E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(2): 633-638

www.fisheriesjournal.com
Received: 06-01-2020
Accepted: 10-02-2020

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Studies on biology, seed production & rearing of *Cyprinus carpio robrofuscus* (Koi carp)

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Abstract
Koi carp {*Cyprinus carpio rubrofoscus (*Linnaeus, 1758)} is a brightly coloured fish native to Asia and Europe. They are called living jewels and swimming flowers for their physical beauty. A detailed study was conducted emphasizing, the induced breeding techniques, breeding behavior and early life history of Koi carp (embryonic and larval stages) including nursery rearing etc. at National Freshwater Fish Brood Bank (20.18'.2" N 85.50'.59"E), Kausalyaganga, Bhubaneswar, Odisha, India. The fertilized eggs of Koi carp were found to be adhesive, demersal and spherical in nature. The diameter of the fertilized egg capsule ranged between 0.8 to1.0 mm while the yolk sphere ranged from 0.6 to 0.8 mm. The hatchlings ranged between 2.0 and 2.5 mm in length. A female weighing one kilogram will give approximate 23,985 nos of spawn in the happa breeding method. The survival of spawn in the nursery rearing was varying between 27% to 32% and the size also varies between 35 mm to 42 mm. The fry growth varies from 61-80 mm and the survival from fry to fingerling was varying from 57-62%. The successful induced breeding of Koi fish may reduce the uncertainty and unavailability of fish seed/fry, may increase the large scale production for export purpose and may be a potential sector for meeting the national demand and help to increase foreign exchange earnings. The present study will certainly paves the way for the start-ups to take up commercial production and marketing of Koi carp in the days to come.

Keywords: Koi carp, induced breeding, happa breeding, spawn. fry, fingerling

Introduction
During the last five decades, carp culture in India has grown both in geographical coverage terms with diverse systems and farming intensification. Carp culture is regarded as backbone to freshwater aquaculture practice in India and the share has gone up from 46 percent in the 1980s to over 85 percent in the recent years [1]. The three Indian major carps, *viz*. catla (*Catla catla*) rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) has been the main contributor in the fish production of the country. The three domesticated exotic carp *viz*., silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) are regarded as second important group in the Indian fish farming. [2]
Besides Indian major carps, common carp (*Cyprinus Carpio*) has emerged as one of the important fish species for culture, especially in seasonal community tanks. Further, breeding throughout the year, unlike Indian major carps which breed only during monsoon months, consumer preference for small size common carp, have helped common carp to emerge as important and desired fish species for culture [3].
Koi carp {*Cyprinus carpio rubrofoscus* [4] is a brightly coloured fish native to Asia and Europe. Koi carp appear to be an ornamental variant of the east Asian common carp that were taken to Japan from China and bred for coloration and scale patterns [5],They are an ornamental variant of common carp (*Cyprinus carpio)* and were developed by selective breeding from the Asian sub-species *cyprinus carpio haematopterus*. Koi carp is also called living jewels and swimming flowers for their physical beauty. This species has symbolic significance in our culture and it is believed that this carps grow large in size depending upon the aquatic environment [6]. Koi carp live up to 15 -24 years [7]. Males are known to live longer than females [8]. Carps can mature at 3 months of age and some at 5 years of age [9]. Males appear to mature earlier than females and under natural conditions carp rarely live longer than 15 years [9, 10].
Koi carp female produce 1,00,000 eggs per kg of body weight. A typical female can produce 3,00,000 eggs annually (or more if they spawn more than once).

Spawning is the process of releasing the egg cells by the female and sperm by the male, followed by the fertilization of the egg cells by the sperm [11]. In general, fish spawning can be done in two ways namely natural and induction. Natural spawning is spawning that is carried out in the open in accordance with the nature of life without human treatment and assistance. Natural spawning has excess and too large costs [12].

The determination of fecundity and the length of spawning period are fundamental for understanding fish biology [13]. Accurate estimates of fecundity increase the efficiency of stock management and improve predictions of offspring production [14]. Carps are highly fecund species. A ripe 5 Kg female can produce 10,00,000 mature oocytes [14,15]. Typically, relative fecundity ranges from 100000 to 300000 oocytes / Kg body weight [16]. This species exhibits gono-chorism, external fertilization, with the spawning frequency that varies throughout their range [17]. The common carp is considered as batch spawner [18].

Koi carp due to their aesthetic colors, are reared in aquarium at home and in temple / spiritual ponds. They are also reared as food fishes. As, Koi carp are easily available in Indian aquatic system, easy to breed species and has high economic value, therefore the species has been selected for the present study. Secondly considering the enormous importance of Koi carp, a detailed study was conducted emphasizing, the induced breeding techniques, breeding behavior and early life history of Koi carp (embryonic and larval stages) including nursery rearing etc. at National freshwater Fish Brood Bank (20.18'.2" N 85.50'.59"E), Kausalyaganga, Bhubaneswar, Odisha, India., since these aspects has significance to the farming community those are venturing into the breeding and culture of ornamental fish species.

Materials and Methods

The Koi carp brood-stock were collected from different sources like private farms (Dixit Farm, Sakhigopal, Odisha; Kailash Fisheries, Mayurbhanj, Odisha; Duba Fish seed farm, Jagnnath prasad, Bhanjanagar, Odisha) and Govt. farm from National Freshwater Fish Brood Bank, Kausalyaganga, Bhubaneswar, Odisha. The species were segregated from common lots of common carp and are kept in cement tanks for conditioning.

At NFFBB farm (20.18'.2" N 85.50'.59"E) two ponds of size 400 Sq. M were selected. Initially the marginal grasses and weedy grasses were cleared and the nursery pond bottom was ploughed in order to tilt the soil for better aeration. Water was filled into the pond and the mahua oil cake @ 2,500 kg/ha was applied to the water for eradication of the weed and predatory fishes. The water was filled up to 1.0 meter. Then the Mixture of groundnut oil cake at 750 kg, 200 kg, and single super phosphate 50 kg/ha was added in order to get desired primary productivity in the pond water. After three days of fertilization the Kerosene oil @ 100 lit per ha was used to kill the aquatic insects.

The Koi carp male and female brooders (size between 0.5 to 1.5 Kg) were stocked separately and they were fed @ 2% of Body weight with the prepared farm made feeds (Feed composition is given in Table-1. The bag feeding was carried out on morning hour by placing bags in corner location of ponds. On daily basis the water quality parameters were checked and on weekly basis the sampling were carried out to find out the development of gonads. The females were observed physically for bulging belly and the males were observed to find out if the oozing milt was coming out freely by slight pressing of the abdomen. After 4 weeks it was found that brooders were ready for induced breeding.

Four (4) nos. of nylon breeding happas (Size- 2 m X1m X 1m) (Fig-1) were tied in pond and fixed by the support of G.I pipes. The best females and males were selected from the brood ponds to undertake the breeding. The selected fishes were induced with the GONOPRO - FH (Amrit Pharmaceuticals, Aurangabad). The females were injected with 0.3 ml per Kilogram body weight and the males were injected with 0.2 ml per Kilogram body weight. After injection the male and females were kept in 1:1 ratio in the happa. In every happa two pairs of brooder (two male and two female) were released. After that injected brooders were released in the happa, the plastic strips/water hyacinth floating weeds were spread on the water surfaces for attachment of eggs. The happas were covered there after so that the fish don't jump out from the happa. The happas were kept undisturbed till morning as the fishes spawn after 4-6 hrs of the hormonal injection.

Fig 1: Happa Breeding of Koi carp at NFFBB, Kausalyaganga.

Next day morning the outer happas were fixed in the pond with the help of GI pipes. The floating plastic strips / water hyacinth floating weeds attached with fertilized eggs were collected from the breeding happa and kept in the outer happa. After 96 hrs the spawns hatched out of the fertilized eggs. The spawns were collected and counted for ascertaining the fecundity rate. One set per week was taken and the induced breeding and happa breeding was continued for 5 more weeks. The collected spawns were stocked in the well prepared nursery ponds for further rearing to obtain fry and fingerlings. Some parts of the produced spawn were also sold to the local Seed growers.

Two nursery ponds each of the size 0.04 ha with depth of 1.5 m were selected for seed rearing. Ponds were prepared as stated in case of brood fish ponds. After 96 hrs of egg development, the spawns were transferred to the nurseries. The stocking was done during morning hours by acclimatizing them to the new environment. The stocking density of spawn was @ 25 Lakhs /ha. The mixture of groundnut/mustard oil cake and rice bran was used as nursery feed. After 30 days in the nursery the fry were transferred to rearing ponds. The Rearing ponds were also prepared in the similar manner like nursery pond. The stocking density in the rearing pond was 1, 00,000 nos per ha. The rearing pond fishes were fed with commercial floating feed @ 10% of the

body weight at initial stage till they attain the fingerling stage. The spawn to fingering stage was obtained in 60 days. Water quality parameters in brood stock, nursery and rearing ponds were also and recorded throughout the study period in accordance with standard methods of APHA.

Results and Discussions

Koi carp body may vary from elongated to deep oval. The body was found to be elongated torpedo-like and has cycloid scales. The colour of the body varies from fishes to fishes. Some are found to be white with red and black spots, some fishes are red, some are orange and few are found to be completely black or red or white. They have one long dorsal fin which possesses 2–3 hard and 17–22 soft rays. The first (largest) hard ray is sharp and is serrated on its posterior margin. Additional morphological characteristics include 2–3 anal spines, 5–6 anal rays and 36–37 vertebrae which were also observed by [19]. The mouth was found to be large and have large eye. They had two pairs of barbels, one pair on the upper lip and the other pair at the corners of the mouth.

In the present study, **t**he Koi carp breeding was taken up at NFFBB during 18th January, 2020 to 10th February, 2020. During the experiment it was observed that fertilized eggs of Koi carp were adhesive, demersal and spherical in nature. The egg envelope is thick, transparent and sticky which is similar to the observation made by [20]. The eggs were deposited singly and were highly adhesive throughout the incubation period. Due to the adhesive nature of the egg, considerable debris adhered to the capsule of the egg. The yellowish white egg capsule was transparent, while the yolk was pale yellow or green and granular. The eggs became translucent as development progressed. The diameter of the fertilized egg capsule ranged between 0.8 to1.0 mm while the yolk sphere ranged from 0.6 to 0.8 mm. The result is similar to the finding of [6].

The hatched larvae was free itself through violent whipping movements of the tail which eventually rupture the egg capsule. Hatching occurred at 75-80 hrs after fertilization and the hatchlings were transparent characterized by the presence of an almost round yolk sac. Newly hatched larvae were slender, straight and transparent, gradually tapering towards the tail. The hatchlings ranged between 2.0 and 2.5 mm in length and tried to hide in any refuge they find. At this stage of development they had no swim bladder, mouth or vent. They breathe by absorbing oxygen through the fine blood capillaries that surround the yolk sac, which were still attached to the gut. The head of the hatchlings were seen above the yolk sac, and the brain was clearly visible. 11-13 hours old larva: After 11-13 hrs of hatching the fin folds were seen continuously around the tail. While observing the hatched larvae under microscope it was found that the vent and gill rudiments were formed. The gut was straight to slightly curve in the anterior portion. The air bladder was shallow, and seen behind the pectoral region, which developed into two chambers in the post larval stage. The 2nd day old larvae length was 2.7-2.9 mm. The finding of the present study is same as mentioned by [6]. The larvae were transparent; fin fold; fin fold originates and heavy ovoid yolk sac. The larvae increased 3.0±0.05 mm in size. On the 3rd day, the hatchlings showed free movement. Larvae were able to successfully adhere to the sides of happa or any fragments of plants. The heart developed chambers, although it is still almost vertical in position at the anterior end of the yolk sac. On the 4th day the hatched larvae started feeding on the plankton. This stage was found to be fully grown spawn and the same were collected and transferred to well prepared nursery.

During the course of experiment, total 18,95,000 nos. of spawn were produced out of which 3,25,000 spawn was sold and rest spawn was stocked in Two (2) nursery ponds covering an area of 0.4 hectare each for rearing. The details of breeding programs are given in Table 1.

Table 1: Details of Koi carp seed Production at NFFBB

Particulars	1st Breeding	2nd Breeding	3rd Breeding	4th Breeding	5th Breeding	6th Breeding
Date of breeding	18-01-2020	23-1-2020	28-1-2020	2-2-2020	8-2-2020	10-2-2020
Number of Female taken for breeding	9	10	12	11	6	13
Weight of female fish	13.6	12.8	15.7	15.1	9	14
Number of Male taken for breeding	10	10	14	11	6	11
Weight of male fish	15.2	14.5	18.9	15.4	12	14
Spawn produced (in Lakh)	4	4	4.5	2.75	1.5	2.2
No of Spawn recovered per Kilogram of Female	29,411	35,250	28,662	18,211	16,666	15,714

The temperature recorded during the study period was varying between 18.3^0 C to 25°C. The present study result is similar to the study undertaken by [9]. He stated that the spawning in *C. carpio* occurs at a water temperature of around 18°C. The mean monthly water temperature that ranged from 18.9 to 23.1°C during the study period appears to favor year round spawning of common carp in the reservoir [9]. Year round breading pattern for *C. carpio* has been reported in other tropical lake [21]. From the present study it is evident that Koi carp breeds at a temperature between 18^0C to 25^0C.

In the present study altogether six sets of breeding were taken at NFFBB. The result of this study indicates that the fecundity of *C. carpio* did not differ significantly with respect to fish size. In this case, generally the larger fish gave a greater number i.e. when considering egg production. Per kilogram of Female the spawn recovered from these Six (6) sets varies between 15,714 to 35,250 nos. This indicates that a female weighing one kilogram will give approximate 23,985 nos of spawn in the happa breeding method. The female *C. carpio* deposits eggs - approximately 1,00,000 per kilogram of body weight. [22]. The less number of eggs were found in this study which may probably due to a smaller brood size and may be due to the traditional happa method. The result indicated by [22] might be in the natural environment not confined water.

Determination of fecundity and spawning season are indispensable in understanding the population dynamics of fish species [14]. Fecundity also explains the degree of invasiveness and ecosystem impacts [23]. The mean relative fecundity in Amerti reservoir 177 786 per Kilogram is larger than 97 200 oocytes per Kilogram reported in New-zealand [24]; but comparable with 163 000 eggs per Kilogram total body weight [14]. Females *C. carpio* can carry >1,00,000 oocytes for length groups >60 cm [23]. But in the present study the fecundity is found to vary from 24,250 nos to 38,550 nos

which differs from the study by [14]. This may be due to the different strain, smaller size females and confined environment.

During the present study the females were of 280 mm to 450 mm. Length at first maturity is variable, ranging from 90 to 430 mm TL for both males and females in wild *C. carpio* population [9, 16]. The first maturity for male and female which were 155 mm FL 170 FL respectively did not vary from other studies. However, the length at first maturity (272 mm FL for female and 23 mm FL for male) is lower than Lake Naivasha were it is 340 mm for male and 420 mm (LT) for females [21]. Length and age at maturity in common carp are related to latitude and sex. Males often mature before females, and fish mature earlier at low latitudes when compared with higher latitudes [24]. In Amerti Reservoir, males matured at smaller sizes (272 mm FL) than females (283 mm FL). This may be related to the preparation of females to sustain large number of eggs. Males attaining maturity at a smaller size than females are also reported in both temperate and tropical aquatic ecosystems [24, 25]. The present study is also agreeable with the later study.

After 15 days of stocking of spawn, a distinguishable metamorphosis occurred to the early fry stage. Most of the fry were lemon yellow in color whereas others had a black and orange coloration. The early fry stage were of 10 -18 mm in size which is smaller compared to other carp species 20-25 mm (Rohu, Catla, mrigal etc). After 30 days of spawn rearing, the advanced Fry stage (35-42 mm) were noticed. At this stage, the distinguished 8 branched rays in the dorsal fin and 7-9 in the caudal fin. Fins were well developed with 17-18 pectoral fin rays, 17-21 pelvic fin rays and 5-6 anal fin rays. They were entirely covered by scales and appeared similar to an adult. The details of the nursery rearing and the no of spawns retrieved is given in Table.2

Table 2: Details of Nursery Rearing at NFFBB Farm

Sl. No	Nursery Pond No	Size of Pond (ha)	No of Spawn Stocked	Rearing period	No of Fry recovered	Survival Percentage	Av. size of fry retrieved (in mm)
1	NP1	0.04	1,00,000	30 days	32,000	32%	35
2	NP2	0.04	1,00,000	30 days	27,000	27%	42
3	NP3	0.04	1,00,000	30 days	28,500	28.5%	39
4	NP4	0.04	1,00,000	30 days	31,500	31.5%	37

From the table-2 it is observed that the survival of spawn was varying between 27% to 32% and the size also varies between 35 mm to 42 mm. It is understood that the maximum growth of the nursery phase which at about a month gives rise to 42 mm size fry. The stocking density was 25 Lakhs per hectare and the survival was found to be about 30%.

Table 3: Details of Rearing of Fry to Fingerlings at NFFBB Farm

Sl. No	Nursery Pond No	Size of Pond (ha)	No of Fry Stocked	Rearing period	No of Fingerlings recovered	Survival Percentage	Av. size of Fingerling retrieved (in mm)
1	RP1	0.32	32,000	30 days	19,840	62%	61
2	RP2	0.27	27,000	30 days	15,390	57%	80
3	RP3	0.28	28,500	30 days	17,080	61%	75
4	RP4	0.31	31,500	30 days	18,427	58.5%	79

The growth and the survival details of the Koi carp Fry rearing is given table 3. In the present study after 30 days of rearing of advanced fry, Fingerlings of size were obtained. From the table-3 it is seen that the fry growth varies from 61-80 mm and the survival from fry to fingerling was varying from 57- 62%. Similar study was conducted by [26]. They revealed that maximum number of large sized fingerlings in the range of 75-92 mm with mean total length of 78.8. mm was obtained. Considerable studies have been made regarding fry to fingerling rearing by the earlier workers using natural and artificial feed [27, 28, 29, 30, 31, 32]. It was observed from the results and work done by earlier scientist that under stocking density of 10 lakh fry per ha, the growth (length and weight) and survival percentage was better in all the three ponds. The size recorded was suitable for stocking the medium and large irrigation tanks. Further it was recorded that optimum growth up to advanced fingerling size was possible in rainfed ponds by applying inexpensive supplementary feed and fertilizers. There was even growth of large sized fingerlings (75-92 mm) which was very essential for stocking in the reservoirs to raise the overall growth and survival percentage. The studies reported have given very useful information regarding rearing of seed up to advanced fingerling size in the soil having low fertility and acidic nature (pH 6.5) under rain fed condition. The present study is also in comparison to the study conducted by [26]. However it is revealed from the present study that the growth of Koi carp in the rearing pond is quite encouraging which might be due to the better managed ponds and the quality feed supplied to the reared fry. This paves the way for commercial production of Koi carp in a commercial manner. However the retrieval of the fry and fingerlings from the earthen ponds are difficult as these fishes are bottom dwellers. It is recommended from the experience of nursery rearing that Koi carp spawn may be reared n the cemented nurseries for better output of fry and fingerlings.

Table 4: Water quality parameters in the Brood stock, Nursery and Rearing Ponds

Parameters	Range Recorded
Water pH	7.5 -8.2
Water temperature	18.3 -25^0 C
Hardness of water	100 – 110 ppm
Dissolve Oxygen (DO)	4.5 – 5.2 ppm
Free CO2	0 ppm
Alkalinity	114- 118 ppm

The water quality parameters recorded during the study is given in Table-4. It is clear from the table that the water quality parameters were maintained up to the optimum level in order to obtain best result out of the experiment. The above observed water parameters were recorded from Brooder pond, Nursery Pond, Breeding happa. As the results from spawn, fry

and fingerling output are encouraging it is concluded that the water parameters are in optimum range.

Conclusion

As there had no commercial approaches of induced breeding and seed production of Koi carp by any scientific organizations but there is a great demand of Koi carp in our country for its colorful and attractive appearance the present study gains importance at the present context. From the present study, it can be concluded that the commercial breeding can be attempted in Happa breeding. It was also observed that fertilized eggs of Koi carp were adhesive, demersal and spherical in nature. The fecundity is found to vary from 24,250 nos to 38,550 nos which is concluded that based on the size of Koi carp the fecundity varies. The nursery rearing certainly gives better growth and survival which is comparable with other common carp growth and survival. The detailed observation of embryonic development in the present study is also gives lot of impetus for further research in the days to come. The breeding techniques discussed in the present paper can be considered as a first simple and commercial seed production to further large scale breeding of this species.. The present study will certainly paves the way for the start-ups to take up commercial production and marketing of Koi carp in the days to come.

Acknowledgement.

The authors are grateful to the Chief Executive, NFDB, Hyderabad and the OIC, NFFBB for providing the facility to carry out the research work at National Freshwater Fish Brood Bank, Kausalyaganga, Bhubaneswar, Odisha. Further we are thankful to the Dean, Centurion University of Technology and Management, Bhubaneswar for assigning the research work for which the study could be conducted.

References.

1. Food and Agricultural Organization (FAO). Review of the State of World Aquaculture, FAO Fisheries circular, 1997, 163-886.
2. Laxmappa, B. Status of carp farming in India. Aquaculture Asia. 2014; 19(1):9-13.
3. Basavaraju Y, A Narasimha Reddy. Growth performance of Amur strain of common carp in Southern Karnataka. The Mysore Journal of Agricultural Sciences. Mysore Journal of Agriculture Science. 2013; 47(1):119-123.
4. Linnaeus C. (1 Jan.) Systema Naturae, Ed. X. (Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima, reformata.) Holmiae. *Systema Naturae*, Ed. X. v. 1: i-ii + 1-824. [Nantes and Pisces in Tom. 1, pp. 230-338; a few species on later pages. Date fixed by ICZN, Code Article 3]. 1758.
5. Axelord HR. Koi of the world: *Japanese coloured carp*. Neptune city, TFH Publications, 1973, 239.
6. Ghosh AK, Biswas S, Sarder L, Sabbir W, Rahaman S.M.B. Induced breeding, embryonic and larval development of Koi carp (Cyprinus carpio) in Khulna, Bangladesh Mesopot. Journal of Marine Science. 2012; 27(1):1-14.
7. Kuroki T. The latest manual to nishikigoi. Shin-Nippon Kyoiku-Tosho Co. Ltd. Japan. 1981, 272.
8. Haniffa MA, Allen Benziger PS, Jesu Arockiaraj A, Nagarajan M, Siby P. Breeding Behaviour and Embryonic Development of Koi Carp (*Cyprinuscarpio).*Taiwania. 2007; 52(1):93- 99.
9. Fernandez-Delgado C. Life history patterns of the common carp, *Cyprinus carpio*, in the estuary of the Gusdalquivir River in south-west Spain. Hydrobiologia. 1990; 206:19-28.
10. Mc Crimmon HR. Carp in Canada. Fisheries Research Board of Canada Bulletin. 1968; 165:1-89.
11. Vilizzi L, Walker KD.. Age and growth of the common carp. *Cyprinus carpio*,in the River Murray, Australia: validation, consistency of age interpretation, and growth models. Environmental Biology of Fishes. 1999a; 54:77-106.
12. Putri FP, Dewi NN. Growth monitoring of Koi fish (Cyprinus carpio) in natural hatchery techniques in Umbulan, Pasuruan, East Java. IOP Conference Series: Earth and Environmental Science. 2019; 236:012016.
13. Darseno. Smart Book of Cultivation and Catfish (Jakarta: Business Agromedia Pustaka), 2010, 158.
14. Sivakumaran KP, Brown P, Stossel D, Giles A. Maturation and reproductive biology of female wild carp, *Cyprinus carpio*, in Victoria, Australia. Environmental Biology of Fishes. 2003; 68:321-332.
15. Crim LW, Glebe BD. Reproduction. In: Schreck CB, Moyle PB ed. Methods for fish biology. Maryland, American Fisheries society, 1990, 529-547.
16. Prochelle O, Campos H. The biology of the induced carp *Cyorinus carpio*, in the River Cayumapu,Valdivia, Chile. Studies on Neotropical Fauna and Environment. 1985; 20:65-82.
17. Hanchet S. The effects of koi carp on New Zealand's aquatic ecosystems. New Zealand Freshwater Fisheries Report No. 117. Fresh water fisheries Center, MAF Fisheries, Rotorua, 1990, 41.
18. Balon EK. Epigenesis of an epigeneticist: the development of some alternative concepts on the early ontogeny and evolution of fishes. *Guelph Ichthyology Reviews*. 1990; 1:1-48.
19. Kailola PJ, Williams MJ, Stewart PC, Reichelt RE, Mc Nee A, Grieve C *et al*. Australian fisheries resources. Bureau of Resource Sciences, Canberra, Australia, 1993, 422.
20. Froese R, Pauly D. Fish Base. In: World Wide Web electronic publication, May, 23 2001, Available from: *www.fishbase.org*, 2011.
21. Oyugi DO, Cucherousset J, Ntiba M.J, Kisia SM, Harper DM, Britton JR *et al*. Life history traits of an equatorial common carp *Cyprinus carpio* population in relation to thermal influences on invasive populations. Fisheries Research. 2011; 110:92-97.
22. Freeman E. Breeding Koi. (Sexing, Spawning, Incubation of Koi Eggs, Development of Koi eggs and fry, Feeding and Growing). Aquaculture. 1987; 35:41-53.
23. Bajer P, Sorensen P. Recruitment and abundance of an invasive fish, the common carp, is driven by its propensity to invade and reproduce in basins that experience winter-time hypoxia in interconnected lakes. *Bilogical. Invasions.* 2010; 12:1101-1112.
24. Tempero GW, Ling N, Hicks BJ, Osborne MW. Age composition, growth, and reproduction of Koi carp (*Cyprinus carpio*) in the lower Waikato region. New Zealand Journal of Marine and Freshwater Research. 2006; 40:571-583.

25. Britton JR, Davies GD, Brazier M, Pinder AC. A case study on the population ecology of a top mouth gudgeon *Pseudorasbora parva* population in the UK and the implications for native fish communities. Aquatulture Conservervation of Marine and Freshwater Ecosystem. 2007; 17:749-759.
26. Shingarei PE, Sawant NH, Bhosale BP, Belsare SC. Studies on Growth and Survival of *Cyprinus carpio* Fry up to Advanced Fingerlings in the Rainfed Ponds. Journal Indian Society Coastal Agriculture Research. 2006; 24(2):258-260.
27. Charlon, N. Bergot, P. Rearing system for feeding fish larvae on dry diets, trial with carp (Cyprinus carpio L.). Journal of Inland Fishery Society of India. 1984; 15:24-28.
28. Dabrowski, K, Dabrowski H, Grudniewski CZ. A study of the feeding of common carp larvae with artificial food. Aquaculture. 1978; 13:57-64.
29. Jeyachandran, Raj Samuel Paul. Experiments with artificial feed on Cyprinus carpio fingerlings. Journal of Inland Fishery Society of India. 1976.8:33-37.
30. Jeyachandran, Raj Samuel Paul. Formulation of pelleted feeds and feeding trials with common carp. Journal of Inland Fishery Society of India. 1977; 9:42-52.
31. Lakshmanan MAV. Study on new artificial feed for carp fry. FAO Fish Report. 1966; 44(3):373-387.
32. Szlaminska M, Przybyl A. Feeding of carp (*Cyprinus carpio*) larvae with an artificial dry food, living zooplankton and mixed food. Aquaculture. 1986; 54(1-2):77-82.