucleoli, appearance and movement of yolk vesicles, yolk deposition, condition of the nuclear membrane and the degree of final yolk loading. This cellular sequence follows established descriptions of teleost oocyte growth [4] and is comparable with six-stage regional classifications [5], [6].

2.3 Data handling and presentation

Monthly values were taken from the original data table and checked against the stage ranges given in the accompanying descriptive record. Two values were corrected as evident transcription errors: the January Stage II proportion was entered as 14% rather than 24%, so that Stage I and Stage II total 100%, and the September nuclear diameter was entered as 0.084 mm rather than 0.84 mm, consistent with the recorded nuclear dimensions of the species. Leading zeros were restored where they had been omitted. No other numerical value was altered.

3 Results and Discussion

3.1 Seasonal pattern in ovary mass and GSI

Ovarian investment remained low from October through March and rose sharply during late spring and early summer. Mean ovary mass increased from 0.053 ± 0.046 g in April to 0.28 ± 0.15 g in May, 0.67 ±

0.38 g in June and 1.44 ± 0.57 g in July (Table 1). The corresponding GSI values were 1.61 ± 0.86, 4.94 ± 0.75, 10.08 ± 3.47 and 21.84 ± 3.65. Thus, both variables reached their annual maximum in July.

Table 1 Monthly morphometric measurements and gonadosomatic index of female Rasbora rasbora

Month	Length (cm)	Body mass (g)	Ovary mass (g)	GSI
January	6.55 ±0.78	2.53 ±0.52	0.022 ±0.006	0.84 ±0.09
February	6.80 ±1.20	2.15 ±0.87	0.025 ±0.010	1.195 ±0.19
March	6.00 ±1.26	2.47 ±1.08	0.039 ±0.016	1.54 ±0.07
April	6.22 ±1.40	2.50 ±1.40	0.053 ±0.046	1.61 ±0.86
May	7.50 ±1.37	5.13 ±2.20	0.28 ±0.15	4.94 ±0.75
June	7.60 ±1.45	6.26 ±2.84	0.67 ±0.38	10.08 ±3.47
July	8.20 ±1.13	6.50 ±0.45	1.44 ±0.57	21.84 ±3.65
August	7.80 ±1.01	3.87 ±0.96	0.37 ±0.34	8.22 ±6.26
September	7.77 ±0.84	4.80 ±1.06	0.059 ±0.054	1.84 ±0.59
October	8.40 ±0.672	5.85 ±0.65	0.067 ±0.026	1.11 ±0.37
November	6.40 ±1.25	3.87 ±1.30	0.034 ±0.017	0.80 ±0.21
December	6.10 ±0.90	3.50 ±0.73	0.021 ±0.004	0.58 ±0.004

Values are mean ± SD. GSI, gonadosomatic index.

GSI fell by 62.4% between July and August and by 91.6% between July and September. This decline, together with the reduction in ovary mass and the appearance of post-ovulatory structures, marks the release of mature ova. The broad August SD indicates that females were not all in the same reproductive condition during the transition from ripe to spent ovaries. The annual trajectory is shown in Figure 1.

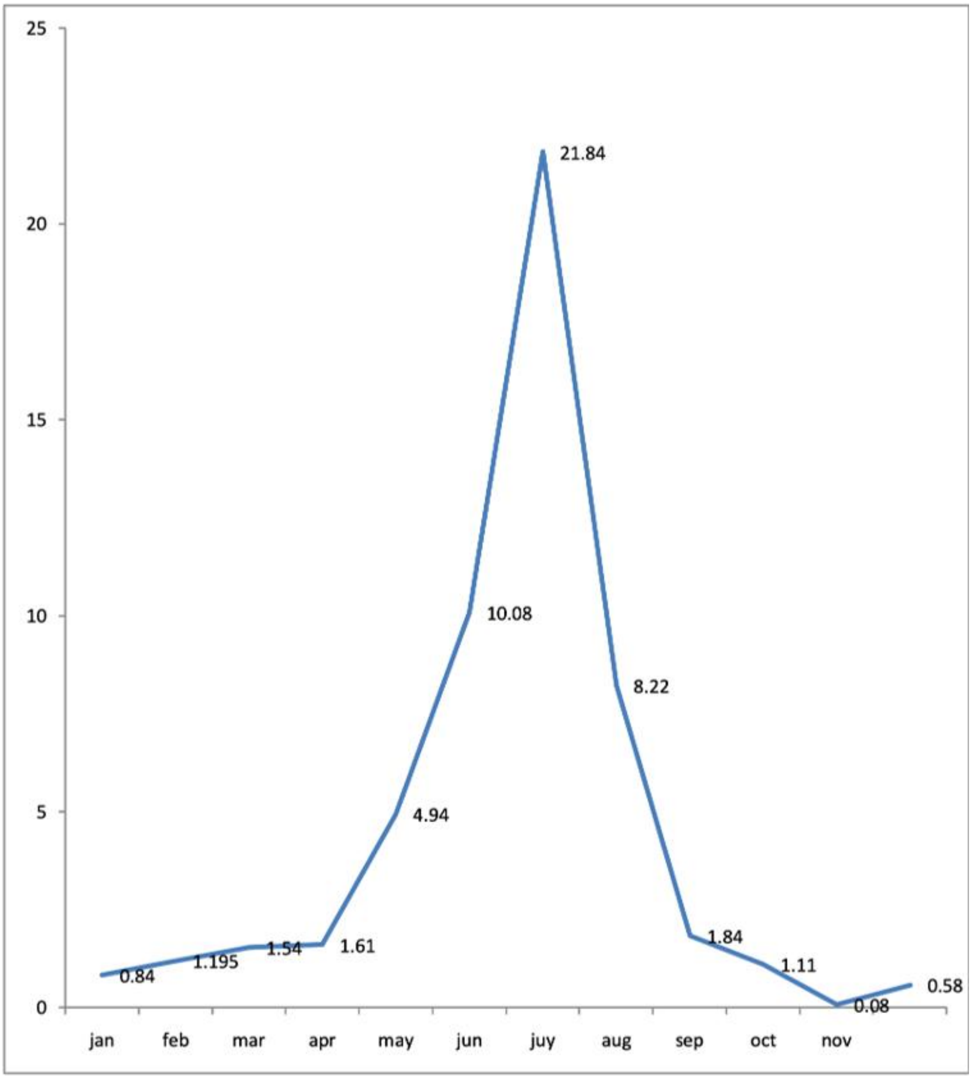


Figure 1 Monthly gonadosomatic index of female Rasbora rasbora. Points show means and error bars show standard deviations

The July maximum and abrupt August decline agree with the earlier Jammu account of R. rasbora [6]. More generally, a GSI peak immediately before spawning and a rapid decline during egg release are expected features of a seasonal teleost cycle [2], [3]. The close agreement among GSI, ovary mass and oocyte composition strengthens the interpretation because the breeding period is not being inferred from a single index.

3.2 Monthly oocyte composition and cellular dimensions

The cellular record paralleled the gonadal indices (Table 2). Small Stage I and II oocytes dominated from October through March. Stage III and IV oocytes became prominent in April and May, and advanced Stage V and VI oocytes dominated in June and July. Mean oocyte diameter increased from 0.0421 ± 0.0114 mm in January to 0.462 ± 0.135 mm in May, 0.812 ± 0.240 mm in June and 0.982 ± 0.011 mm in July. Mean nuclear diameter reached 0.126 ± 0.005 mm in July.

Table 2 Monthly oocyte-stage composition and cell dimensions of female Rasbora rasbora

Month	Most prevalent oocyte stages	Oocyte diameter (mm)	Nuclear diameter (mm)
January	I 86%; II 14%	0.0421 ±0.01143	0.0245 ±0.00756
February	I 64%; II 36%	0.09125 ±0.01532	0.0542 ±0.01035
March	I 35%; II 65%	0.136 ±0.015	0.071 ±0.013
April	I 30%; II 45%; III 25%	0.266 ±0.010	0.084 ±0.009
May	I 10%; II 15%; III 35%; IV 40%	0.462 ±0.135	0.084 ±0.010
June	V 30%; VI 60%; other 10%	0.812 ±0.240	0.112 ±0.012
July	V 20%; VI 40%; other 40%	0.982 ±0.0112	0.126 ±0.005
August	V 15%; other 85%	0.694 ±0.016	0.087 ±0.017
September	I and II 90%; other 10%	0.266 ±0.013	0.084 ±0.013
October	I and II 100%	0.028 ±0.017	0.0175 ±0.014
November	I and II 100%	0.030 ±0.017	0.018 ±0.011
December	I and II 100%	0.039 ±0.011	0.021 ±0.020

Values are mean ± SD. ‘Other’ comprises stages and post-ovulatory structures not separately quantified in the source data.

By August, the mean oocyte diameter had declined to 0.694 ± 0.016 mm and the table assigned 85% of observations to the residual ‘other’ category. In September, Stage I and II oocytes again accounted for 90% of the observed population, while mean ovary mass and GSI approached resting levels. The sequence indicates that one dominant cohort completed maturation, was released over a short interval, and was followed by rapid return to an immature ovarian profile.

3.3 Oocyte developmental stages

A tunica albuginea enclosed the ovary. Ovigerous lamellae, arising from the germinal epithelium, extended into the ovocoel, and developing oogonia lay close to this epithelium. Six oocyte stages were distinguished (Table 3). The progression from a large central nucleus and sparse cytoplasm to yolk-vesicle formation, vitellogenesis, nuclear displacement and final yolk loading conforms to the cellular pattern described for teleost oogenesis [4].

Table 3 Diagnostic features and dimensions of ovarian stages in Rasbora rasbora

Stage	Designation and diagnostic feature	Oocyte diameter (mm)	Nuclear diameter (mm)
I	Chromatin-nucleolar; small spherical oocyte with a large central nucleus	0.028–0.056	0.017–0.035
II	Perinucleolar; nucleoli arranged along the inner nuclear membrane	0.070–0.140	0.035–0.070
III	Yolk-vesicle; peripheral vesicles extend centripetally through the ooplasm	0.098–0.280	0.056–0.086
IV	Vitellogenic; yolk granules accumulate and the vitelline membrane thickens	0.322–0.462	0.070–0.084
V	Maturation; nuclear membrane indistinct, with occasional acentric nucleus	0.700–0.812	0.070–0.112
VI	Ripe egg; fully yolk-laden, opaque oocyte with comparatively thin envelopes	0.672–0.986	Not separately recorded

The six-stage series is comparable with the regional classification used for Ophiocephalus punctatus [5] and with earlier work on R. rasbora from Jammu [6]. Its value for routine broodstock assessment lies in the diagnostic transitions: Stage III marks the appearance of yolk vesicles; Stage IV records active yolk deposition; and Stages V and VI identify females approaching or ready for spawning. Comparable histological criteria have also been used to define seasonal maturity in other Jammu fishes [12].

3.4 Post-ovulatory structures and ovarian phases

Post-ovulatory follicles in R. rasbora retained the thecal and granulosa layers and passed through four successive appearances, comparable to those reported in regional teleost studies [7], [8]: shrinkage of the discharged follicle; hypertrophy of granulosa cells; proliferation into cell masses or ‘cell pearls’; and formation of a compact corpus luteum-like body. Atretic oocytes contained coalesced or liquefied yolk and were most conspicuous during the maturation, ripe and spent conditions. Similar post-ovulatory and atretic structures have been reported in regional teleost studies [7], [8], while follicular atresia is widely regarded as the resorption pathway for oocytes that are not ovulated [9]. The present material establishes their value as markers of recent spawning; it does not determine an endocrine function.

The annual ovarian cycle can be organized into four practical phases. The resting phase extends from November to February and is dominated by Stage I and II oocytes. The pre-spawning phase extends from March to June, during which yolk vesicles appear, vitellogenesis accelerates and GSI rises. The principal spawning phase covers July and August, with some activity extending to mid-September. September and October form the post-spawning transition, characterized by low GSI, reduced ovary mass, early-stage oocytes and post-ovulatory or atretic tissue.

Fig.1 Photomicrograph showing the cross section of ovary of *Rasbora rasbora* depicting tunica albuginea, germinal epithelium, ovigerous lamellae and stage I oocytes.

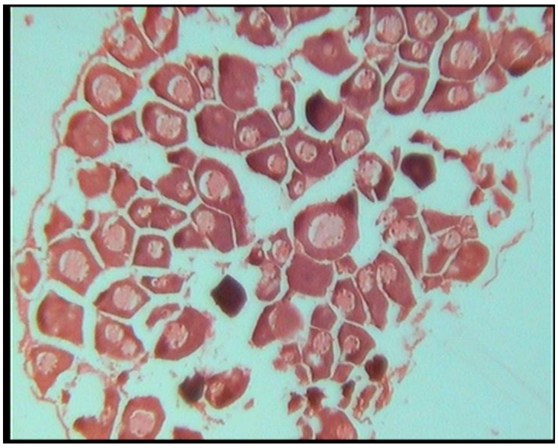
Fig.2 Photomicrograph showing StageII oocytes of *Rasbora rasbora*. Note the arrangement of nuclei along nuclear circumference.

Fig.3 Photomicrograph showing Stage III oocyte of *Rasbora rasbora*. Note the presence of Yolk Vesicles in the peripheral part of ooplasm.

Fig.4 Photomicrograph showing an enlarged view of stage III oocyte of *Rasbora rasbora*. Note the centripetal invasion of Yolk Vesicles into the ooplasm and the undulating nuclear membrane and the presence of vitelline membrane, follicular membrane and theca in stage III oocytes of *Rasbora rasbora.*

Fig.5 Photomicrograph showing nucleolar extrusion in stage III nucleus of *Rasbora rasbora.*

Fig.6 Photomicrograph showing Stage IV oocyte of *Rasbora rasbora* showing vitellogenesis.



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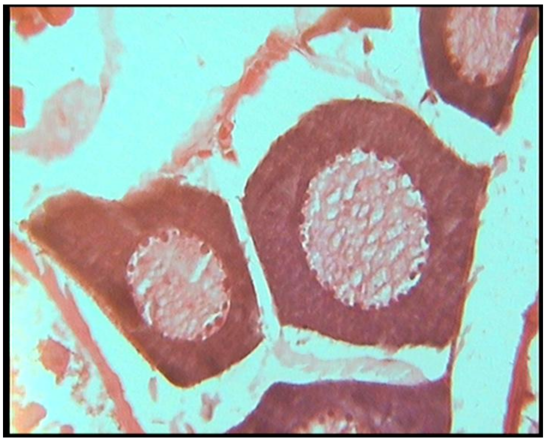

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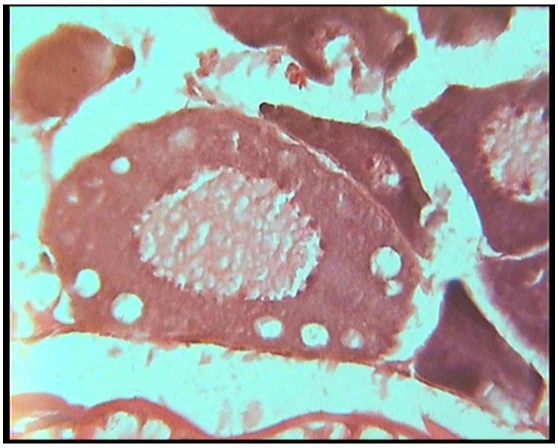

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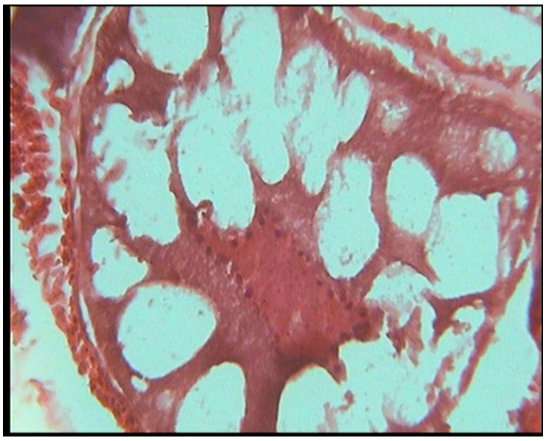

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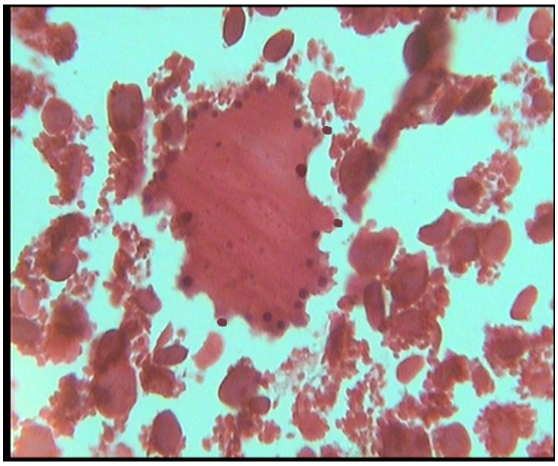

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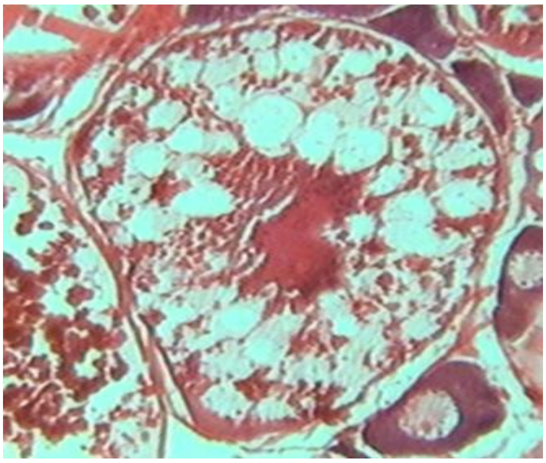


fig. **6**

Fig.7 Photomicrograph showing yolk granules in cytoplasm of stage IV oocyte of *Rasbora rasbora*

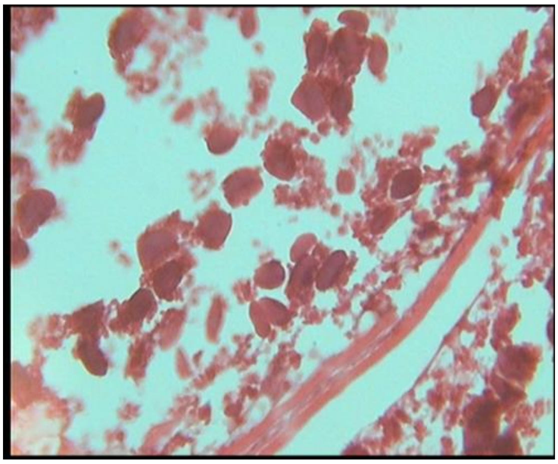
Fig.8 Photomicrograph showing Stage V oocyte of *Rasbora rasbora. Note the acentric nucleus.*

Fig.9 Photomicrograph showing Stage VI oocyte of *Rasbora rasbora.*

Fig.10 Photomicrograph showing Stage VI oocyte of *Rasbora rasbora.* Note the lack of characteristic adhesive nature of the three layers.

Fig.11 Photomicrograph showing atretic oocytes of *Rasbora rasbora* at a later stage. Note the yolk at a dissolved state.

Fig.12 Photomicrograph showing oogonial nests in a section of ovary of *Rasbora rasbora*.



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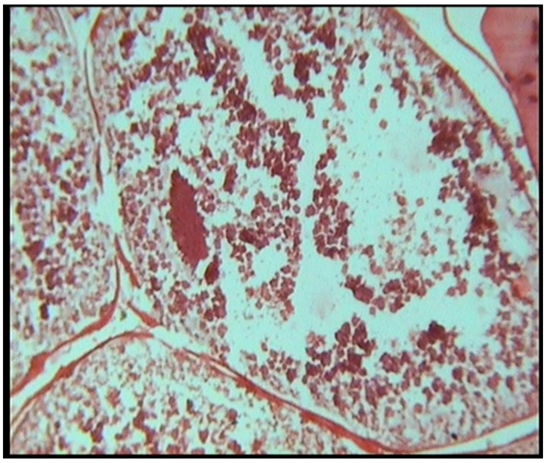

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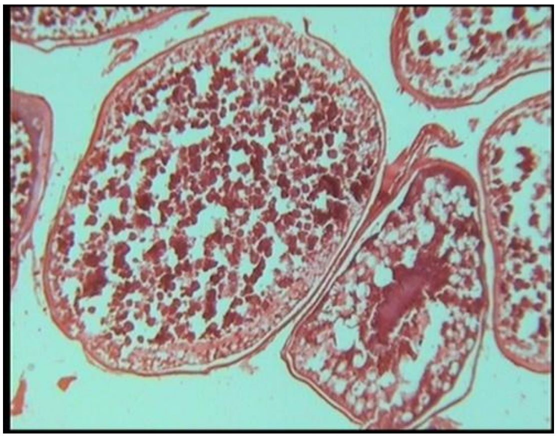

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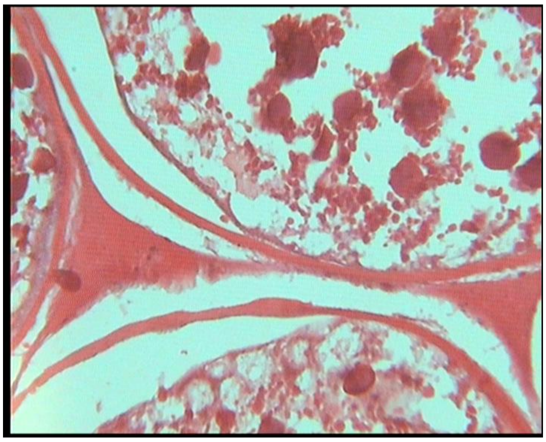

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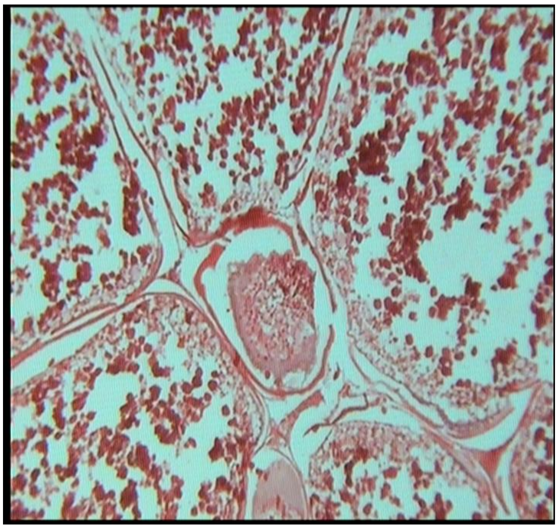

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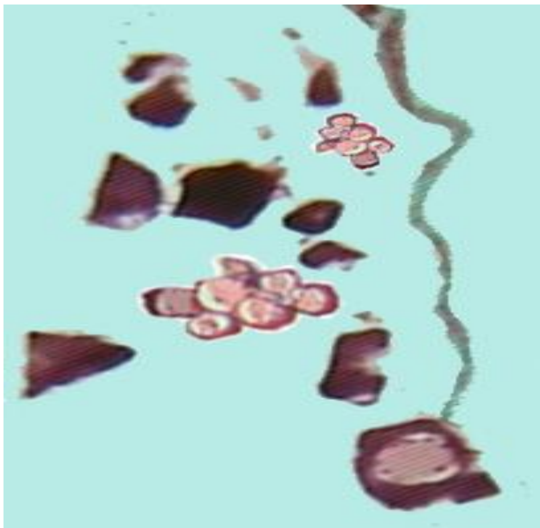

fig. **12**

3.5 Spawning periodicity and culture significance

The July GSI maximum, prevalence of ripe oocytes in June and July, abrupt decline in August, and return of early-stage oocytes by September identify R. rasbora as a monsoon-associated seasonal spawner. A monsoon breeding period has also been reported for the species in the River Padma system [10]. In the classification proposed for Indian fishes [11], the present pattern corresponds to spawning once in a year over a short period. The monthly stage distribution further suggests broadly synchronous development of the dominant oocyte cohort rather than continuous recruitment of ripe eggs throughout the year.

For captive propagation, females should be monitored from April, when Stage III oocytes become evident, and conditioned most intensively during May and June as ovary mass and GSI rise. July provides the strongest signal of final maturation, while the August decline indicates that collection of broodfish from the wild may already coincide with active spawning. Culture-based seed production should therefore emphasize pre-monsoon broodstock acquisition and minimize removal of ripe females during July and August. These timings translate the ovarian record into a practical conservation measure for an indigenous ornamental resource.

4 Conclusion

Female Rasbora rasbora in Jammu showed a single annual ovarian cycle. Ovarian development accelerated from March, active vitellogenesis occurred during late spring and early summer, and GSI reached 21.84 ± 3.65 in July. The subsequent reduction in GSI, ovary mass and oocyte diameter, together with post-ovulatory and atretic structures, placed the main spawning period in July and August with extension to mid-September. Six histological stages described the progression from chromatin-nucleolar oocytes to ripe eggs. The combined monthly record supports pre-monsoon broodstock conditioning and captive breeding as alternatives to harvesting spawning females from natural waters.

Acknowledgement

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