INDUCED SPAWNING OF THE CHINESE GRASS CARP, *CTENOPHARYNGODON IDELLUS* (C. & V.) AND THE SILVER CARP, *HYPOPHTHALMICHTHYS MOLITRIX* (C. & V.) IN PONDS AT CUTTACK, INDIA

by

K.H. Alikunhi, K.K. Sukumaran & S. Parameswaran

Central Inland Fisheries Research Sub-Station,
Cuttack, India

ABSTRACT

The paper discusses sexual maturation in ponds of Chinese carp (Grass Carp, Silver Carp and Bighead). Fertilizable eggs and viable milt were obtained by intramuscular injection of pituitary extracts, homoplastic, and hoteroplastic using Indian carp as donors. Rate of hatching and subsequent survival and growth of the fry in described.

INTRODUCTION

Herbivorous, fast-growing, non-predacious species of fishes are preferred for cultivation in ponds as they are efficient convertors of organic matter into fish flesh and consequently give high yields. Several such species of fish are available in Southeast Asia. Notable among these are the Indian Carps *Catla catla*, *Labeo rohita*, and *Cirrhina mrigala* and the Chinese carps, *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis* and *Mylopharyngodon piceus*. All these are riverine species confined to the major river systems of Indian and China. Ordinarily they breed once a year, during monsoon months, in flooded shallow areas along the course of the river. Though they grow rapidly and attain sexual maturity in ponds they do not normally breed there (Gidumal, 1958). The Indian carps are, however, known to breed in certain special ponds called 'Bundhs' which are minor irrigation tanks, with extensive catchment area and liable to sudden flooding resulting in sharp rise in water level during monsoon (Hora *et al*, 1945).

The Indian and the Chinese carps are extensively cultivated in ponds. As these fishes do not breed in ponds, their young ones, required for stocking, are to be collected every year from natural sources along the course of rivers. Millions of developing eggs, hatchlings and fry of these carps are thus collected and reared in ponds to fingerling size, and then transported over long distances for stocking all over the country. The quality of fish seed collected from natural sources is, however, uncertain and the collections always comprise a mixture of several species some of which may be predatory in habit or of an uneconomic nature (Gidumal, 1958). The percentage of the quick growing species also widely fluctuates from time to time and from place to place. In view of these and the several difficulties associated with collections from rivers, the need for ensuring supply of quality fish seed by inducing these fishes to breed in confined waters has been keenly felt particularly with the rapid increase in the demand for fish seed (Chaudhuri & Alikunhi, 1957). At present, the demand for fry and fingerlings of Chinese carps from various countries in South-east Asia has to be met by exports from mainland China, *via* Hongkong. Heavy mortality during transport, fluctuations in the quantity expected every year and the consequent high cost of fry by the time they reach the stocking pond, have rendered the need for an alternative, dependable means of supply of Chinese Carp seed more imperative than in the case of Indian carps (Gidumal, 1958).

Induced breeding of major Indian carps by injection of fish pituitary hormones has been successfully developed and commercial production of quality fish seed in ordinary

ponds has been carried out in India since 1957 (Chaudhuri & Alikunhi '57, Alikunhi *et al*, '60; Chaudhuri, '60). Similar attempts to induce the Chinese carps to spawn in ponds have not so far succeeded (Malacca Institute Rep. '59, '60, '61; Tang, 1954;).

Alikunhi and Sukumaran(1962) reported the first introduction of experimental consignments of Chinese silver carp and grass carp into India in 1959 and stated that both the species attained sexual maturity in ponds at Cuttack when about 2 years old, by June-July 1961. Experiments on the induced breeding of these Chinese carps were therefore taken up since June 1961. During July 1962, when the fish were just three years old ripe specimens of silver carp and grass carp were successfully induced to breed in ponds by administering pituitary gland hormones. This, to our knowledge, being the first instance of successful breeding of a Chinese carp in the confined waters of ponds, the experiments conducted and the observations made are described in detail in this paper, together with notes on their fecundity, life-history and early growth in the new environment.

MATERIAL AND METHODS

During June-July 1961 the stock of mature fish available was as follows:—

TABLE I

Details of brood stocks of Chinese Carps available at Cuttack during June-July 1961

Species	Number			Length range (Cm.)		Range of weight (Kg.)	
	Males	Females	Total	Males	Females	Males	Females
Grass Carp	15	14	29				
Silver Carp	45	37	82	54.2 - 73.5	55.3 - 74.0	1.98 - 4.71	2.69 - 6.52

24 silver carps and one grass carp were used for preliminary experiments during June-July 1961 and the rest of the stock were held in selected ponds for the 1962 season. By June 1962 these had attained the following size:

TABLE II

Particulars of brood stock of Chinese Carps at Cuttack during June, 1962

Species	Number			Length range (Cm.)		Range of weight (Kg.)	
	Males	Females	Total	Males	Females	Males	Females
Grass Carp	11	13	24	75.2 - 86.0	73.8 - 79.2	4.54 - 6.61	4.76 - 7.03
Silver Carp	29	29	58	62 5 - 71.0	63.5 - 81.2	2.80 - 4.96	4.99 - 7.49

The breeders were sexed early in April and the males and females kept in separate ponds. When weather became fairly cool they were netted and ripe females and oozing males were selected for injection. The injected fish were released in cloth *hapas** fixed in ponds containing a heavy population of other carps. Depth of water in the *hapas* was about 2.5 ft. Ordinarily injections were administered late in the evening or at night. The pituitary gland required were calculated in mg. per Kg. weight of the breeder; and extracted in 0.3% saline at the time of injection. When the injected fish in the hapas started spawning, they were taken out, stripped in clean trays and the eggs were fertilized. Fertilized eggs were hatched in cloth hapas fixed in the pond. Two days after hatching when the yolk was fully absorbed, the fry were stocked in prepared nursery ponds, each 0.1 acre in area. The fry were artificially fed daily with a mixture of mustard oil cake powder and rice bran. In order to study their development and growth samples of fry were collected from the nursery ponds every day and at biweekly or weekly intervals from rearing ponds. Nine days after stocking the silver carp fry were netted from nursery ponds and released in rearing ponds where also artificial feeding was continued.

Mature females which died or which had to be cut and examined after their failure to breed inspite of repeated injections were utilised for studying fecundity. 22 specimens of silver carp, 6 of grass carp and 1 of bighead were utilised for fecundity counts.

FECUNDITY OF POND REARED SPECIMENS

According to Lin (1935) in China a female grass carp weighing 7 Kg. will have about 100,000 eggs. This is quite low compared to many other carps. Inaba *et al* (1957) found a grass carp 88 cms long and weighing 7.1 Kg. having 485,000 eggs in both the ovaries together. A silver carp from Tone river, 81.5 cms long and weighing 12 Kg. had an estimated number of 800,000 eggs which were nearly completely stripped (Inaba *et al*, '57).

Available figures on the fecundity of grass carp and silver carp grown in ponds at Cuttack are given in Table III.

TABLE III

Size and fecundity of grass carp and silver carp at Cuttack, India

Total length (Cms)	Wt. of fish (g.)	Wt. of ovaries (g.)	Wt. of fish: Wt. of ovaries	Total No. of eggs	Average Diameter of ovaries (mm)	Remarks
Grass Carp (*Ctnopharyngodon idellus*)						
73.8	4766	540	6.7:1	372,600	1.21	
75.0	5830	880	6.6:1	441,700	1.37	
75.8	4880	744	6.5:1	563,900	1.19	
78.6	5476	656	8.3:1	396,200	1.35	
78.9	5724	1129	5:1	618,100	1.30	
79.2	7036	553	12.7:1	308,800	1.33	

* The fish breeding *hapa* is made of fine meshed cloth, in the form of an inverted mosquito net, provided with a top cover which opens only on one side where it can be securely tied by means of strings specially provided. Size: 12 ft. x 6 ft. x 3 ft.

TABLE III

Total length (Cms)	Wt. of fish (g.)	Wt. of ovaries (g.)	Wt. of fish: Wt. of ovaries	Total No. of eggs	Average Diameter of ovaries (mm)	Remarks
Silver Carp (*Hypophthalmichthys molitrix*)						
56.5	3178	456	7:1	145,000	—	
60.3	3575	935	3.8:1	629,000	—	
62.5	3746	710	5.3:1	675,000	—	
65.8	4540	1080	4.2:1	769,000	—	
67.5	5391	1884	2.9:1	1,426,000	—	
69.5	4994	1559	3.2:1	1,169,000	—	
71.7	6073	1385	4.4:1	1,039,000	—	
74.0	6527	2170	3:1	2,044,000	—	
63.5	4994	794	6.3:1	646,000	1.22	
70.5	5333	1011	5.2:1	1,043,000	1.24	
70.9	5277	1067	5:1	837,000	1.29	
71.4	5786	1576	3.7:1	816,000	1.26	
72.8	6015	1002	5.4:1	739,000	1.26	
74.4	6176	1233	5.0:1	998,000	1.22	
74.5	6194	1169	5.2:1	959,000	1.24	
75.1	6044	669	—	456,000	1.36	after stripping
76.0	5859	1515	3.9:1	1,335,000	1.21	
76.5	7064	1316	5.3:1	1,077,000	1.22	
77.6	7491	1021	7.3:1	754,000	1.36	
78.9	6694	1620	4.1:1	1,338,000	1.24	
81.2	6756	1013	6.7:1	809,000	1.22	
82.8	8512	2278	3 7:1	1,909,000	1.24	

Alikunhi and Sukumaran (1962) reported that two years old grass carp and silver carps attained sexual maturity in ponds at Cuttack. At this age both males and females of silver carp were found fully ripe; while in the case of grass carp only the males were in oozing condition and the females were apparently not mature. By the end of the third year, however, grass carp females also became mature. In their natural habitats in China these fishes are reported to attain sexual maturity at the age of four years (Chen and Lin, 1935; Tang 1954). Most of the fish caught in their natural spawning grounds on the West river in China are four years old and weigh from 9 to 13 lb.; no mature grass carp, male and female, recorded weighing less than 8 lb. or less than 3 years in age (Lin, 1935; Hickling, 1960). The smallest mature silver carp recorded at Cuttack—male 54.3 cm and 1.87 Kg.; female 54.6 cm and 2.38 Kg. and the smallest mature grass carp male, measuring 53.5 cm and 1.81 Kg. were only 2 years old (Alikunhi and Sukumaran '62). One of the smallest, 3 years old female grass carp measured 73.8 cm and weighed 4.76 Kg.

The earlier attainment of sexual maturity of the Chinese carps in India* may be due to the relatively higher water temperature. In the Tone River in Japan the water temperature ranges from 17.6° to 22° C at the time of spawning of these carps. In the Chinese rivers also the temperature of water during June-July would be comparable to that in Japan. However, the water temperature in ponds at Cuttack during June-July ranges from 28° to 34° C.

In fully gravid females of silver carp the total weight of the fish ranges from 2.9 to 8.1 times the weight of the two ovaries. In Taiwan, Tang (1954) found a female specimen of *H. molitrix*, 69 0 cm long having the ovaries together weighing 670 g. The ovaries weigh relatively less in grass carps, mature females in ponds at Cuttack showing a total weight: Weight of ovaries ratio of 5.0 to 12.7:1.

In the matter of development of gonads and attainment of sexual maturity in ponds the Chinese carps (grass carp, silver carp and bighead) are thus exactly similar to the Indian carps, catla, rohu or mrigal. Their response to pituitary hormone injections also is similar to that in Indian carps, as it has been possible to successfully induce them to breed in ponds. The stress reaction in the form of a developmental check on gonads shown by grass carps in ponds in Malacca does not seem to prevail in ponds at Cuttack, where well-fed fish ordinarily attain sexual maturity (1959). Further, the specimens examined at Malacca during May-July '60 do not appear to have been fully ripe from the weight of gonads given (1960). The relative weight of gonads in fully ripe female specimens of grass carp and silver carp is compared with the corresponding weight of Indian carps in Table IV.

* Three specimens of bighead, *Aristichthys nobilis* which were accidentally included in the consignment of silver carp fry from Japan during 1959 attained full sexual maturity when they were just 23-24 months old. All the 3 specimens were females. When 3 years old, one of these measured 67.2 cm in total length, weighed 4.76 kg. and had the two ovaries together weighing 552 g. with 218,000 ova. In Taiwan the ovaries of a 74 cm long female weighed 820 g. (Tang, 1954).

TABLE IV

Size of fish and weight of gonad in mature female specimens of Chinese and Indian carps grown in ponds at Cuttack

No. of specimens examined					Length range in mm	Average weight of ovaries (g.)					Weight of fish : Weight of ovaries				
Silver carps	Grass carps	Catla	Rohu	Mrigal		Silver carp	Grass carp	Catla	Rohu	Mrigal	Silver carp	Grass carp	Catla	Rohu	Mrigal
—	—	—	6	—	401 - 450	—	—	—	237	—	—	—	—	4.9:1	—
—	—	—	18	2	451 - 500	—	—	—	292	240	—	—	—	6.0:1	4.6:1
—	—	2	58	1	501 - 550	—	—	525	487	181	—	—	4.9:1	4.7:1	10.6:1
1	—	2	18	2	551 - 600	456	—	1087	652	239	7.0:1	—	3.7:1	4.5:1	9.0:1
3	—	1	—	—	601 - 650	813	—	1171	—	—	5.1:1	—	5.0:1	—	—
3	—	—	—	—	651 - 700	1507	—	—	—	—	3.4:1	—	—	—	—
8	2	—	—	—	701 - 750	1260	713	—	—	—	5.0:1	6.65:1	—	—	—
5	4	—	—	—	751 - 800	1368	770	—	—	—	5.1:1	8.1:1	—	—	—
2	—	—	—	—	801 - 850	1645	—	—	—	—	5.2:1	—	—	—	—

It is seen from the above table that fully mature, medium size specimens of silver carp, catla and rohu show almost the same relative proportion of total weight: gonad weight. In the case of grass carp the proportionate weight of ovaries seems to be lower than in the above specimens but compared well with that in mrigal.

The number of eggs produced by silver carp and grass carp at Cuttack also appears to be appreciably higher than that recorded elsewhere in these specimens. How this compares with the condition in Indian major carps in indicated in Table V.

TABLE V

Relative number of eggs produced by the major Chinese and Indian carps at Cuttack

Specimens	Number of eggs per	
	g. total weight	g. ovary weight
H. molitrix	171	792
C. idellus	82	610
Catla catla	78	—
L. rohita	142 to 424	931 - 1956
C. mrigala	147	—

(Figures for Catla and Mrigal calculated from Khan, 1934; for *L. rohita:* unpublished data; Fish Breeding Unit, Central Inland Fisheries Research Sub-station, Cuttack).

It is seen from the above that the fecundity of *C. idellus* compares with that of *C. catla;* and *H. molitrix* with that of *C. mrigala.* Fecundity of *L. rohita* appears to be much higher. Even in the case of catla and mrigal, examination of more specimens might record appreciably higher fecundity.

INDUCED BREEDING IN PONDS

Experiments on silver carp (*H. molitrix*) were undertaken during June-July 1961 as the fishes were mature by that time. 8 sets of fishes (a set means 1 female and 2 males) were injected and released in hapas fixed in ponds or cisterns for breeding. The details of injections given and the results in brief are given in Table VI.

TABLE VI

Particulars of pituitary hormone injections administered to Silver carp, H. molitrix, during June-July, 1961 at Cuttack

Sl. No.	Date	Hours	Weight of breeders, (g.)		Donor fish of pituitary gland	Dose injected (mg./Kg.)		Remarks
			Female	Male		Male	Female	
1.	8.6.61	18.30	2696	1986	*C. mrigala*	2 5	5.6	No spawning. A few eggs oozing; could not be artificially fecundated. Males not oozing freely.
	9.6.61	06.00	—	2668	- do -	3.0	6.0	
2.	21.6.61	14.30	3746	3320 2611	*L. rohita*	—	2.0	Initial low dose to female only.
	- do -	20.30	—	—	- do -	3.0 2.5	5.0	No spawning; but female oozing freely. Artificial fecundation not successful. Males with very little milt.
3.	4.7.61	13.30	6072	3576 3234	*H. molitrix*	—	5.2	Initial dose to female only. Female released a few eggs by 7 hrs. on 5.7.61— not fertilized.
		19.30	—	—	- do -	3.0	6.0	
	5.7.61	07.30	—	—	- do -	2 0	4.0	
4.	4.7.61	13.30	3576	3234	*L. rohita*	—	2.0	Initial dose for female only.
		19.30	—	2298	- do -	3.0	6.0	No spawning for the next 12 hours.
	5.7.61	07.30	—	—	- do -	2.0	2.0	
5.	5.7.61	18.00	3173	3007 3067	*L. rohita*	2.0+4.0	10.0	Single high dose; no spawning; by next morning a small cluster of ova was projecting out from the vent.
6.	6.7.61	18.00	4540	3405	*L. rohita*	3.5	12.0	No spawning till next. morning.
	7.7.61	07.00	—	3320	- do -	4.0	6.0	No spawning till 1600 hours.
	—	16.30		—	- do -	2.5	5.0	No spawning till next morning.
7.	12.7.61	20.00	6526	4710	*H. molitrix*	6.0+8.0	15.0	No spawning; a small bunch of eggs projecting out from the vent. Eggs not oozing freely.
8.	12.7.61	13.30	5392	4313	*L. rohita*	—	3.0	Initial dose for female only.
	—	20.00	—	3688	- do -	8.0	22.0	No spawning till next morning. A bunch of eggs projecting out of vent; not freely oozing.

Homoplastic injection as well as injections of pituitary glands collected from Indian carps were administered. A preparatory low dose injection to the female alone, followed by a higher dose for both the sexes was repeatedly tried. In several instances an initial high dose of hormones resulted in the release of a few unfertilized eggs and a bunch of eggs projecting out from the vent as a cluster. In one instance (set 2) the eggs were freely oozing on gentle pressure but could not be fertilized. Though the various doses of injections tried did not yield fertilizable eggs, the response of the injected specimens appeared to be similar to that of major Indian carps.

During 1962, by mid-June the three years old silver carps as well as grass carps were mature. While the males in both the species had developed pronounced roughness on the outer aspect of the pectoral fin—a distinctive feature of mature or maturing males, the females particularly silver carps appeared fully gravid with soft bulging abdomen. The two female specimens of bighead (*A. nobilis*) were also fully gravid. Concerted efforts at inducing these mature specimens to breed were therefore taken up by administering pituitary hormones. Three sets of silver carp, two of grass carp and one bighead responded positively and the eggs could be fertilized and hatched. Water qualities in ponds where successful spawning took place were as follows:—

Water temp. (°C)	pH	D.O.	CO_2	Total Alkalinity
28.2 - 34.9	8.4- 8.8	5.37- 8.88	Nil	102 132

The particulars of successful as well as unsuccessful doses of injections administered during the 1962 season are given in Table VII.

TABLE VII

Details of pituitary Hormone injections administered to the Chinese carps H. molotrix: C. idellus and A. nobilis during June-July 1962 at Cuttack

Set No.	Date	Hours	Weight of Breeders (Kg.)		Donor fish of pituitary gland	Dose administered mg./kg.		Remarks
			Female	Male		Male	Female	
Bighead, Aristichthys nobilis:								
1.	21.6.62	16.00	6.00	4.3; 3.7	*L. rohita*	—	2.0	Initial dose for female only.
		22.00	—	(Silver carps)		3.0	5.0	Seven hours after 3rd injection
	22.6.62	08.30	—	—	- do -	1.0	5.0	spawning commenced. Stripped by 7.30 p.m.
2.	6.7.62	21.00	4.60	3.4; 2.7	*H. molitrix*	0.5	2.0	No spawning; a few dead eggs oozing on pressure.
	7.7.62	04.00	—	(Silver carps)	- do -	2.0	5.0	
		14.00	—	—	- do -	1.0	3.0	
Grass carp, Ctenopharyngodon idellus:								
1.	21.6.62	16.00	6.50	4.9	*L. rohita*	—	2.0	Initial dose for female only.
		22.00	—	—		3.0	5.0	No spawning till 7.30 p.m./22.6.62.
	22.6.62	08.30	—	—		1.0	5.0	A few eggs oozing on pressure.
2.	6.7.62	21.00	5.70	4.54	*L. rohita*	—	3.0	Initial dose for female only.
	7.7.62	04.00	—	—		3.0	6.0	No positive response. No eggs
		14.00	—	—		1.0	4.0	oozing.
3.	9 7.62	22.00	5.20	4.3; 4.0	*C. idellus*	—	2.0	Initial dose for female only.
	10.7.62	06.00	—	—	*L. rohita*	2.0	5.5	No spawning till 10 p.m.
		14.00	—	—	*H. molitrix*	2.0	5.0	
4.	19.7.62	21.50	5.30	6.8	*L. rohita*	1.0	3.0	Started spawning 7 hours after
	20.7.62	04.45	—	—		3.0	6.0	second injection. Eggs freely oozing. Stripped and fertilized.
5.	19.7.62	22.10	5.10	5.0	*L. rohita*	1.0	3.0	Eggs not freely oozing; 8 hours
	20.7.62	04.55	—	—		3.0	6.0	after second injection. A few stripped and artificially fertilized.
6.	21.7.62	22.00	1) 5.30;4.80		1) *C. idellus*	1.0	3.0	3rd injection, Rohu glands for 2nd
			2) 4.80		2) *L. rohita*			female only.
	22.7.62	05.00	—	—		1.0	6.0	No spawning.
		13.00	—	—		—	6.0	

7.	30.7.62	19.15	5.10	4.6	*L. rohita*	—	3.0	For female only.
	31.7.62	02.00	—	—		3.0	7.0	No spawning till 16 hours.
		09.00	—	—		—	4.0	
Silver carp, Hypophthalmichthys molitric:								
1.	21.6.62	16.00	7.8	4.5; 4.4	*L. rohita*	—	2.0	Initial dose for female only.
		22.00	—	—	- do -	3.0	5.0	By 8 a.m. on 22.6.62, eggs freely oozing. Stripping & artificial fertilization attempted. Eggs were fully swollen but not fertilized.
2.	26.6 62	19.00	5.4	4.5; 4.0	*L. rohita*	—	2.0	Initial dose for female only.
	27.6.62	02.30	—	—		2.0	6.0	No spawning Abdomen full and turged; vent protruding.
3.	6.7.62	21.00	7.8	3.8; 3.4	*H. molitrix*	2.5	2.0	Initial dose for female & one male only.
	7.7.62	04.00	—	—	- do -	2.0	5.0	No spawning: A cluster of eggs
		14.00		—	- do -	1.0	3.0	projecting out of vent.
4.	9.7.62	22.00	6.0	3.9; 3.0	*H. molitrix*	—	3.0	Initial dose for female only.
	10.7.62	05.30	—	—	- do -	3.0-4.0	6.0	Spawning commenced within 5 hours of second injection. Eggs stripped and fertilised.
5.	12.7.62	20.30	6.1	4.6	*H. molitrix*	—	3.0	Initial dose for female.
	13.7.62	03.30				3.0	6.0	Spawning started within 6.5 hours of second injection. Eggs stripped and fertilised.
6.	15.7.62	21.00	6.0	4.3; 4.5	*H. molitrix*	—	3.0	For female only.
	16.7.62	04.00	—	—	- do -	3.0	6.0	Began spawning within 5 hours of second injection. Eggs stripped and fertilised.
7.	19.7.62	21.15	4.1	4.5; 4.5	*H. molitrix*	1.0	3.0	For female and one male only.
	20.7.62	04.15	—	—	- do -	3.0	6.0	Started spawning 7 hours after second injection. Eggs freely oozing. Could not be fertilised.

Out of the seven sets of silver carps injected two were administered pituitary glands of *L. rohita;* while the rest were given homoplastic injections (silver carp glands) and three out of the latter yielded positive results. In all the three cases, the female started laying eggs, 5 to 6.5 hours after the second injection. The spawning female in all the three cases had the eggs freely oozing. The eggs were stripped in dry enamel trays and immediately mixed with milt pressed out from the injected male. In all three cases the eggs were fertilized. Percentage of fertilization was low in the first two instances, while it was about 65% in the third at the time when embryos were well formed.

In the case of the bighead, *A. nobilis,* only two gravid females were available. One specimen reacted positively to injections of *L. rohita* glands. Seven hours after the third injection, eggs were freely oozing. These were stripped and fertilized with the milt of *H. molitrix; C. idellus, L. rohita* and *C. catla.* Only a few eggs in each case were fertilized.

Seven sets of grass carps were injected, all except two females, with *L. rohita* glands. Only in one case (set 4) the eggs became freely oozing about 7 hours after the second injection. In set 5 only a few eggs were oozing but these were viable and could be fertilized. As in the case of silver carps, the spawning fish was taken; the eggs pressed out in clean dry trays and fertilized with milt taken from injected males. Fertilized eggs hatched out normally.

Ordinarily, in inducing Indian carps to breed by pituitary injections, the eggs laid by the female are fertilized in the hapa by milt shed by the male. In the case of *H. molitrix* and *C. idellus,* because of the very limited stock of breeders available and because of the need to arrive at the correct dosage first, the injected fish, as soon as they started spawning, were taken out and the eggs were artificially fertilized. However, the response of these Chinese carps to pituitary injections appears to be identical with that of the Indian carps. *C. catla* and *L. rohita.* Response to injections administered to mature specimens of *L. rohita* and *C. catla* at the same time and in the same environment as the Chinese carps indicate extreme similarity (vide Table VIII).

TABLE VIII

Relative response of gravid specimens of Chinese and Indian carps to pituitary hormone injections

Species	No. of sets injected	Range of Wt. (Kg.)		Donor of glands	No. of injections given		Dose (Mg./Kg.)		Positive results within 8 hours of injections	Remarks
		Males	Females		Male	Female	Male	Female		
L. rohita	1	1.2-1.9	2.5	*L. rohita*	—	1	nil	2.0	1	Eggs were fertilised by the uninjected males.
,,	1	1.9	3.5	,,	1	2	2.0	2.0 + 4.0	Nil	Did not breed.
,,	1	1.4-1.5	1.6	,,	1	2	3.0	2.0 + 5.0	1	Eggs were fertilized.
,,	7	1.3-2.5	2.0-3.8	,,	1	2	2.0	2.0 + 5.0	7	In all these cases eggs were fertilized and duly hatched out.
C. catla	1	3.6	4.5	*C. catla*	1	1	1.0	2.0	1	Eggs were fertilised.
,,	1	2.2	5.3	*L. rohita*	1	1	2.0	2.0	1	Eggs were fertilised.
C. catla (albinos)	1	—	2.7	*C. catla*	—	1	nil	2.0	1	Spawned without male.
,,	1	2.8	1.9	,,		1	nil	2.0	1	Eggs were fertilised by the uninjected male.
,,	2	2.0-2.5	2.5-2.8	*L. rohita*	1	2	2.0	2.0 - 5.0	2	Eggs were fertilised.
,,	1	1.5-1.8	1.9	,,	1-	2	2.0	2.0 - 4.0	1	Eggs were fertilised.
,,	2	1.5-2.9	2.7-3.4	*C. catla*	2	2	1.0-1.5	2.0 + 3.0	Nil	
H. molitrix	4	3.0-4.6	6.0-6.1	*H. molitrix*	1	2	3.0	3.0 + 6.0	3	In all three cases eggs were fertilised.
	2	4.0-4.5	5.4-7.8	*L. rohita*	1	2	2.0 or 3.0	2.0 + 5.0 or 6.0	Nil	
	1	3.4-3 8	7.8	*H. molitrix*	3	3	0.5+2.0+1.0	2.0+5.0+3.0	Nil	
C. idellus	2	5.0-6.8	5.1-5.3	*L. rohita*	2	2	1.0+3.0	3.0 + 6.0	2	Eggs fertilized in both cases.
	4	4.0-4.9	5.2-6.5	*L. rohita* *C. idellus*	+2	3	3+1 & 2+ 2 & 1+1	2+5+5&3+ 6 + 4/6	nil	
	1	4.6	5.1	*L. rohita*	1	3	3.0	3 + 7 + 4	nil	

In ordinary pond water nine out of ten sets of *L. rohita* receiving one or two homoplastic injections at a total dose ranging from 2 to 3 mg/kg. for males and 2.0 to 7.0 mg/kg. for females responded positively, laying viable eggs which were fertilized and hatched. Equally good response was found in *C. catla* also where 40% of the specimens spawned as a result of a single low dose injection (Male: 1 to 2 mg/kg. Female: 2 mg/kg.). When two injections were required, dose for the female was increased to 6 or 7 mg/kg. In the case of *H. molitrix*, positive response was obtained in two injections to the female, though the total dose was higher than that required for catla or rohu. (Male: 3 mg/kg.; Female 9 mg/kg.). At similar doses grass carp also reacted positively, even though the glands injected were those of *L. rohita* (Male: 4 mg/kg.: Female: 9 mg/kg.). It is thus clear that the common species of Chinese carps grown in ponds, normally attain sexual maturity and breed in response to pituitary hormone injections, very much like the major Indian carps. With further experience it would certainly be possible to standardise the doses of injections required to ensure large scale production of fry and fingerlings of these valuable carps in ponds.

NOTE ON DEVELOPMENT

Hypophthalmichthys molitrix

On the 9th-11th; 12th-14th and 15th-17th July 1962 when silver carp spawned and the eggs were fertilized and hatched, the water temperature in the pond in which spawning and hatching took place ranged as follows:—

TABLE IX

Range of water temperature (°C) in the pond during the period when silver carp spawned

Hour	9/7	10/7	11/7	12/7	13/7	14/7	15/7	16/7	17/7
02.00									
04.00		28.9			28.9				
06.00		28.8						28.2	
08.00		29.5	29.1					28.6	28.5
10.00					29.9			28.8	
12.00					32.0			29.6	31.0
14.00			31.1					29.9	
16.00					32.2			29.0	
18.00					31.4				
20.00				29.2			29.0		
22.00	29.7								
24.00									

On all the three days (10th; 13th and 16th July) spawning commenced at 9-10 hours. Within half an hour after commencement of spawning the eggs were stripped and artificially fertilized. The freely oozing, viable eggs are pale bluish in colour. When fully swollen the colour of the egg, seen against a white background is more ashy grey than bluish. Within five minutes of mixing the eggs with milt, they started swelling; during the next half hour swelling was complete and almost all the eggs were uniformly swollen and measured as follows:

	Specimen 1	Specimen 2	Specimen 3
Outer diameter—	4.76 mm	4.62 mm	4.2 mm
Inner diameter— (egg proper)	1.28 mm	—	1.35 mm

After fertilization the progress of development was as follows:—

Age in hours	Stage of development
00.30	Egg fully swollen.
00.40	First cleavage; two blastomeres seen.
00.45	Second cleavage.

Age in hours	Stage of development
01.00	Third cleavage.
01.35	16, 32 and 64 cell stages seen.
07.00	Gastrulation over; embryo indicated.
09.00	Embryo better differentiated; optic cup distinct and clear at head end; 9-10 myotomes formed; tail portion not separate from yolk which is still spherical or slightly oblong.
18-20.00	Embryo hatches out.

Hatchling: Average measurements are as follows:

Total length	—	4.90 mm
Length of yolk sac.	—	3.33 mm
Max. height of body		1.25 mm
Max. height of yolk sac.		1.09 mm

Yolk sac is quite conspicuous; eyes are not pigmented and pectoral fin rudiments are yet to appear. There are 42-44 myotomes of which 14-16 are behind the anal level.

Pre-larval stages: Kept in laboratory trays and in hapas in the pond the hatchlings measured as follows:—

	Age after hatching				
	5hrs.	36hrs.		60hrs.	
	Hapa	Tray	Hapa	Tray	Hapa
Total length (mm)	5.41	6.73	6.92	6.98	7.53
Length of yolk mass (mm)	3.18	3.50	3.91	3.06	x
Max. height of body (mm)	1.01	1.07	0.84	1.06	1.21
Max. height of yolk mass (mml)	0.71	0.71	0.39	—	x

Kept in hapas in the pond, the yolk is fully absorbed by the end of the second day after hatching and the post-larva starts feeding from the environment. At this stage they were stocked in nursery ponds. The average measurements were:—

Total length — 7.42-7.53 mm
Height of body — 1.21 mm

Survival and production of fry:—

The approximate total number of spawn (i.e. two days old hatchlings) obtained from the three fish that bred are:-

Specimen 1. — 800 only
Specimen 1. — 5000 only
Specimen 3. — 50,000

A series of experiments on the growth of these fry as compared with the growth of similar fry of *C. catla* and *L. rohita* had been taken up and will be reported in detail later.

The fry from specimen 3 were stocked in two nursery ponds and their survival and growth during the first fortnight have been as follows:—

Pond No.	Area (acres)	Rate of stocking per acre	Rearing period	No. harvested	Survival%	Total length mm.		Av.wt. (g)
						Range	Average	
14	0.1	300,000	9 days	25000	83	19.0-24.0	22.1	0.0895
16	0.1	200,000	9 days	85 00	42.5	22.0-26.0	24.1	0.1038

After the initial thinning fry were left in the two ponds at the rate of 2,500 and 10,000 respectively per acre. A third nursery pond was stocked at the rate of 4000 per acre. Growth of these fry during the next 10 days has been as follows:

Pond No.	Rate of stocking per acre	Total length(mm).		Average weight (g.)
		Range	Average	
16	2500	41.0—68.0	60.6	2.33
3	4000	—	60.0	2.40
14	10000	32.0—57.0	48.3	1.30

Further observations on their growth and fattening in ponds are in progress.

***Ctenopharyngodon idellus*:**

By about 11 a.m. on 20-7-62 the injected female had started laying eggs. Within the next 20 minutes the freely oozing eggs were stripped and mixed with milt in clear dry trays. The progress of development from the time of stripping is given below:

The ovarian eggs are of a characteristic yellowish or deep golden brown colour. Water temperature at the time of stripping and fertilization was 30.3°C. The eggs soon started swelling uniformly and were fully swollen in about half an hour, measuring about 4.58 mm in outer diameter. The egg proper was 1.27 mm in diameter.

Age in Hours

00.40	First cleavage.
01.30	8-16 celled stages.
03.30	Morula-a cluster of cells as a cap over the yolk.
04.00	Gastrulation in progress.
06.00	Gastrulation over; yolk plug stage. In some, embryo indicated.
10.30	Embryo well-differentiated; movement not yet started; head and tail ends distinct; yolk mass elongated; embryo about 2.4 mm long with the yolk measuring 1.7 mm in length 23 myotomes seen clearly; auditory vesicles without concretions; Kupfer's vesicle just indicated; optic-cups distinct.
12.30	Embryo started distinct movement inside the egg membrane.
18.30	Embryo actively moving inside; egg membranes weak and crumbling.
19.00	Hatching commenced.
23.00	Hatching completed.

Approximately 428,000 eggs were stripped from the female and artificially fertilized. About 6 hours after fertilization when the embryo was clearly indicated a sample of 890 eggs showed 60% fertilization. Several of the embryos were, however, deformed and lagging behind in development as compared to normal ones. A second sampling about 8.5 hours after fertilization showed much lower percentage than the earlier sample. The eggs were distributed in hapas fixed in the pond for hatching.

***Hatchling*:**

Total length	— 4.5 mm
Length of yolk sac	— 2.84 mm
Maximum height of body	— 2.90 mm
Maximum height of yolk sac	— 0.78 mm

Yolk mass is conspicuous and of a pale brown colour. The two concretions in each of the auditory vesicles are of equal size. In the eye a small dark spot has started appearing ventro-medially. Blood corpuscles are not pigmented. Pectoral fin rudiments are absent. There are 45 myotomes, 14 of which are posterior to the anal level.

***One day old Hatchling*:**

Approximately 20 hrs. after hatching samples taken from the hapa in the pond measured as follows:-

Total length	5.86 — 6.05 mm
Length of yolk sac	2 47 — 2.75 mm
Maximum height of body	0.80 — 0 90 mm
Max. height of yolk sac	0.35 — 0.50 mm

The hatchling has grown appreciably; the eyes have become fully dark and the pectorals are functional. The yolk mass has still the characteristic pale yellow colour, particularly conspicuous against a white background.

Two days old hatchling :

Total length — 6.33 to 6.51 mm
Length of yolk sac — 2.66 to 2.84 mm
Maximum height of body — 0.92 to 0.95 mm
Maximum height of yolk sac — 0.33 mm

Portion of the yolk still remains to be absorbed. The mouth has been formed but no contents are visible in the gut. 8—10 Chromatophores have appeared on the dorsal aspect of the head. From the level of the air bladder backwards there is a continuous line of chromatophores reaching beyond the anal level. Dorsal part of the head has a light yellow background colour. Eyes are fully dark. The tip of the notochord is straight.

The third day after hatching the fry were stocked in a prepared nursery pond when they measured as follows :—

Total length — 6.98 mm
Maximum height of body — 0.99 mm

Survival of hatchlings in the *hapas* during the first two days was low and on the third day only about 5,000 fry could be obtained for stocking. These had the yolk fully absorbed and had started feeding on plankton. After 15 days of rearing, survival in the nursery pond was found to be only about 5 per cent; while during the same period in experimental jars, there was nearly 100 percent survival. In the pond, however, the fry had grown very rapidly as follows :—

Age in days after hatching	No. of days of pond rearing	Length at stocking (mm)	Size attained in 15 days length (mm)		
			Range	Average	weight
18	15	6.8—7.0	38.0—52.0	47.0	1.5

Detailed observations on their feeding habits and growth are on hand.

Attempts at Hybridisation :

Kuronuma (1954) reported crossing of *C. idellus* males with the female *Cyprinus carpio*, but the hatchlings obtained did not survive long. As mature specimens of *C. idellus*, *H. molitrix* and *A. nobilis* were available and as it was possible to get spawning specimens of Indian major carps by administering pituitary hormone injections, attempts were made to cross Chinese carps with Indian carps and vice versa. Selected specimens of *L. rohita* and *C. catla* were injected at the same time as the Chinese carps and as soon as they started laying eggs they were pressed out in trays and fertilized with milt from injected males of the required species. In this way positive results were obtained in the following crossings :—

Male		Female	Results obtained
C. idellus	x	*A. nobilis*	Embryos died before hatching.
C. idellus	x	*L. rohita*	Over a lakh of hatchlings produced; most died within a week. One survived for 2 weeks.
H. molitrix	x	*A. nobilis*	Embryos died before hatching.
H. molitrix	x	*L. rohita*	Repeated; nearly a lakh of hatchlings produced; most died within a week.
H. molitrix	x	*C. catla*	Hatchlings died on first day.
C. catla	x	*C. idellus*	Hatchlings died on first day.
L. rohita	x	*C. idellus*	Hatchlings died on first day.
C. catla	x	*H. molitrix*	Hatchlings died on first day.
C. catla	x	*A. nobilis*	Embryos died before hatchling.
L. rohita	x	*A. nobilis*	Embryos died before hatchling.

The successful fertilization of the eggs of Chinese carps with milt of Indian carps and the eggs of Indian carps with the milt of Chinese carps, resulting in the production of hatchlings in appreciable number is of considerable scientific interest. Though work during the 1962 season did not result in the production of fry or fingerlings in any of the above crossings, except a solitary instance of a *C. idellus* x *L. rohita* hybrid, it is clearly indicated that with greater attention it would be possible to successfully cross the desired species and produce hybrids of value.

Size of eggs and hatchlings obtained by crossing Indian carps and Chinese carps

Species crossed		Diameter of fully swollen eggs (mm)		Size of Hatchlings (mm)			
Males	Females	Inner	Outer	Total length	Length of yolk mass	Maximm height of body	Maximm height of yolk mass
C. *idellus*	x *A. nobilis*	1.64—1.93	6.17	Embryo did not hatch		out.	
H. molitrix	x *A. nobilis*	1.93—2.3	6.46	Embryo did not hatch		out.	
C. *catla*	x *A. nobilis*	1.93—2.3	5.5	Embryo did not hatch		out.	
L. rohita	x *A. nobilis*	—	6.56	Embryo did not hatch		out.	
C. *idellus*	x *L. rohita*	1.35	4.34	3.75—3.84	2.38—2.47	1.0	
H. molitrix	x *L. rohita*	4.25	—	3.86	2.6	1.00	0.77
H. molitrix	x C. *catla*	—	—	3.95	2.41	1.05	0.87
C. *idellus*	x C. *catla*	—	—	3.72	2.62	1.02	0.88
L. rohita	x C. *idellus*	—	—	5.21	2.96	1.12	0 95
C. *catla*	x C. *idellus*	—	—	4.82	2.80	0.96	0.86

DISCUSSIONS

The Chinese carps are extensively used for stocking in ponds because of their rapid growth and non-predacious habits. The grass carp, *C. idellus* has the additional advantage that it might check rank growth of weeds in ponds (Hickling, 1960, Alikunhi and Sukumaran, 1962). In their natural habitats in China, these fishes breed every year during the monsoon months and millions of fry are collected from the flooded river (Lin 1949). Lin has also shown that spawning fish from the river may be caught, the ova and milt stripped and eggs fertilized successfully. Though these fishes have been transported to various countries, the general belief, for a long time has been that though they may grow normally they will never spawn when stocked in waters other than those of their native habitat (Kuronuma, 1954). In recent years, however, all the species of Chinese carps were found to have established themselver in the Tone River system in Japan, where they are now breeding normally every year (Kuronuma, 54, 55, 58, Inaba et al, 1958 Suzuki et al, 1958). Following Lin (1949) the Japanese workers also collect the spawning fish from the river, press out the eggs and milt and artifically fecundate the eggs to raise quality fry on a limited scale.

Though the Chinese carps grow rapidly in ponds, they have never been observed to breed there and it was doubtful if they would develop gonads to maturity in ponds(Gidumal, 58; Kuronuma, 54). Tang (1954) reported gravid specimens of *H. molitrix* and *A. nobilis* from Taiwan; while Grass carps grown in ponds at the Malacca Institute attained ma-

turity at the end of two years (Rept. 1959). The first consignments of early fingerlings of silver carp and grass carp stocked at Cuttack in 1959 also attained sexual maturity by June-July 1961 (Alikunhi and Sukumaran, 1962). As has now been shown in the present paper the pond reared fish not only attain full maturity, but they also respond in the same way as the Indian carps to pituitary hormone injections.

In their natural habitats in China these fishes breed during April-July. In the Tone River in Japan they breed during June-July. Maturing and mature specimens of grass carp were available during June-July at Malacca (Institute Report 1960.) At Cuttack, maturing gonads were seen even as early as in March. Oozing males of silver carp and grass carp were common during April-May, while fully gravid females of silver carp were available by the end of May or early in June. Thus, outside their native habitats also, the breeding season of these carps appears to be the monsoon months, May-July. In this feature also they resemble the Indian carps.

Tang (1954) has described certain characteristic processes and ridges appearing on the pectoral fin rays in the males of *H. molitrix* and *A. nobilis*. According to him these are found even in the immature fish, growing larger with age and showing no seasonal changes. Such characteristic processes we have also noticed in the mature male specimens of *C. idellus* and *H. molitrix* at Cuttack. By feeling the pectoral fin with the fingers a distinct roughness can be easily felt in the males and this is a useful distinguishing feature for sexing breeders in the field. A similar feature of the mature males in Indian carps has been described by Chaudhuri (1959). We have, however, seen that this characteristic roughness of the pectoral fins in the mature or maturing males of grass carp and silver carp disappears after the breeding season and by October—November, the fins of both the male as well as the female feel alike and equally smooth to touch. This is the condition in Indian carps also.

The observations on breeding recorded in this paper clearly show that the Chinese carps are closely similar in habit to the Indian carps. The techniques of breeding adopted were essentially the same as those followed in the case of Indian carps. When adequate stocks of pituitary glands of different species of Chinese carps are made available the breeding techniques including proper dosages could be systematised. The fact that *C. idellus* responded positively to injections of *L. rohita* glands is of interest. The pituitary glands of mature specimens of silver carps are larger than those of grass carps of corresponding size. Mature males had distinct smaller glands than the females. Details of the weight of pituitary glands in 38 specimens of silver carps and 15 of grass carps are given below.

Species	Sex	Length (cm)	Wt. (Kg.)	Wt. of Pit. gland (mg)
H. molitrix	Male	59.5–71.0	2.6 –4.9	16.44
	Female	56.5–82.8	3.17–8.4	22.4
C. idellus	Male	67.9–86.0	4.1 –6.6	9.6
	Female	73.8–79.2	4.7 –7.0	10.9

In all the three species studied (*C. idellus, H. molitrix* and *A. nobilis*) the eggs are demersal and will settle at the bottom in still water, as in the case of Indian carps. Inaba et al (1957) described the colour, in life, of grass carp eggs as pale blue with slight tinge of yellow. We have, however, seen the eggs to be of a characteristic deep

brown or golden brown colour, In mature specimens the ovaries also appear dirty brown.

At 20°–26°C. in still water, grass carp and silver carp eggs hatched out within 36 to 50.5 hours after fertilization. In running water, with temperature ranging from 20° to 21.5°C., the incubation period was 29 to 73 hours. (Kuronuma, 1958, Suzuki et al,1958). At Cuttack, with water temperature in the ponds ranging from 28° to 33°C. the period of incubation was only about 20 hours for both the species. Under such conditions the size of eggs and hatchlings recorded from different places may be compared.

Species	Kuronuma '58	Inaba et al '58	at Cuttack
C. idellus–			
Developing egg	–	3.8–5.5 mm	4.58 mm
Hatchling	5.9 mm	5.1 mm	4.5 mm
H. molitrix–			
Developing egg	–	4.0–4.75 mm	4.2–4.76 mm
Hatchling	5.5 mm	5.33 mm	4.9 mm

Measured just after hatching, the young ones of both grass carp and silver carp appear slightly smaller at Cuttack than what is recorded in Japan. However, these hatchlings are appreciably bigger than the hatchlings and fry of *C. catla* or *L. rohita.*

Species	Length of hatchlings (mm)	Length of Post larva, at stocking, 2 days after hatching. (mm)
C. idellus	4.5	6.8
H. molitrix	4.9	7.42
C. catla	4.19	6 44
L. rohita	4.06	6.16

Stocked in nursery ponds the growth of fry has been very rapid. The extremely rapid growth of grass carp fry, from 6.88 mm to 38 to 52 mm. in the course of 15 days of pond rearing, averaging a daily increase in length of 2 to 3 mm at this early stage may be due to the relatively small number (2500 per acre) surviving in the pond. In the case of *H. molitrix* however, the survival was good. At a density of slightly over 2.5 lakhs per acre the fry grew from 7.4 mm to 19 to 24 mm in the course of 9 days of pond rearing, averaging a daily increment in length of 1.3 to 1.8 mm At 10,000 per acre 22.1 mm long fry attained an average length of 48.3 mm in the course of 10 days, averaging a daily increase in length of 2.62 mm Kuronuma (1958) records a length of 20 mm for grass carp and 14.5 mm for silver carps, 17 days after hatching. Inaba *et al* (1958) record juvenile specimens of grass carp and silver carp as follows:–

Grass carp –	21.3 mm	One month after hatching.
	36.7 mm	50 days after hatching.
	63.7 mm	55 days after hatching.
Silver carp –	23.7 mm	31 days after hatching.

35.8 mm 50 days after hatching.
51.3 mm 55 days after hatching.

Growth of fry under relatively warmer conditions at Cuttack appears to be definitely more rapid.

SUMMARY

1. Successful spawning of pond–reared specimens of three species of Chinese carps, *C. idellus*, *H. molitrix* and *A. nobilis*, carried out at Cuttack during June–July 1962 is recorded as the first instance of pond breeding of Chinese carps.

2. Two years old specimens, ranging in weight from 2 to 6 kg. attain sexual maturity in ponds. The ratio between total weight of fish and weight of ovaries varies from 3.4 to 7.0 : 1 in silver carp and 6.6 to 8.1 : 1 in grass carp.

3. Fecundity in these specimens averages at 792 ova per g. ovary weight in silver carp and 610 in grass carp. Number of ova per g. total weight averages at 171 for silver carp and 82 for grass carp.

4. Induced breeding techniques as developed for the major Indian carps were followed. Intramuscular injections of pituitary gland extracts in 0.3 % saline were administered; tha males always receiving a lower dose than the females.

5. Positive response was obtained in homoplastic injections as well as in injections of pituitary gland extracts from Indian carps. Viable eggs which were fertilized and hatched were obtained from 3 sets of silver carp, 2 sets of grass carp and one of bighead.

6. Response of *C. idellus*, *H. molitrix* and *A. nobilis* to pituitary hormone injections has been demonstrated to be closely similar to that of *C. catla* and *L. rohita*, selected specimens which were also induced to breed under the same conditions as the former.

7. Successful spawning took place in 2 or 3 injections within a period of 18-24 hours. The spawning fish were stripped and the eggs artificially fertilized by mixing with milt.

8. Incubation period in the case of *C. idellus* and *H. molitrix* was found to be about 20 hours at water temperature ranging from 28 °to 33 °C.

9. The hatchlings of both the species were found to be appreciably bigger than those of *C. catla* and *L. rohita*. A total number of 55,800 fry of *H. molitrix* and 5000 fry of *C. idellus* were stocked in ponds, 2 days after hatching.

10. Survival of fry during the first fortnight ranged from 42.5 to 83% in *H. molitrix* and 5% in *C. idellus*.

11. Early growth of fry in the pond has been very rapid. 23 days after hatching (20 days in pond) the maximum length attained by *H. molitrix* is 68.0 mm. Fry of *C. idellus*, in 15 days of pond rearing attained a maximum length of 52.0 mm.

12. Partially successful attempts at hybridising males and females of *C. catla* and L. rohita, with females and males of *C. idellus*, *H. molitrix* and *A. nobilis* have been carried out. In 10 such cross breedings, hatchlings were produced in varying number but none survived over a week.

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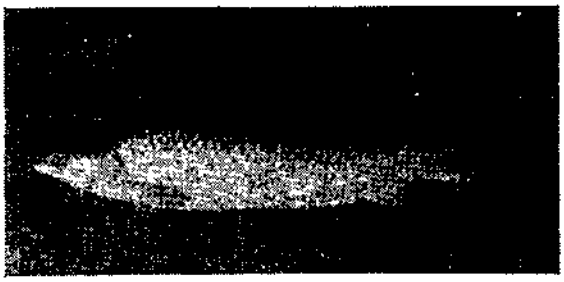
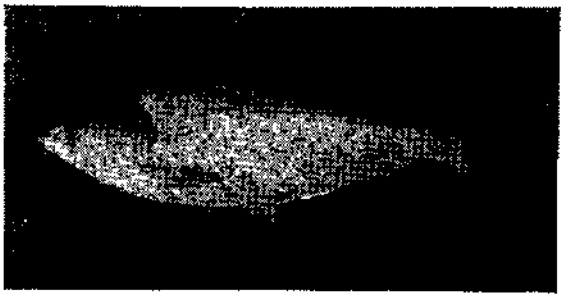


The Grass carp, *Ctenopharyngodon idellus* (C. & V.)

The Big head, *Aristichthys nobilis* (Richardson)



The Silver carp, *Hypophthalmichthys molitrix* (C. & V.)

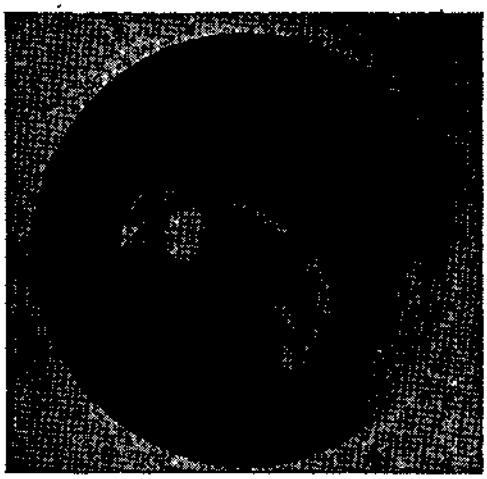
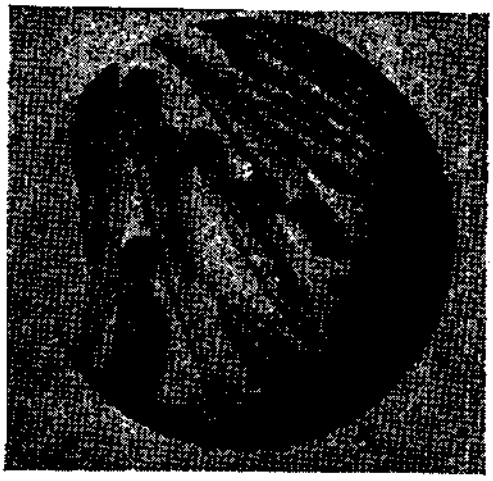
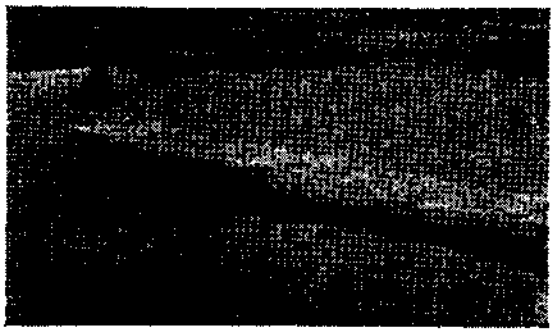


Photo-micrograph of a developing egg of Grass carp, 10.5 hours after fertilization.



Photomicrograph of hatchlings of Silver carp, 24 hours after hatching.

A haul of breeders of Silver carp, *H. molitrix*, for sexing and selection.



Breeding hapas, 12 ft x 6 ft x 3 ft, fixed in a pond. Injected breeders are inside the hapas. Sample of eggs laid is being taken for examination.

Administering pituitary hormone injection to a male Silver carp breeder.

Developing eggs being released in hatching hapas fixed in a pond. Inner hapa is made of round mesh, mosquito netting cloth.