pared to KII × AdeC. Hybrid No. 2 was only superior to the Golden Bantam parent. In grain yield, Hybrid No. 1 outyielded all the four parents, while Hybrid No. 2 gave significantly more yield than the two sweet maize parents. It will also be seen that Hybrid No. 1 was significantly better than the other entries. Moreover, it possessed one to two well-developed ears per plant which made very attractive roasted or boiled ears.

A test conducted for taste and sweetness placed the two hybrids at the top of the list. Another important character of the hybrids was their right maturity ; they flowered at the same time as the local variety, KT 41 and Stowell's Evergreen. Research is in progress to find out the range of adaptation of these hybrids in the country.

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

K. H. ALIKUNHI, K. K. SUKUMARAN AND S. PARAMESWARAN

Central Inland Fisheries Research Substation, Cuttack

Introduction.—The cultivated species of Indian carps (*Catla catla, Labeo rohita, Cirrhina mrigala*) and Chinese carps (*Ctenopharyngodon idellus, Hypophthalmichthys molitrix, Aristichthys nobilis ; Mylopharyngodon piceus*) are riverine species which normally breed only in flooded rivers during the monsoon months, May to July. They grow rapidly and attain sexual maturity in ponds but do not breed. Young ones required for stocking are therefore collected every year from natural sources. These collections are always fluctuating in quantity as well as quality and hence are often undependable. The need for a dependable method of pond breeding of these carps ensuring production and supply of quality fish seed has therefore been keenly felt in South-East Asia where these fishes are extensively cultivated.

Since 1957 a successful method of inducing the Indian carps (*C. catla, L. rohita, C. mrigala* and others) to breed in ponds in response to pituitary hormone injections has been developed in India and millions of fry of these fast-growing carps are now being produced every year by this method.[2,4,7,8,9,16] Though attempts have been made to breed the Chinese carps also in ponds by adopting similar techniques, they have not so far responded positively to the treatment.[5,12,17]

Chinese Carp in India.—With a view to find out the possibilities of utilising the Grass carp, *C. idellus*, for controlling rank growth of weeds in fish ponds and enriching the indigenous stock of cultivable species of fishes with fast-growing exotic forms experimental consignments of *H. molitrix* and *C. idellus* were introduced into India for the first time in 1959.[3] Within the next two years these fishes attained sexual maturity in ponds at Cuttack. During July 1962 experiments on inducing Grass carp and Silver carp to breed in ponds were successfully carried out. Three sets of Silver carps, two sets of Grass carps and a female Bighead yielded viable eggs after receiving pituitary injections. These eggs were fertilized and hatched and the young ones reared in ponds. This, to our knowledge, being the first successful instance of pond breeding of a Chinese carp, a brief resume of our observations is given in this contribution.

Size Attained.—Three years old, mature specimens of these carps ranged in size as shown in Table I.

TABLE I

Specimens	Sex	Length (cm.)	Weight (Kg.)
C. idellus ..	Male	75·2–86·0	4·54–6·61
	Female	73·8–79·2	4·76–7·03
H. molitrix ..	Male	62·5–71·0	2·80–4·96
	Female	63·5–81·2	4·99–7·49
A. nobilis ..	Female	67·2–70·3	4·76–6·00

***Breeding Techniques.*—Mature males of Silver carp and Grass carp were easily distinguished in the field by the marked roughness of the outer surface of the pectoral fins.[15] Freely**

oozing males and fully gravid females were selected for injection, usually late in the evening or at night when weather was generally cool with light showers. Pituitary glands for injection were collected from mature fish and were preserved in absolute alcohol. These were extracted in 0·3% saline at the time of injection and the concentration of the extract ranged from 10 to 40 mg. per c.c. The dose to be injected was calculated in mg. per Kg. weight of the breeder ; the males always receiving a lower dose than the females. Injections were administered intra-muscularly. Injected fish were released in cloth *hapas* fixed in ponds. Water was stagnant and had the following physico-chemical qualities :

Temperature : 28·2–34° C. ; pH : 8·4–8·8 ; Dissolved Oxygen : 5·37–8·88 p.p.m. ; Free CO_2 : nil ; Total alkalinity : 102–132 p.p.m.

Injection.—Successful doses of injection administered are as in Table II.

6 to 8 hours after the second injection to the female. The breeding hapas were periodically examined and as soon as the female started spawning, it was taken out and the oozing eggs were stripped in clean dry enamel trays and immediately mixed with milt pressed out from the injected male. The fertilised eggs were hatched in hapas fixed in the pond.

Stages of Development.—The fertilised, fully swollen egg measured 1·28 to 1·35/4·2 to 4·76 mm. in diameter in *H. molitrix* and 1·27/4·58 mm. in *C. idellus*. At water temperature ranging from 28 to 31° C. the period of incubation was 18 to 20 hours in both the species. The hatchlings were 4·5 mm. long in *C. idellus* and 4·9 mm. in *H. molitrix*.

Nursing Fry.—Two days after hatching the yolk was fully absorbed and the post-larva started feeding from the environment. At this stage (average length : *H. molitrix* — 7·42 mm. ;

TABLE II

No.	Date	Hour	Weight of breeders (Kg.) Male	Weight of breeders (Kg.) Female	Donor fish of pituitary gland		Dose administered (Mg./Kg.) Male 1st	Male 2nd	Female 1st	Female 2nd	Female 3rd
Hypophthalmichthys molitrix:											
1	9-7-1962	22·00	3·0, 3·9	6·0	*H. molitrix*		..	..	3·0	..	..
	10-7-1962	05·30	..	..	,,	(1)	3·0	..	..	6·0	..
						(2)	4·0	..	..	..	..
2	12-7-1962	20·30	4·6	6·1	,,		..	..	3·0	..	..
	13-7-1962	03·30	..	..	,,		3·0	..	..	6·0	..
3	15-7-1962	21·00	4·3, 4·5	6·0	,,		..	..	3·0	..	..
	16-7-1962	04·00	..	..	,,		3·0	..	..	6·0	..
Ctenopharyngodon idellus :											
1	19-7-1962	21·50	5·3	6·8	*L. rohita*		1·0	..	3·0	..	..
	20-7-1962	04·45	..	..	,,		..	3·0	..	6·0	.
2	19-7-1962	22·10	5·1	5·0	,,		1·0	..	3·0	..	..
	20-7-1962	04·55	..	..	,,		..	3·0	..	6·0	..
Aristichthys nobilis:											
1	21-6-1962	16·00	Silver carp males	6·0	*L. rohita*		..	..	2·0	..	..
	21-6-1962	22·00	,,	..	,,		3·0	..	..	5·0	..
	22-6-1962	08·30	..	..	..		..	1·0	..	..	5·0

Spawning.—Homoplastic injections as well as injections of pituitary glands collected from Indian carps were administered with success. Thus, while Silver carp females responded to two doses of homoplastic injections amounting to 9 mg. per Kg. weight of the fish, identical doses of Rohu pituitary gland gave similar positive results in Grass carp. The female Bighead required a higher dose to yield viable eggs. Spawning commenced ordinarily about

C. idellus — 6·8 mm.) they were released in prepared nursery ponds where the natural food was supplemented by daily artificial feeding with oilcake powder and sieved rice bran.

55,000 fry of *H. molitrix* and 5,000 of *C. idellus* were stocked in three nursery ponds. During the first 15 days of pond rearing survival and growth of fry ranged as shown in Table III.

Thinned out into other nurseries and rearing ponds the fry are rapidly growing and experi-

ments on their growth as compared with that of Indian carps are in progress.

TABLE III

Species	Stocking No. per acre	Rearing period (days)	Percentage of survival	Size attained	
				Length (mm.)	Average wt. (g.)
H. molitrix	3,00,000	9	83·0	19·0–24·0 (22·1)	0·0695
„	2,00,000	9	42·5	22·0–26·0 (24·1)	0·1038
C. idellus	50,000	15	5·0	38·0–52·0 (47·0)	1·50

Hybridization.—With the successful breeding of Indian carps by pituitary hormone injections it has been possible to hybridize selected species and produce hybrids with a view to obtaining fish of better cultural qualities.[1,6] In view of their fast growth and other desirable cultural qualities attempts were made to hybridize the Chinese carps with Indian carps and *vice versa*. By injecting gravid specimens of *C. catla* and *L. rohita* simultaneously with *H. molitrix*, *C. idellus* and *A. nobilis* the intergeneric crosses were carried out with partial success as shown in Table IV.

TABLE IV

Male	Female	Result obtained
C. idellus	× *A. nobilis*	Embryos died before hatching
C. idellus	× *L. rohita*	Over 1,00,000 hatchlings produced. Most of them died within a week; one survived for two weeks
H. molitrix	× *A. nobilis*	Embryos died before hatching
H. molitrix	× *L. rohita*	About 1,00,000 hatchlings produced; all died within a week
H. molitrix	× *C. catla*	Hatchlings died on first day
C. catla	× *C. idellus*	,,
C. catla	× *H. molitrix*	,,
C. catla	× *A. nobilis*	Embryos died before hatching
L. rohita	× *C. idellus*	Hatchlings died on first day
L. rohita	× *A. nobilis*	Embryos died before hatching

Though production of fry or fingerlings could not be achieved during 1962 by the above crosses, the results obtained clearly indicate that it may be possible to produce hybrids of value as we obtain greater experience in the pond breeding of Chinese carps.

Discussion.—Pond breeding of fast-growing, large, riverine carps which ordinarily breed only in rivers is an important step in developing fish culture. Methods of successful pond breeding of Indian carps have been developed recently; while the Chinese carps, even though of similar habits, have not been responding to inducements to pond breeding.

Kuronuma[13] mentioned the 'absolute sterility' of Chinese carps in ponds in Japan and Kawamoto's experiments on Grass carp by administering hydrosol of androsteron and enteron mixed with the diet resulted in the maturity of only males in ponds. It may be inferred from Tang[15] that in ponds in Taiwan specimens of *H. molitrix* and *A. nobilis* with fairly well-developed ovaries are found, even though these species do not propagate in that country. According to Yashouv Grass carps attain sexual maturity in ponds in Israel but experiments to induce the species to spawn by injections of carp hypophysis, Pregnil, Gestyl and Yochimbin did not succeed. Russian workers also believe that Grass carp attains sexual maturity in ponds.[17] Experiments at the Tropical Fish Culture Research Institute at Malacca have shown that 2-3 years old specimens of Grass carp mature in the Institute's ponds but continued attempts to induce them to breed by simulating natural conditions by flooding and by injections of Grass carp and Tilapia pituitary glands, Armour ACTH, Cortisone acetate and Actocortin have not met with success.[5] Our own observations now confirm that the common species of Chinese carps like Grass carp, Silver carp and the Bighead attain sexual maturity in ponds, and like the Indian carps, can be induced to breed by administering pituitary hormone injections.

In the Tone river in Japan the Chinese carps spawn when the water temperature ranges from 17·6 to 22° C. in June-July. pH of the water was then only 6·9.[14] Inaba *et al.*[11] record the monthly average temperature in the Tone river as ranging from 5·0° C. in January to 27·7° C. in July. At the Malacca Institute ponds where Grass carp has attained sexual maturity in 2-3 years the water temperature shows a diurnal variation from 28 to 31° C. with the average at about 29·5° C.[10] pH of these waters is reported to be low. The pond waters are distinctly alkaline at Cuttack, where the monthly average temperature in ponds ranged as shown in Table V.

Average water temperature (°C.) *in a pond at the Killa farm, Cuttack, during 1961-62*

	Jan.	Feb.	Mar.	Apr.	May	June
Average temperature °C. at 12·00 hours	26·6	27·1	33·3	33·6	34·6	31·0
	July	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Average temperature °C. at 12·00 hours	31·3	31·8	31·6	31·9	29·2	25·7

During December-January, water temperature at 6·00 hours would be about 20° C. The maximum water temperature of 39·5° C. is recorded in May. During June-July the averdge temperature ranges from 25·4 to 33·4° C. It is thus seen that the Chinese carps attain sexual maturity in waters with a wide range of temperature and if the proper dose of hormones are injected could be induced to spawn.

The feasibility of successful hybridisation of Chinese carps with Indian carps and *vice versa* demonstrated in this paper indicates that hybrids of selected desirable qualities could probably be produced in numbers during the ensuing seasons.

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THE H-ALPHA LINE IN THE SOLAR FLARE OF NOVEMBER 12, 1960

THE solar flare, of magnitude 3 +, which occurred on November 12, 1960, gave rise to a series of remarkable solar and associated geophysical events, which have been reported in scientific journals by various observers and study groups. In addition to extensive ionospheric and geomagnetic activities which accompanied the flare, there was also the intense increase in the ground-level solar cosmic ray component which followed within a few minutes after the start of the flare. The flare began at $13^h\ 23^m$ U.T. and ended at $18^h\ 30^m$.

The increase in the ground-level cosmic ray intensity has been interpreted in terms of injection of particles into a "magnetic bottle", which, at the time of the flare, extended from the sun into the immediate vicinity of the earth. This interpretation suggests that the geophysical events subsequent to the flare of November 12, 1960, may have been due only to a fortuitous configuration of magnetic fields in the inner solar system which existed prior to the flare, and not to some special properties of the flare itself. It will therefore be of interest to examine the H-alpha spectra of the flare and to make a comparison of the results with observations of other great flares.

Such a comparison has been made on the H-alpha spectra taken at the McMath-Hulbert Observatory, University of Michigan, and the results are reported by Richard G. Teske in the *Astrophysical Journal*, 1962, 136, 534. During the progress of the flare which lasted for about 2×10^4 seconds, spectra of the H-alpha line were recorded with the vacuum spectrograph of the Observatory, on Super Panchromatic Process emulsion, at a dispersion of 6·0 mm./Å. Exposure times were 90 seconds.

The observed intensity in H-alpha during the premaximum phase and after flare maximum was comparable with, or less than, that generally observed in importance 3 + flares. The data do not show that the flare of November 12, 1960, departed in anyway from values of H-alpha width and central intensity, excitation temperature, optical thickness, and rate of radiation in the H-alpha line, that have already been obtained by others of importance 3 + flares.

Material recovered from the artificial satellite, EXPLORER XVII, which was exposed while in circumterrestrial orbit to bombardment by particles from the November 12 flare was found to contain a high concentration of tritium (reported 1961), which was attributed as having emanated from the flare itself. Search in the spectrogrum for deuterium, which is also a product of the tritium producing process, showed no evidence of deuterium.—(*Astrophy. Jour.*, 1962, 136, 534.)