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GROWTH PERFORMANCE, REPRODUCTIVE STERILITY AND DISTINCT MORPHOLOGY OF TRIPLOID FRINGED LIPPED CARP, *LABEO FIMBRIATUS*

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Abstract: The present study was conducted to determine the optimum conditions for the induction of maximum percentage of triploid *Labeo fimbriatus* with high survival rates and to assess the impact of triploidy on survival, growth and reproduction. Optimum heat shock treatment required for triploidy induction in *L. fimbriatus* was 41°C for 3 minutes duration on 2.5 minute old fertilized eggs. By this treatment, 95% triploids were produced. The triploids were as viable as diploids and were externally identifiable at an early stage. Triploidy was confirmed by erythrocyte's nuclear volume measurements and chromosome count. The triploids had 75 chromosomes and diploids had 50 choromosomes. The growth rate of triploids was higher than diploids from juvenile stage onwards. The triploids were 23% heavier than diploid counterparts when grown for one year. All the survived triploids were sterile females. They had reduced gonad and GSI (1.09) than diploids (15.77). The commercial cultivation of triploid *L. fimbriatus* may be more profitable than that of diploids.

Key words: Edible fish, survival, chromosome, GSI, commercial cultivation, heat shock

INTRODUCTION

There has been a constant effort in increasing fish production through different methods. The biotechnological tools are the latest ones being employed for achieving this, through chromosome manipulation. Induced triploidy in fishes has been attracting many aquaculturists and researchers throughout the world. Triploids are often produced with an expectation that they may become sterile and grow faster. The sterility is due to irregular meiotic division of chromosomes resulting in either a failure of gonad development or production of aneuploid gametes. In such fish therefore, energy consumption for sexual maturation may be avoided and more biological effort is directed towards improving flesh quality and somatic growth (Thorgaard and Gall, 1979; Lincoln, 1981; Wolters *et al.,* 1982; Peruzzi *et al*., 2004). According to Stanley *et al*. (1984),Thorgaard (1986) and Scheerer and Thorgaard (1987), the higher heterozygosity of triploid fish may enhance growth. Generally creation of triploid fish has been considered as a biotechnological tool to improve growth and yield and to prevent unwanted reproduction when fishes are raised for food or stocked in natural water bodies.

Induction of triploidy has been achieved in many fish species using a variety of techniques. Methods used to date include exposing fertilized eggs to temperature shock - heat or cold (Thorgaargard, 1983), chemicals such as colchicine (Smith and Lemoine, 1979), Cytochalasin B (Refstie *et al*., 1977), high pH multiplied by high calcium (Ueda *et al*., 1988), Nitrous oxide (Johnstone *et al*., 1989), combined caffeine-heat shock treatment (Durand *et al*., 1990), electric shock (Teskeredzic *et al*., 1993) and hydrostatic pressure shock (Piferrer *et al.,* 1994). Generally physical treatments are most successful and widely used to induce triploidy in fish (Guoxiong *et al.,* 1989 Teskeredizic *et al.,* 1993; Johnson *et al*., 2004 and Haffray *et al*., 2005). The

heat shock technique is widely used to ploidy induction, because it is inexpensive, less sophisticated and can be successfully adopted by farmers. However the timing, temperature, and duration of shock must be determined for each species.

Labeo fimbriatus (Bloch) is commonly known as fringed-lipped carp, is endemic to peninsular rivers. This fish is commonly used in composite fish culture, but not that much preferred as Indian major carps, as this fish does not grow as fast as major carps. However, it has few advantages such as small head, pleasing appearance and excellent meat quality. *L. fimbriatus* becomes sexually mature in their second year. Usually breeds once in a year. Breeding occurs in running waters during the monsoon season (June – September). This fish can be artificially bred in confined conditions by hypophysation

In an attempt to enhance the growth rate of *L. fimbriatus,* triploidy was induced by heat shocking. The main objectives of the present study was to determine the optimum heat shock treatment which ensure maximum percentage of triploidy and survival and compare the growth rate and maturation of the triploids with their diploid counterparts.

MATERIALS AND METHODS

Breeding and Triploidisation

Sexually matured and healthy brood fish were procured from National Fish Seed Farm, Neyyar Dam, Thiruvananthapuram, during the monsoon season. Breeding was performed by artificial propagation method with carp pituitary hormone injection. Eggs and sperm were collected separately by stripping. Artificial fertilisation was initiated by mixing the eggs and sperm well for one minute and excess milt was washed off. About 2 ml of fertilised eggs were taken in plastic strainers and heat shock was applied.Shock was applied from 1 minute to 3 minutes after fertilisation. The temperature and duration of the shock were 39^0 to 43^0C and 1 to 4 minutes respectively. Eggs of control groups involving no heat shock were also maintained in order to ascertain the experimental procedure. Hatchability of eggs, number of deformed fry and survival of feeding fry were monitored.

PloidyAssessment

Efficiency of heat shock treatment was ascertained by chromosome counts on 4-5 month old fish from each treatment group. Chromosome slides were prepared according to the method described by Kligerman and Bloom (1977) with slight modifications. Ploidy was also determined by cell and nuclear volume measurements of erythrocyte´s (RBC). Student's ¿t¾ test was conducted to find any significant difference between diploids and triploids in volume measurements of erythrocytes. The morphology of 4 month old *L. fimbriatus* were analysed to visually evaluate successful production of triploids.

Growth Analyses

Triploidy induced and normal larvae were reared separately in similar troughs of 50 litre capacity for three weeks. Fifty percentage of water was exchanged daily. After three weeks nursing, the fry were transferred to cement tanks of 500 litre capacity, in equal numbers of 20 each to undertake a comparative study of growth. About 25% of water was replenished once in every week after siphoning out the accumulated detritus and faecal matter. Three replicate samples were maintained for each group. The larvae were fed initially with boiled hens' egg and then with cultured plankton, powdered dry pellets and at one month age they were fed with 35% protein feed pellets to satiation once daily. After two months, the fingerlings were transferred to larger cement tanks of 4000 litres capacity. Total weight and total length measurements were recorded monthly for one year starting at one month. The data were analysed using ANOVA. The percentage composition of the different ingredients in the 35% protein feed is given in Table 3.

Gonadal Development and Sex Ratio

Twenty month old fish of both control and ploidy induced were sacrificed and weighed. The sex of each fish was determined by dissection of the

gonads. The gonads were weighed to calculate the GSI using the following formula.

Gonadosomatic Index (GSI) = (Weight of ovary (g) / Weight of Fish (g)) x 100

Development of gonads was assessed using histological procedure. The relationship between gonad weight and body weight was analysed by simple regression analysis.

RESULTS

Effect of Heat Shock

Eggs hatched within 20 to 24 hours at 26^0 to 27^{0}C. The effect of heat shock on triploidy induction, survival and abnormal fry resulting from the heat shock experiment in *L. fimbriatus* is summarised in Table. 1. The optimum heat shock treatment required for the induction of triploidy, in *L. fimbriatus*, was 41^{0}C for 3 minutes duration on 2.5 minutes old eggs. The percentage of hatching was higher in diploids (76) than triploids (67). The triploid fish were almost as viable as diploids (41 versus 42).

Ploidy status

Triploidy was confirmed by observing morphological peculiarities, chromosome counts and nuclear volume measurements of erythrocytes.

Morphological variations

The triploid *L. fimbriatus* could be visually identified from diploids at an early stage of two month old. The triploid fish were distinctly larger than control groups. The triploids had more elongated head and dorsal side of the head was lightly pigmented than the rest of the body. A shallow depression could be seen between the head and trunk of triploids. The diploid and triploid L.fimbriatus are shown in Figs. 1 & 2

Chromosome counting

The metaphase spreads of diploid and triploid L. fimbriatus are shown in Figs. 3 and 4. The diploid cells had 50 chromosomes and triploid cells had 75 chromosomes.

Nuclear volume measurement of erythrocytes

Figures 5 and 6 show the erythrocytes of diploid and triploid *L.fimbriatus*.Triploid erythrocytes and erythrocyte nuclei were larger than diploid erythrocytes and erythrocyte nuclei. The size differences of erythrocytes between diploid and triploid fishes are presented in Table 2. The differences observed for the cellular as well as nuclear measurements of diploid and triploid *L. fimbriatus* are shown in Fig. 7a, 7b, 7c & 7d. Volume of the triploid nucleus and cell was significantly larger (1.92 and 1.95 times).

Growth

The triploids were superior to the diploids in growth even during the juvenile stage and this superior growth continued up to the termination of the experiment. Tables 4 and 5 show the comparative growth of diploid and triploid *L. fimbriatus*. Triploids were 23% heavier than diploids at one year old. The comparative growth pattern is presented in Figures 8 and 9. Regression equation relating culture days and percentage length and weight increment of diploid and triploid *L. fimbriatus* are given in Figs. 10, 11, 12 and 13.

Gonad Maturation and Sex Ratio

In *L. fimbriatus* all triploids were females. The triploid fish had very thin, elongate, paired and fleshy ovaries. The peritoneum was thick and highly vascularised (Fig.14). They had reduced gonado-somatic index (0.56%) compared to diploids (19.74%).

The diploid ovary was elongate, paired and completely filled the abdominal cavity. It was pale yellow in colour. The peritoneum was thin and moderately vascularised. One lobe of the ovary was shorter than the other (Fig.15).The ovaries of diploid and triploid fishes are shown in Fig.16. The comparative GSI between diploid and triploid fishes are presented in Fig.17. Table 6 shows the average gonad weight and gonado-somatic indices for triploids and diploids at 20 months old.

The histological observations of diploid and triploid ovaries showed that the diploid ovary was a ripe one with mature oocytes (Fig.18). Whereas the triploid ovary was an attrite one with extensive connective tissue (Fig. 19).

Table 1. Effect of heat shock on triploidy and survival in *Laeofimbriatus*

Heat shock	Duration of shock	Time after Fertilization	Hatching	Feeding fry survival	Triploidy	Deformed fry
(°C)	(min.)	(min.)	(%)	(%)	(%)	(%)
27 (Control)	-	-	76	43	0	3
41	3	1.5	57	27	0	7
	3	2	62	33	70	5
	3	2.5	67	42	95	8

Fig. 1. Diploid *L.fimbriatus*

Fig. 2. Triploid *L. fimbriatus*

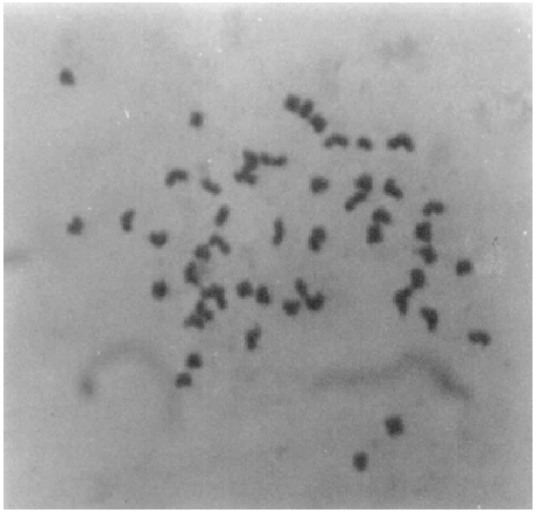


Fig. 3. Diploid

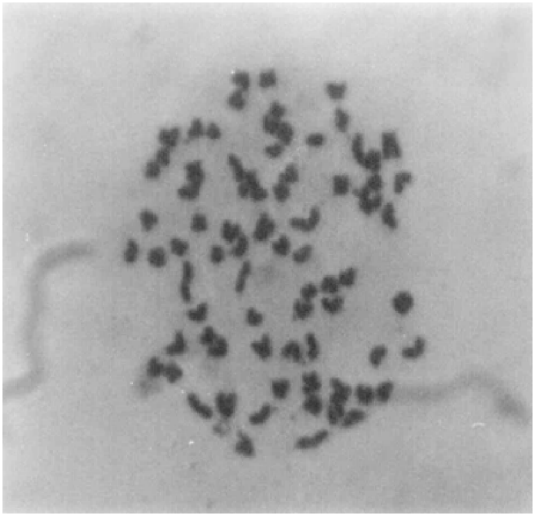


Fig. 4. Triploid

Chromosomes

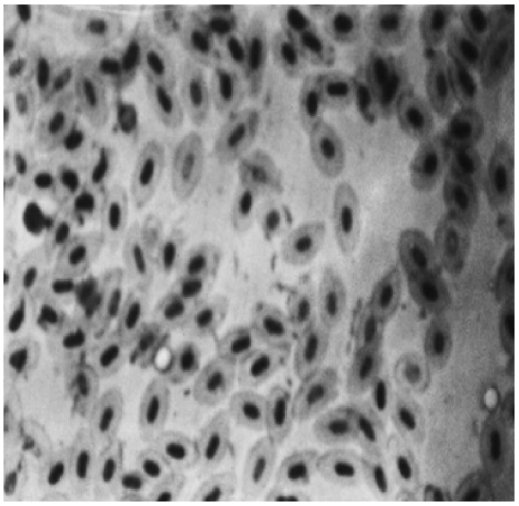


Fig. 5. Diploid

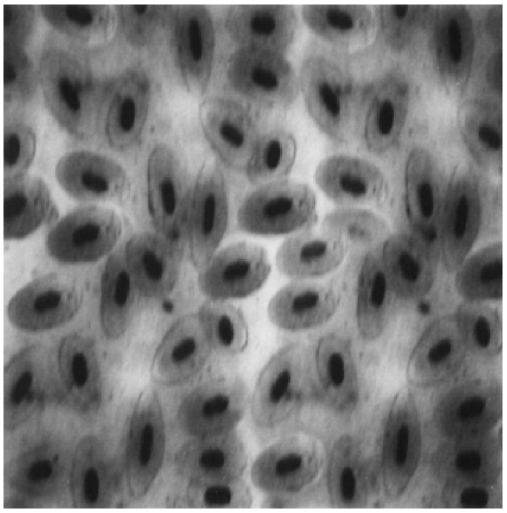
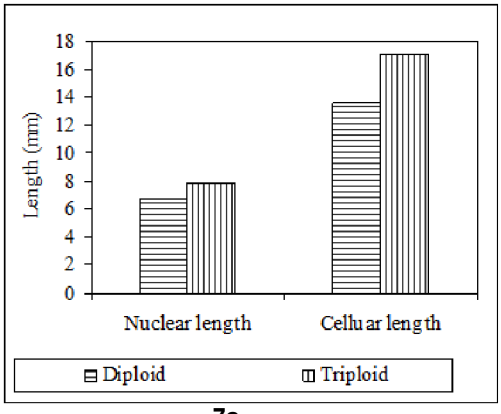
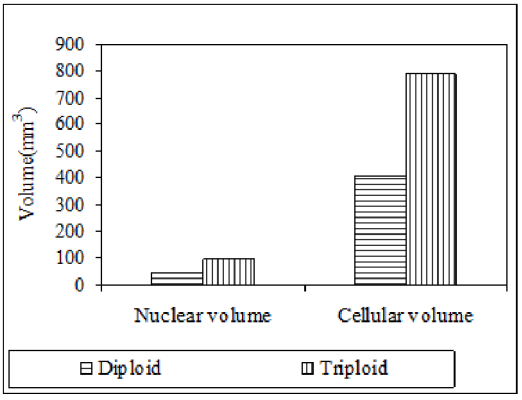


Fig. 6. Triploid

Erythrocytes



7a



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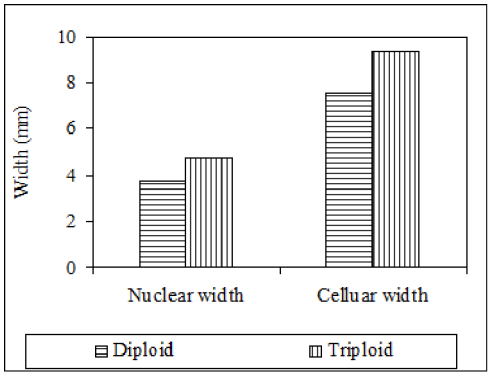

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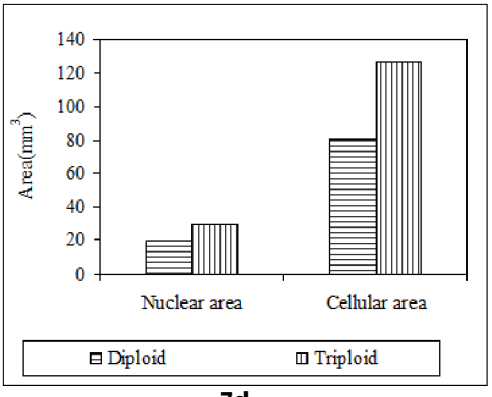

7d

Fig. 7. Comparison of nuclear and cellular measurements of triploid and diploid *L. fimbriatus*

Table 2. Comparative cellular and nuclear measurements of diploid and triploid *L.fimbriatus*

Sl. No.	Parameters	Diploid		Triploid		t value
		Mean	± SD	Mean	± SD	
1	Nuclear length (µm)	6.77	0.32	7.84	0.32	- 7.425**
2	Cellular length (µm)	13.53	0.65	17.07	0.32	- 15.429**
3	Nuclear width (µm)	3.7	0.32	4.76	0.32	- 7.356**
4	Cellular width (µm)	7.54	0.32	9.38	0.32	- 12.728**
5	Nuclear volume (μm^3)	49.07	9.76	94.09	17.98	- 6.959**
6	Cellular volume (μm^3)	404.48	50.65	788.99	72.31	- 13.774**
7	Nuclear area (μm^2)	19.69	2.54	29.41	3.33	- 7.343**
8	Cellular area (μm^2)	80.2	7.05	125.85	6.86	- 16.053**

** P < 0.01

Table 3. Proportion of feed ingredients and proximate composition of feed

Ingredients	Proportion (g)	Protein content (%)	Proximate composition of diet (Dry weight basis)	
			Parameter	Percentage
			Moisture	14.59
Rice bran	17.82	1.23	Protein	34.96
Tapioca flour	17.82	0.37	Fat	5.9
	32.18	18.06	Carbohydrate	10.13
Groundnut oil cake	32.18	15.44	Fiber	4.2
			Ash	2.7

Table 4. Growth of diploid and triploid *L .fimbriatus*

	Fish	Culture period (days)												
	genotype		0	30	60	90	120	150	180	210	240	270	300	330
Length (cm)	Diploid	Mean	0.81	2.09	4.17	6.56	8.76	10.7	12.52	14.34	16.2	17.82	19.25	20.72
		6SD	0.14	0.33	0.49	0.57	0.56	0.53	0.68	0.8	0.88	1	1.05	1.11
	Triploid	Mean	0.79	2.31	4.62	7.25	9.81	12.28	14.76	17.05	19	20.9	22.51	24.15
		6SD	0.14	0.29	0.38	0.44	0.53	0.67	0.78	1.03	1.25	1.39	1.52	1.66
Weight (g)	Diploid	Mean	0.5	1.26	3.74	7.89	15.79	28.11	45.31	67.96	97.1	133.2	174.21	221.87
		6SD	0.01	0.17	0.52	0.72	1.18	1.6	2.13	2.9	4.65	5.6	8.92	12.92
	Triploid	Mean	0.5	1.26	4.28	10.9	22	38.12	59.82	87.57	121	163.46	214.07	273.7
		6SD	0.02	0.19	0.54	1.44	2.51	3.76	5.19	6.75	8.35	10.79	14.01	17.75

Table 5. Percentage increment of *L. fimbriatus*

Parameter	Fish Genotype	Culture period (Days)										
		30	60	90	120	150	180	210	240	270	300	330
Length (%)	Diploid	158	415	710	981	1221	1446	1670	1896	2100	2277	2458
	Triploid	192	485	818	1142	1454	1768	2058	2308	2546	2749	2957
F value		14.03**	8.01*	5.44*	5.19*	6.46*	9.37**	10.47**	9.23**	8.92**	8.00*	39.63**
Weight (%)	Diploid	152	648	1478	3058	5522	8962	13492	19312	26540	34742	44274
	Triploid	152	756	2080	4300	7524	11864	17414	24140	32592	42714	54640
F value		0	5.74*	38.72**	55.38**	66.23**	74.00**	78.68**	70.55**	68.55**	63.67**	55.72**

* P<0.05 ** P<0.01

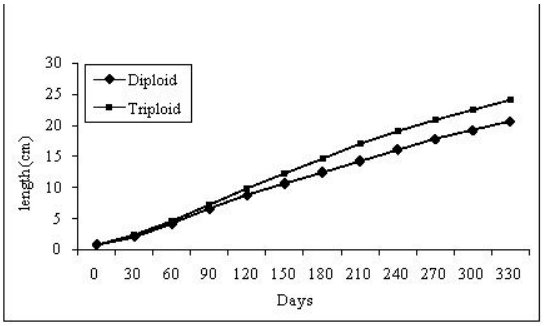

Fig. 8 . Mean length of diploid and triploid *L. fimbriatus*

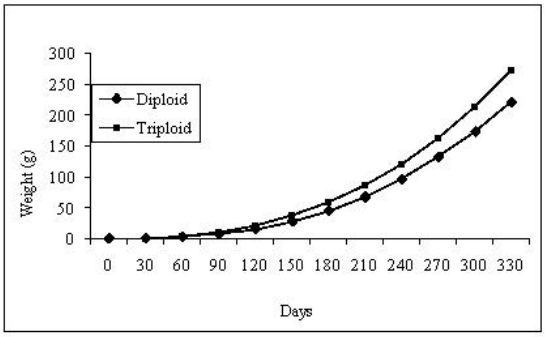

Fig. 9. Mean weight of diploid and triploid *L. fimbriatus*

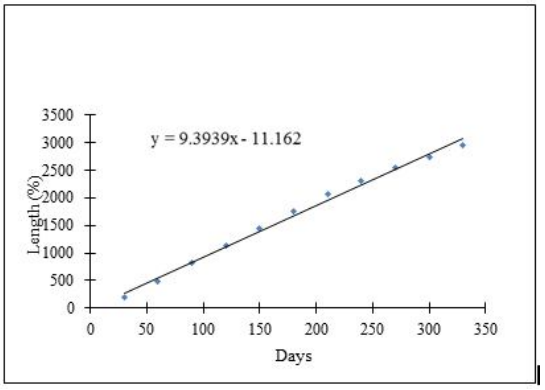

Fig. 10. Regression between days and percentage length increment of tripoid *L. fimbriatus*

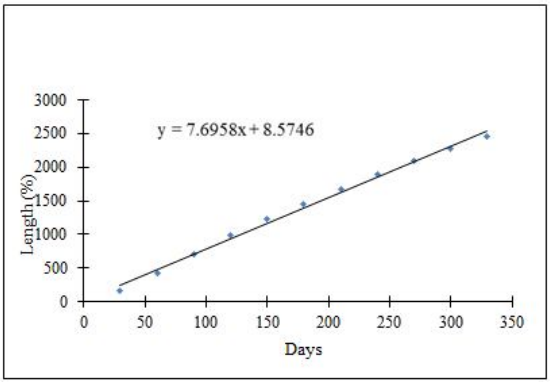

Fig. 11. Regression between days and percentage length increment of dipoid *L. fimbriatus*

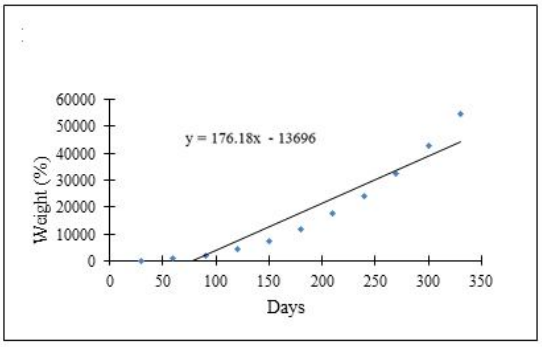

Fig. 12. Regression between days and percentage weight gain of tripoid *L. fimbriatus*

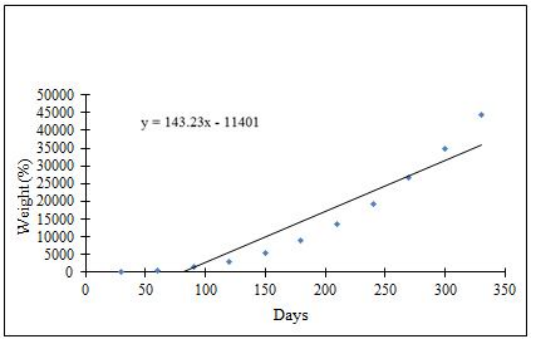

Fig. 13. Regression between days and percentage weight gain of dipoid *L. fimbriatus*

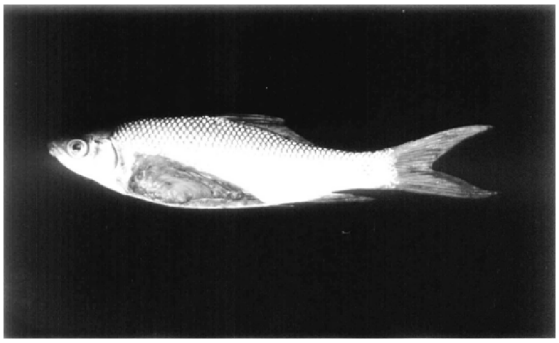

Fig. 14. Triploid *L.fimbriatus* with visceral cavity cut open to show the ovary

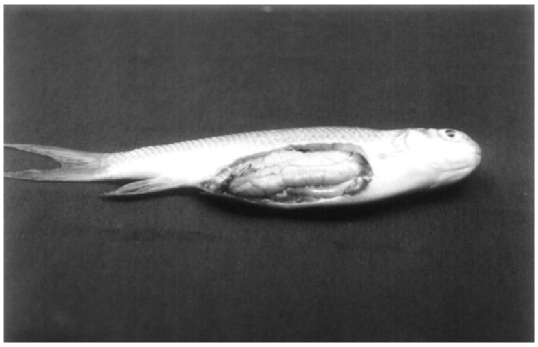

Fig. 15. Diploid *L.fimbriatus* female with visceral cavity cut open to show the ovary

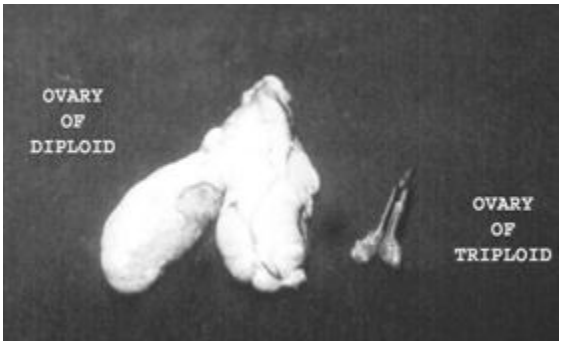

Fig. 16. Ovaries of diploid and triploid *L. fimbriatus*

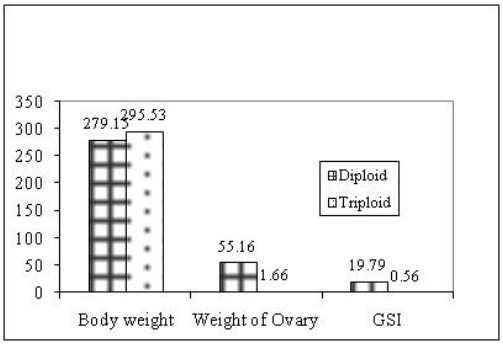

Fig. 17. Weight of body and ovary and Gonado-Somatic Index of *L. fimbriatus*

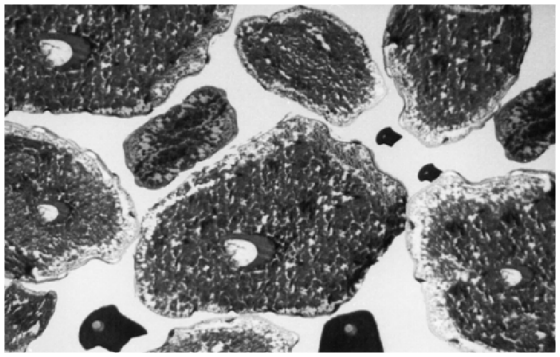

Fig. 18. Cross section of diploid ovary

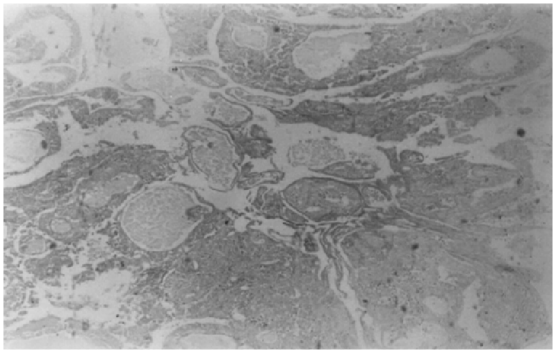

Fig. 19. Cross section of triploid ovary

DISCUSSION

The present study demonstrates that heat shock treatment is an effective method for the production of triploidy in *L. fimbriatus*. The optimum heat shock treatment was 41^{0}C for 3 minutes duration on 2.5 minute old eggs. The highest triploid induction rate was 95%.

Although heat shock is 100% effective in certain species like *O. mossambicus* (Pandian and Varadaraj, 1988a) and *B. rerio* (Kavumpurath and Pandian, 1990), in the present study heat shock induced only 95% triploidy in *L. fimbriatus*. As reported by Lou and Purdom (1984b), the difference in the percentage of triploidy may be related to egg quality or to the susceptibility of

Table 6. Gonodo-Somatic Index (GSI) of *L. fimbriatus*

	Diploid	Triploid
Body weight	279.15	295.53
±SD	65.1	57.34
Weight of Ovary	55.16	1.66
±SD	12.55	0.36
Gonadosomatic Index	19.79	0.56
±SD	0.55	0.05

eggs of different origin to triploidization treatment.

Considering the early embryological development, heat shock treated eggs exhibited comparatively higher mortalities relative to their diploid controls. The percentage of hatching was higher in diploids (76) than triploids (67). Major losses irrespective of treatment occurred between hatching and feeding stages as in the case of rainbow trout (Chourrout, 1980; Chourrout and Quillet, 1982) and *Bettasplendens* (Kavumpurath and Pandian, 1992). This may be due to the deleterious effects of heat shock on early embryological development.From feeding stage onwards survival was similar in both ploidies. Similar observations were reported by many workers (Gervai *et al.,* 1980; Krasznai *et al*., 1984; Benfey and Sutterlin, 1984a; Oliva-Teles and Kaushik, 1990; Simon *et al.,* 1993; Carter *et al.*, 1994; Withler and Clarke, 1998; Sheehan *et al.,* 1999; Piferrer *et al;* 2003; Cal *et al.,* 2006; Opstad *et al*., 2013).

Most triploid induction techniques result in some diploids mixed with triploids. A number of techniques exists for separating triploid and diploid fishes *viz*, flow cytometric measurement of fish erythrocyte DNA (Allen and Stanley, 1979; Thorgaard *et al*., 1982; Allen, 1983), Coulter counter estimation of erythrocyte nuclear size (Wattendorf, 1984), spectroflurometry of erythrocyte DNA (Schwarzbaum *et al*., 1992) and measurement of erythrocyte nuclear volume by light microscopy (Wolters *et al*., 1982a; Wattendorf, 1984). However, these methods generally are impractical for screening large numbers of fish. But the presence of any morphological markers in triploids would be ideal for screening large numbers of fish. In the present study the triploid *L. fimbriatus* were larger than their diploid counterparts and exhibited distinct morphological features. An experienced person can easily distinguish the triploids from diploids by observing such morphological peculiarities. The ability to distinguish between the diploid and triploid *L. fimbriatus* based onexternal morphology may provide an easy method for determining the effectiveness of induced triploidy in hatcheries.

The change in external morphology due to triploidy has also been noted in several fishes. In stickleback, triploids had larger tail and shorter trunk than its diploid siblings (Swarup, 1959b). Cassani and Caton (1985) and Bonar *et al*; 1998 reported that grass carp larger than 300 mm total length could be separated visually with an accuracy of 95%. In Atlantic salmon (*Salmosalar*), protruding lower jaw was found to be the abnormality associated with triploidy (Sutterlin *et al.*, 1987). Altered body shape is reported as a morphometric indicator of triploidy in Indian catfish, *H. fossilis* (Tiwary *et al.*, 1999). The ratio between standard length and body depth (SL/BD) was found to be a precise indicator of triploidy in this fish. According to Ihssen *et al.* (1990), the morphological difference would have to be due to a dosage or co-dominant effect, because the diploids and triploids share the same alleles.

The diploid and triploid chromosome numbers of *L. fimbriatus* were 50 and 75 respectively. Presence of one additional set of chromosomes confirmed the successful induction of triploidy in *L. fimbriatus*. The model number of diploid chromosomes in Cyprinidae is 50 (Manna and

KhudaBuksh, 1977a). The diploid chromosome number of *L. fimbriatus* corresponds this model number of 50.

The triploid *L. fimbriatus* had larger erythrocytes than that of their diploid siblings. Volume of the triploid nucleus and cell was significantly larger (1.92 and 1.95 times). The increased nuclear volume also confirmed triploidy. These results agree well with previous studies by other workers dealing with other fish species. (Wolters *et al*., 1982a; Small and Benfy, 1987; Kavumpurath and Pandian, 1990; Arai *et al.*, 1993; Kim *et al*., 1994; Tiwary *et al*., 1999; Svobodova *et al*., 1998; Felip *et al*., 1999).

Growth in the triploid *L. fimbriatus* was found to be faster than the normal diploids even during the juvenile stage and this superior growth rate continued up to the termination of one year growth study. The triploids were 23% heavier than diploids at the end of one year growth. This result is in good agreement with results for other species. Purdom (1972) reported that triploid plaice, *Pleuronectesplatessa* grew faster than the diploid sibs. Similar observations were also reported by Wolters *et al*. (1982a) in channel catfish (*Ictalurus punctatus*), Cassani and Caton (1985) in grass carp (*Ctenopharyngodon idella*), Suzuki *et al*. (1985) in loach (*Misgurnus anguillicaudatus*), Thorgaard (1986) in rainbow trout (*Onchorhynchus mykiss*), Tave (1993) in big head carp (*Hypophthalamicthys nobilis*), Galbreath *et al*. (1994) in Atlantic salmon (*Salmosalar*), Islam *et al*. (1994) in rohu (*Labeorohita*), Tiwary *et al.* (1997) in catfish (*Heteropneustes fossilis*), Reddy *et al.* (1998) in carp (*Cyprinus carpio*) and Taranger *et al.*(2003) in Atlantic salmon (*Salmo salar*), and Cal *et al*. (2006) in turbot (*Scophthalmus maximus*). According to Hawkins *et al.* (1998) the higher growth of triploids not only resulted from reduced reproductive output, but also from higher net growth efficiencies that were associated with greater genetic polymorphism and resulted energy requirements for protein turnover renewal as seen for heterosis generally.

The most striking observation of the present study was that all the triploids produced were females and sterile. Triploids had rudimentary ovary and reduced gonadosomatic index (GSI). The lack of gonad development in triploids observed is consistent with results for other species like Asian cat fish (Fast *et al*., 1995), sea bass (Felip *et al*., 1999), sun shine bass (Kerby*et al*., 2002) yellow tail flounder (Manning *et al*., 2004) and turbot (Cal *et al*., 2006). According to Nakamura *et al.* (1987), the sterility observed in female triploids may be in addition to mechanical difficulties involved in chromosome separation at meiosis I due to triploidy, the reduced levels of ovarian steroid hormones could also account for female sterility.

The commercial production of triploid fish might be more profitable than that of normal or monosex culture (Allen and Stanley, 1979; Wolters *et al*., 1982a; Donaldson and Hunter, 1982; Don and Avtalion, 1986, 1988; Vejaratpimol and Pewnim, 1990; Peruzzi *et al*., 2004). Moreover the sexuality of fish has great significance in fish breeding because there are differences in growth rate, behaviour pattern, breeding time, body colour, shape or size between male and female in each cultured species. There is no commercial advantage in producing male triploid fish if testis growth is unaffected by triploidy. On the other hand, the aquaculture production of all female triploid populations is recognised as being of potential advantage for many species of fish were sexual maturation is not desired. Therefore the production of all female triploids may be useful for *L. fimbriatus* culture. All female triploids have been produced generally by inducing triploidy in eggs that had been fertilised with monosex female sperm (sperm from mascularised females) (Lincoln and Scott, 1983; Okada, 1985; Galbreath and Thorgaard, 1995) or by the direct feminization of triploid embryo by direct oestrogen treatment shortly after hatching (Varadaraj and Pandian, 1990; Piferrer *et al*., 1994). Whereas in the present study, the heat shock treatment alone produced all female populations.

In majority of fish species the sex ratio among triploids equals controls. For example in tilapia, *O. mossambicus*, the sex ratio of triploids is 1:1

(Pandian and Varadaraj, 1989). Similarly in common carp, *Cyprinus carpio* (Cherfas *et al*., 1994) and in sea bass, *Dicentrarchus labrax* (Felip *et al*., 1998) the sex ratio of triploids is not different from diploids. At the same time there are a few reports about all male triploids. In bitterling, *Rhodeusocellatus* all triploids were males. Similar result is reported by Kavumpurath and Pandian (1990) in fighter fish, *Brachydanio rerio* and Warrillow *et al*. (1977) in brook trout, *Salvelinus fontinalis*. Whereas Byamungu *et al*. (2001) reported that in blue tilapia (*Oreochromisaureus*) the triploids were predominantly females (80%). The reason for the total absence of males in the present study is unknown. As reported by Streisinger *et al*. (1981), this may be due to variation in the expression of sex determining mechanism among the different ploidy levels.

In the present study the triploid *L. fimbriatus* had much more fat deposits around the digestive tract. Such large fat deposits were also observed by many workers (Thorgaard and Gall, 1979; Chevassus *et al*., 1983; Lincoln and Scott, 1984; Johnson *et al*., 1986). But Sheehan *et al*. (1999) found no such fat deposits in triploid rainbow trout. According to Johnson *et al.* (1986), large fat deposition in triploid female may be due to the failure of lipid withdrawal from body reserves for vitellogenesis, which normally takes place during breeding season in normal diploid fish

The growth performance of triploids is a critical factor in determining their utility in aquaculture. From the present study it is evident that the triploid *L. fimbriatus* were sterile and their sterility allowed better growth performance. The triploids were heavier than their diploid counterparts under controlled conditions.If they were reared in the natural habitat they might exhibit much better growth. Furthermore, triploid *L. fimbriatus* would have less wastage in processing because they have smaller heads. Therefore, triploids of Fringed –lipped carp, *L. fimbriatus*may be of great value to fish farmers.

In conclusion, induction of triploidy by heat shock treatment can be recommended as a technique for efficient *L. fimbriatus* culture.

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