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Seasonal Variations in the Gonadosomatic Index of an Indian Major Carp, *Labeo rohita* (Ham)

[1]Gunwant P. Gadekar and [2]Vidhya V. Baile
[1]Dhote Bandhu Science College, Ram Nagar, Gondia
[2]PGTD Department of Zoology, Nagpur University, Nagpur

Abstract: The study was conducted to determine the changes in the Gonadosomatic Index (GSI) of an Indian major carp, *Labeo rohita*. The fish has only one spawning season of short duration, running from July to August as indicated by the peaks of GSI and the diameter of oocytes and testicular lobules. Both males and females mature simultaneously. The minimum GSI for female was 0.74±0.12 in resting phase and maximum was observed in the spawning phase (16.49±1.70). The GSI for males was minimum in resting phase (0.087±0.004) and maximum in spawning phase (2.02±0.181).

Key words: Gonadosomatic index, *Labeo rohita*, annual cycle, fish, spawning

INTRODUCTION

Environmental changes greatly influence the production of eggs varies not only among different species but also within the same species. This depends upon the length and weight of the gonads (Barmanh and Saikia, 1995). Maturity determination by gonadosomatic ratio has proved to be a significant tool in the life of fishes. Gonads undergoing regular seasonal cyclic changes in weight, particularly in females which help to indicate the spawning season (Dadzie *et al*., 2000). The method of studying the spawning season is to follow the seasonal changes in gonadal weight in relation to body weight which is expressed as the gonadosomatic index (Ahirrao, 2002). Gonadosomatic Index (GSI) is one of the important parameters of the fish biology which gives the detail idea regarding the fish reproduction and reproductive status of the species and help in ascertaining breeding period of fish (Mohan and Jhajhria, 2001; Shankar and Kulkarni, 2005). The gonadosomatic index measures the cyclic changes in gonad weight in relation to total fish weight and can be used to determine spawning periods (Smith, 2008). The objective of the present research has to determine the maturity and spawning period influenced with different seasons in the fish *Labeo rohita*.

MATERIALS AND METHODS

Healthy mature and immature *Labeo rohita* numbering 280 (140 males and 140 females) were collected from Pench fish seed farm, Nagpur. They were brought to the laboratory and were thoroughly washed with water and blotted completely to remove excess of water and each fish was weighed on electrical balance and dissected to remove the gonads. The weight of individual fish and its gonads were recorded and GSI was calculated using the equation:

$$GSI = \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100$$

In the ovary, GSI and diameter of ova in various stages of development was calculated (Table 1 and 2) while in the testes, GSI and diameter of testicular lobules

Table 1: Seasonal gonadosomatic indices of female *Labeo rohita*

Phases	Months	GSI	Mean
Resting (control)	November	0.69±0.10	0.7±0.12
	December	0.60±0.12	
	January	0.95±0.16	
Preparatory	February	1.26±0.05	1.89±0.24
	March	2.56±0.63	p<0.01
Prespawning	April	3.43±0.89	10.42±0.79
	May	8.83±1.66	p<0.01
	June	19.00±1.02	
Spawning	July	21.98±1.80	16.49±1.70
	August	11.01±1.60	p<0.01
Postspawning	September	1.30±0.36	3.08±0.34
	October	0.87±0.09	p<0.01

Table 2: Average oocyte diameter of the female fish during its reproductive phases

Phases	Months	Oocyte diameter (μm)	Mean (μm)
Resting (control)	November	67.82±1.420	70.83±2.650
	December	66.22±1.910	
	January	82.27±1.900	
Preparatory	February	99.89±0.470	111.9±7.0900
	March	124.0±3.4400	
Prespawning	April	313.60±4.730	502.60±44.95
	May	545.00±2.460	
	June	649.10±2.690	
Spawning	July	665.29±5.380	583.80±62.12
	August	506.00 ± 3.81	
Postspawning	September	99.29±3.110	94.19±2.840
	October	89.08±2.140	

Values represent mean±SE of observation based on 140 fishes

Corresponding Author: Gunwant P. Gadekar, Dhote Bandhu Science College, Ram Nagar, Gondia

Table 3: Seasonal gonadosomatic indices of Male *Labeo rohita*

Phases	Months	GSI	Mean
Resting (control)	November	0.081±0.008	0.087±0.004
	December	0.051±0.012	
	January	0.120±0.003	
Preparatory	February	0.130±0.007	2.85±0.058
	March	0.440±0.109	p<0.01
Prespawning	April	0.506±0.046	1.71±0.08
	May	1.505±0.09	p<0.01
	June	3.145±0.117	
Spawning	July	3.00±0.425	2.02±0.181
	August	1.04±0.137	p<0.01
Postspawning	September	0.59 ± 0.075	0.536±0.045
	October	0.089±0.015	p<0.01

Table 4: Average lobules diameter of the testis during different phases of the reproductive cycle in *Labeo rohita*

Phases	Months	Testicular lobule diameter (μm)	Mean (μm)
Resting (control)	November	54.71±3.36	51.39±2.000
	December	49.06±4.05	
	January	49.91±1.58	
Preparatory	February	68.84±1.20	90.82±6.980
	March	92.80±2.01	
Prespawning	April	137.20±1.50	199.40±15.53
	May	186.10±3.44	
	June	274.83±4.55	
Spawning	July	252.60±2.28	221.50±25.28
	August	130.40±2.05	
Postspawning	September	86.44±1.99	77.94±4.080
	October	69.44±2.65	

Values represent mean±SE of observation based on 140 fishes

was calculated (Table 3 and 4). Students t-test was made use of to determine the significance of variation. The study was carried out from January, 2010 to December, 2012.

RESULTS

On the basis of the seasonal changes in the gonads, the annual cycle of *Labeo rohita* has been divided into following 5 phases:

- Resting (November to January)
- Preparatory (February to March)
- Prespawning (April to June)
- Spawning (July to August)
- Postspawning (September to October)

In the resting phase, ovaries are very small in size. They are thin, pinkish red in colour and have inconspicuous vascular supply. GSI is 0.74±0.12. The average diameter of oocytes is this phase is 70.83±2.65 μm. Oocytes are smaller in size, somewhat triangular in shape with darkly stained cytoplasm, nucleus is large and round containing 1-2 nucleoli. The ovaries increase in weight and size in next phase. GSI in preparatory phase is 1.89±0.24. In the preparatory phase, average diameter of oocytes is increase to 111.90±7.09 μm. As ovaries approach maturity during prespawning period, their volume and vascular supply increases significantly. GSI suddenly shoots up to 10.42±0.79. The average oocyte diameter is 502.60±44.95 μm. There is reduction in the interfollicular space because oocytes increase in size due to yolk formation. The ovaries grow considerably in size occupying large area in the posterior half of the body during spawning phase. Ovaries became very large, fill the entire peritoneal cavity and contain fully matured oocytes ladden with yolk. GSI becomes 16.49±1.70. The average diameter of oocytes is 583.80±62.13 μm. However, few oocytes at perinucleolar and yolk vesicle stage are present in the peripheral area of the ovary. In the postspawning phase, ovaries are reduced in volume and weight and have dull colour. Vascular supply is reduced. Some unspent ova are seen. There is a sharp decline in the GSI in this phase which is 3.08±0.34.

In males testes are very small and thread like in November to January. The vascular supply is inconspicuous. GSI value is 0.087±0.004. The average diameter of seminiferous lobules in resting phase is 51.39±2.00 μm. In preparatory phase, testes increase in size and vascular supply also increases. GSI value in this phase is 0.285±0.058. The average diameter of testicular lobules increases to about 90.82±6.98 μm. A prominent interlobular demarcation is observed in this phase. In prespawning phase, testes enlarge in volume. There is rapid increase in GSI in this phase. The GSI is 1.71±0.08. Diameter of testicular lobule increase to about 199.40±15.53 μm. In spawning phase, testes bulge out in the abdominal cavity occupying one third of the body cavity. Vascular supply increases and testis become red in colour. GSI value in this phase is about 2.02±0.18. The average lobule is about 221.50±25.28 μm in diameter. In postspawning phase, size of the testis decreases, GSI value also falls down to about 0.53±0.045. The average lobule diameter in this phase is much reduced to about 77.94±4.08 μm.

DISCUSSION

The annual reproductive cycle in the females of *Labeo rohita* has been divided into 5 phases, such as resting, preparatory, prespawning, spawning and postspawning depending upon seasonal changes in the ovary, variations in GSI, oocyte diameter and testicular lobules diameter. GSI increases gradually from preparatory phase and the increase is statistically significant ($p<0.01$) both in prespawning and spawning phases. It drastically decreases in postspawning and resting phases. In *Garra mullya* also GSI exhibits increasing trend from February onwards and highest is in July which is the spawning phase. It decreases sharply from November to

January (Khan and Mehrotra, 1991). Similar condition is noted in *Heteropneustes fossilis* (Hunge and Baile, 2003) and *Oreochromis mossambicus* (Pathan and Baile, 2005).

During resting phase, the ovary is predominated by the immature oocytes. These are smaller in diameter (70.83±2.65 μm) with darkly stained ooplasm and large nuclei. GSI (0.74±0.12) is lowest during this period. In preparatory phase, there is a gradual increase in GSI (1.89±0.24), as maturation proceeds and new sets of oogonia grow to become oocytes at different stages, Hickling (1945) referred to such oocytes as reserve fund eggs and Vladykov (1956) called them recruitment stock eggs. These yolkless oocytes play an important role in supplying the eggs to be spawned in the following spawning season. Several other researchers have discussed the origin of the yolkless oocytes (Swarup, 1958; Franchi *et al*., 1962). The growth of oocytes is generally called first growth or primary growth of oocytes. This phase of growth does not seem to bring any marked influence on ovarian weight in *Labeo rohita.*

During preparatory phase, the ovaries are predominated by oocytes which are at perinucleor stage with large nuclei and many nucleoli of various sizes. The extrusion of nucleoli into the ooplasm has attracted the attention of many researchers (Lehri, 1968). The significance of nucleolar extrusion is reported to be for the formation of proteins (Khanna, 1996). In *Labeo rohita*, many nucleoli of various sizes are seen in the oocytes which are at early perinucleolar stage. The size of nuclei decreases with developing stages of the oocytes.

During prespawning phase, female *Labeo rohita* shows rapid increase in the GSI (10.42±0.79). The ovaries are enlarged and various cytological changes are observed in the oocytes indicating rapid growth and maturation. The growth during this phase is mainly due to formation of yolk vesicles and deposition of yolk. Such changes in the prespawning phase have been reported in the ovaries of several teleostean species (Jadhav and Bapat, 1983; Burton and Idler, 1984). In *Labeo rohita* during this phase, oocytes proliferate and all types of oocytes are visible except the matured ones.

In the spawning phase, GSI of *Labeo rohita* attains a maximum peak (16.49±1.70). The ovaries during spawning phase are filled with yolk laden oocytes. Very few immature oocytes are also visible along the peripheral region of the ovary. At the end of this phase, the ovary decreases in weight not only due to ovulation or discharge of the eggs but also due to degeneration of oocytes which is referred to as atresia. Similar condition is also reported in many other teleost species, such as *Clarias batrachus* (Lehri, 1968), *Heteropneustes fossilis* (Viswanathan and Sundararaj, 1974). Atresia is the inevitable outcome of the developmental process in the follicle and that all follicles (or oocytes) would age and undergo atresia (Guraya, 1985). In *Labeo rohita* such follicular atresia is noticed to a certain extent in prespawning only and on a large scale in postspawning phase of life cycle. During this phase, GSI also goes down (3.08±0.34).

The annual cyclic changes in the males of *Labeo rohita* are noticed mainly due to maturation of testis. The size, shape, colour and length of the testes undergo variations during different reproductive phases of the life cycle. Similar changes have also been reported in other teleosts by several other researchers (Ruby and McMillan, 1970; Umeda and Hesangawa, 1984). The testes of this fish attain maximum weight between July to August corresponding to spawning season and they show maximum GSI (2.02±0.181) during this phase. It is then followed by a rapid decline. The GSI values during resting phase is very low (0.087±0.004), the seminiferous lobules are small and they are mostly predominated by primary spermatogonia. There is a gradual increase in the GSI during preparatory phase (0.285±0.058). Increase in the GSI is very rapid in prespawning phase (1.71±0.08). In this phase, the testes are predominated by spermatocytes, spermatids and spermatozoa. GSI attains its maximum peak during the spawning phase in the month of July (2.02±0.181). From postspawning phase onwards, there is a sudden fall in the GSI which becomes 0.53±0.045. This low GSI in the postspawning phase is due to the discharge of milt. In this phase, the wall of seminiferous lobules ruptures and spermatozoa are released out. Belsare has reported that the testes of *Gasterosteus aculeatus* remain mature at any time of the year but their functional maturity is attained only in the breeding season (April to May). In *Heteropneustes fossilis*, Ghosh and Kar (1952) have reported that there is no clear seasonal testicular cycle but in the same species, distinct seasonal periodicity in testis is reported by Hunge and Baile (2003) and maximum GSI is reported during spawning phase for this fish.

In *Labeo rohita*, the testes are fully mature only during spawning phase (July to August) of reproductive cycle. The variation in view may be because of different environmental factors which play an important role in gonadal maturation and development. The maturation of testes in *Gasterosteus aculeatus* (Swarup, 1958) is because of high temperature. From April to July maximum gonadal activity is reported for *Heteropneustes fossilis* (Ghosh and Kar, 1952). When the environmental temperature is high and with the onset of mansoon

season maximum values of GSI in final stages of spermatogenesis and spermiation in males is also reported for pink salmon *Onchorhynchus gorbuscha* (Dye *et al*., 1986). Proliferation of spermatozoa occurs during restricted period from end of July to the middle of September in *Gasterosteus aculeatus* (Craig-Bennett, 1931). In *Fundulus heteroclitus*, also marked seasonal periodicity is seen in the testes whereby maximum weight is attained just before spawning and it rapidly decreases immediately after spawning (Matthews, 1938). Seasonal testicular changes are reported in Pacific salmon *Oncorhynchus nerka* (Weisel, 1943), bluegill, *Lepomis macrochirus* and largemouth bass, *Huro salomoides* (James, 1946) and in Cyprinid fish, *Notropis bifrenatus* (Harrincton, 1957).

CONCLUSION

From the present investigation, it is observed that the GSI of fresh water major carp Labeo rohita is maximum during spawning season whereas decreases during postspawning season.

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