Induced Spawning of the two Phytophagous Chinese Carp Species *Ctenopharyngodon idella* (Val.) and *Hypopthalmichthys molitrix* (Val.) with reference to the possible use of the Grass Carp in the control of Aquatic Weeds

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Abstract

The two phytophagous Chinese carp species *Ctenopharyngodon idella* (Val.) and *Hypopthalmichthys molitrix* (Val.) were spawned artificially through the use of a combination of human chorionic gonadotrophin (HCG) and pituitary gland extract (PGE). It was found that an initial injection of low dosage of HCG, followed after twenty four hours by a set of two main dosages, approximately 7 hours apart, of which the first consists of HCG and the last of PGE, provides successful spawning in both species of Chinese carp. Hatching of larvae in both species took place within 24 hours after fertilization. The possible use of phytophagous fish species to control noxious aquatic weeds in rivers and impoundments is discussed.

Introduction

The disposal into streams of sewage and industrial effluents rich in plant and algal growth nutrients such as phosphates and nitrates, has already resulted in the serious eutrophication of several South African rivers and impoundments (Steÿn, *et al.* 1975 a,b; 1976 a,b). Algal blooms and the excessive growths of certain noxious aquatic weeds in some reservoirs now pose a threat to the effective management of such water bodies and considerable expense is required to rid impoundments like the Hartbeespoort dam for example, from the water hyacinth *Eichhornia crassipes* (Mart.) Solms through the application of herbicides.

Although investigations have been carried out in other countries on the possible biological control of certain water weeds by using natural enemies (Bennet & Zwolfer, 1960; Spencer, 1974; Cordo & De Loach, 1975), little has been done in this field in South Africa. At present it is known that the Cichlid *Sarotherodon mossambicus* (Peters) is largely an algal feeder (Du Plessis & Groenewald, 1953) and also that aquatic vegetation forms a sizable proportion of the diet of *Tilapia rendalli* (Boulenger), especially amongst fish larger than 10 cm in length (Potgieter, 1974). However, it does not appear as if *S. mossambicus* is able to utilize phytoplankton efficiently. *T. rendalli,* not being able to tolerate water temperatures below 12—14°C (Schoonbee, personal observations), cannot survive the winter climate in areas of the Transvaal where the submerged aquatic weeds *Potamogeton pectinatus L., Lagarosiphon muscoides* Harv. and *L. major* (Ridley Moss ex Wager), which are readily utilized by this fish species, form dense growths in the littoral regions of several of the larger impoundments used for recreational purposes (Brandt, 1975). In fact none of our indigenous fish species appear to be able to utilize effectively, let alone contain, the excessive algal blooms and growths of submerged and floating aquatic weeds in rivers and impoundments where they develop (Kruger & Brandt, 1975).

As a result of this situation it was decided to import the two Chinese phytophagous carp species, *Ctenopharyngodon idella* (Val.), known as the grass carp or White Amur, and the silver carp, *Hypopthalmichthys molitrix* (Val.). These species are known for their ability to utilize water weeds and phytoplankton very effectively as food (Konradt, 1968; Sneed, 1971). However, before the grass carp is released into local impoundments infested by aquatic weeds, more basic information will be

required on its role in freshwater ecosystems in South Africa and on its ability to control certain noxious aquatic weeds. Although the silver carp was imported primarily for its use by fish farmers in polyculture, its highly specific phytoplankton diet merits further research into its ability to control conditions in reservoirs where excessive algal blooms occur.

Since both fish species normally do not spawn naturally outside their native range in the Amur river basin of mainland China and Russia (Lin, 1965), it was necessary to make use of induced spawning techniques to obtain enough offspring for the planned experiments. In this paper results of the induced spawning trials undertaken on both species at the Fisheries Research Station at Marble Hall, Transvaal, are presented.

History of parent stock imported as fry and young fish

In March 1975 a limited number of silver carp fingerlings was introduced from the fish farm of the Kibbutz Gan Shmuel at Hadera in Israel. The initial mass of the silver carp fingerlings upon arrival at Marble Hall varied between 2 and 3 g. They were transferred to 0,2 ha earthen ponds filled with canal water from the Loskop Dam irrigation scheme. To encourage development of phytoplankton in the ponds, a mixture of 1:1 superphosphate and chicken manure was applied at a rate of 100 kg/ha/week.

Records of growth showed the silver carp to average 1 200 g in mass in February 1976, more than 2 000 g in September of the same year, whilst some of the fish already weighed 3 000 g in January 1977, less than two years after they arrived as fingerlings at the Research Station. At this stage it was already possible to distinguish between the sexes by the appearance of a spiny texture on the pectoral fins of the males.

Two size groups of young grass carp of Hungarian stock were obtained from West Germany during March 1975: 30 of 150 g, and 300 of approximately 20 g in mass. In one and a half years (September 1976) fish of the smaller size group increased in mass to average 740 g, whilst the larger fish exceeded 2 000 g in mass. By June 1977 the younger fish had attained an average mass of 2 000 g and the larger specimens 4 000 g. By September 1977 milting of the males was observed for the first time even though secondary sexual characteristics of mature fish, like development of spines on the pectoral fins, were still absent.

On their arrival from Europe, the grass carp were immediately placed in ponds overgrown with wild rice, *Leersia hexandra* Sw. The fish were periodically transferred to new ponds with fresh growths of wild rice. Additional food included Kikuyu grass, *Pennisetum clandestinum* Hochst. ex Chiov., *Lagarosiphon* spp. as well as young shoots of *Typha* and *Cyperus* spp. Due to the general lack of aquatic growth in the ponds in winter, they were also fed on 25% protein carp pellets during the colder months of the year. Observations showed that this species distinctly prefers succulent growths of vegetation.

The Fisheries Research Station at Marble Hall

The Marble Hall Fisheries Research Station lies within the area of confluence of the Elands and Olifants River Basins, at an altitude of 823 m a.s.l. It is situated approximately 200 km N.E. of Pretoria (latitude 25°S, longitude 29° 15'E). The climate of Marble Hall is of a subtropical nature. Rainfall occurs during the warmer months of the year, from September to May, with a maximum precipitation between December and February. Water temperatures recorded in fish ponds at the Research Station for the period 1975—1977 showed winter minimum values to be not less than 11°C whilst summer maxima exceeded 29°C (Table 1).

TABLE 1
WATER TEMPERATURES RECORDED AT THE MARBLE HALL FISH PONDS BETWEEN 1975 AND 1977 IN °C

Season	1975		1976		1977	
	max.	min.	max.	min.	max.	min.
Winter average	18,4	12,6	16,1	11,3	16,8	12,1
Summer average	29,4	24,7	30,0	23,3	29,6	25,0

Chemical quality of the pond water

Some physical and chemical analyses made during October 1977 of canal water which feeds into the fish ponds and which was also used for the incubation of the eggs of fish during the spawning experiments, showed the water to be alkaline (pH 7,5) and moderately rich in mineral content with a conductivity exceeding 20 mS/m. The total hardness of the water (expressed as $CaCO_3$) was 75 mg/*l* with an alkalinity (as $CaCO_3$) of 50 mg/*l*. Fluoride in the water, being 0,5 mg/*l*, was below the levels laid down by the S.A.B.S. (1971) for drinking water criteria in South Africa (Hattingh & Nupen, 1976).

Hatchery Procedures

As mentioned, unadulterated canal water was used for the holding tanks of the spawners as well as for the fish egg breeding funnels. Water was first passed through a sand filter to a water tower from where the water was fed by gravitation to the hatchery. Compressed air was used to aerate the tanks.

P.V.C. plastic tanks of 500 and 1 000*l* capacity were used, at first to keep the spawners in and later to receive larvae from the breeding funnels. Water was passed through the tanks at an approximate rate of 500*l*/h. The tanks were covered with a fine 20 mm mesh fishing net which was properly secured to hooks around the perimeter of the tanks. This step was necessary due to the behaviour of especially the males of both species, which attempted to jump out of the tanks. In order to avoid unnecessary stress on the fish, jute blanketing was used to obscure the fish from movements in the hatchery.

Selection of spawners

Spawners of both species were selected at the ponds on the basis of the softness and bulging of the bellies of the females, which

Figure 1
Weighing (1A), measuring and determination of body girth (1B) of the grass carp ***Ctenopharyngodon idella.*** *Note woollen strand tag around caudal peduncle of fish*

were taken as signs of the ripeness of the female gonads. Males were tested for milting. Fish were then transported to the hatchery, weighed, measured and each provided with a colour tag of woollen string secured around the caudal peduncle so that each fish could easily be distinguished from other fish in the same tank (Fig. 1). Not more than 4 females were kept per 1 000 *l* tank. Males were kept separately and in larger numbers than the females.

An attempt was also made to determine the belly sizes of females before each injection of hormones so that the swelling of the gonads could be followed. This so-called belly index determination (Schoonbee *et al.*, 1978) did not succeed as the females of both species spawned sooner than anticipated. It is, nevertheless, suggested that such a system be developed at hatcheries in South Africa in order to monitor the effects of pituitary gland extract or of hormones on fish used in spawning experiments.

Disinfection of fish and prophylactic treatment of larvae

Prior to spawning, fish were disinfected in the holding tanks on three separate occasions for periods of two hours each with 25 mg/*l* commercial Formalin (40%). A prophylactic treatment of the larvae in the holding tanks consisted of 2-hourly dosages of 25 p.p.m. Formalin and 0,05 mg/*l* of Malachite Green (Leteux & Meyer, 1972). This treatment was repeated for two consecutive days, interrupted for two days and again done for two days before the fry left the hatchery.

The disinfection of the male and female spawners prior to spawning is of the utmost importance as the transfer of parasites to the fry from the parent stock may lead to heavy mortalities amongst the fry, which can be concentrated in numbers as high as 500 000 fry per 1 000 *l* tank.

Injection Program

There are several important differences in environmental conditions of fish in the Transvaal and certain other areas of the world where the Chinese grass and silver carp were successfully spawned in the past. In contrast with Israel, where induced spawning of fish is a common practice, local conditions differ in the following ways:

1. Fish are spawned here during the wet, summer season of the year whereas the summer season in the Mediterrean area, in which Israel falls, is dry.

2. At the Marble Hall Fisheries Research Station good quality water, relatively low in mineral content and also suitable for domestic and agriculture purposes, is used in contrast to Israel where the water used is largely saline and as a rule not fit for use in agriculture.

According to Tang (1960), Tang *et al.* (1964) and Lin (1965), the natural spawning of both the silver and grass carp

coincides with summer rains. It therefore appears as if conditions at Marble Hall are more favourable for the spawning of these species than those in Israel.

In the present study the aim was mainly to determine the efficacy of pituitary gland extracts (PGE) of the common carp, *Cyprinus carpio* L. against and in combination with human chorionic gonadotrophin (HCG) sold under the trade name of Pregnyl. One major reason why HCG was preferred was because of its Follicle Stimulating Hormone (FSH) characteristics (Pickford & Atz, 1957). For the purpose of this investigation one thousand I.U. of HCG was considered equivalent in potency to a pituitary gland of a 1 000 g female common carp donor, collected at the onset of the spawning season (Schoonbee *et al.*, 1978). All pituitary glands used were collected from female donor common carp of approximately 1 000 g in mass. HCG was dissolved in 0,8% physiological saline. Alcohol preserved pituitary glands were dried and homogenised in a glass homogeniser specially adapted for pituitary gland material. As for the HCG preparations, the PGE was also dissolved in 0,8% saline for the purpose of injection. Care was taken not to exceed 2 m*l* in volume of dosage per fish. Dosage application was made with a syringe and injected intramuscularly at the base of the dorsal fin of fish of both species (Fig. 2).

According to available literature on induced spawning of grass and silver carp, the number of injections of hormones and/or PGE normally vary from one (Wu & Chung, 1964; Konradt, 1968) to two (Lin, 1965; Konradt, 1966; Vinogradov, 1968; Singh, 1969) or even three injections (Lin, 1974; Schoonbee *et al.*, 1978) but usually not more. The main reason is that fish condition usually deteriorates so much with repeated injections that spawning may be jeopardized (Lin, 1965).

The first phase of the experiment was done with silver carp. A total of 4 females and 6 males were used (Table 2). In the case of the grass carp, 6 females and 7 males were selected (Table 3).

Females of both species were given an initial (starter) injection of comparatively low dosage at least 24 hours prior to the actual injection program, which consists of two fractions. At the time of injection of the first main fraction to the females, the males of both species received one injection of pituitary gland extract only and at a lower dosage than the females (Tables 2 and 3). This was done to facilitate the release of the milt. In the case of the silver carp the starter injection constituted either 0,5 of a pituitary gland or 500 I.U. of HCG per female spawner. This was followed on the second day by a set of two fractional injections, the first of which consisted of either 0,33 pituitary

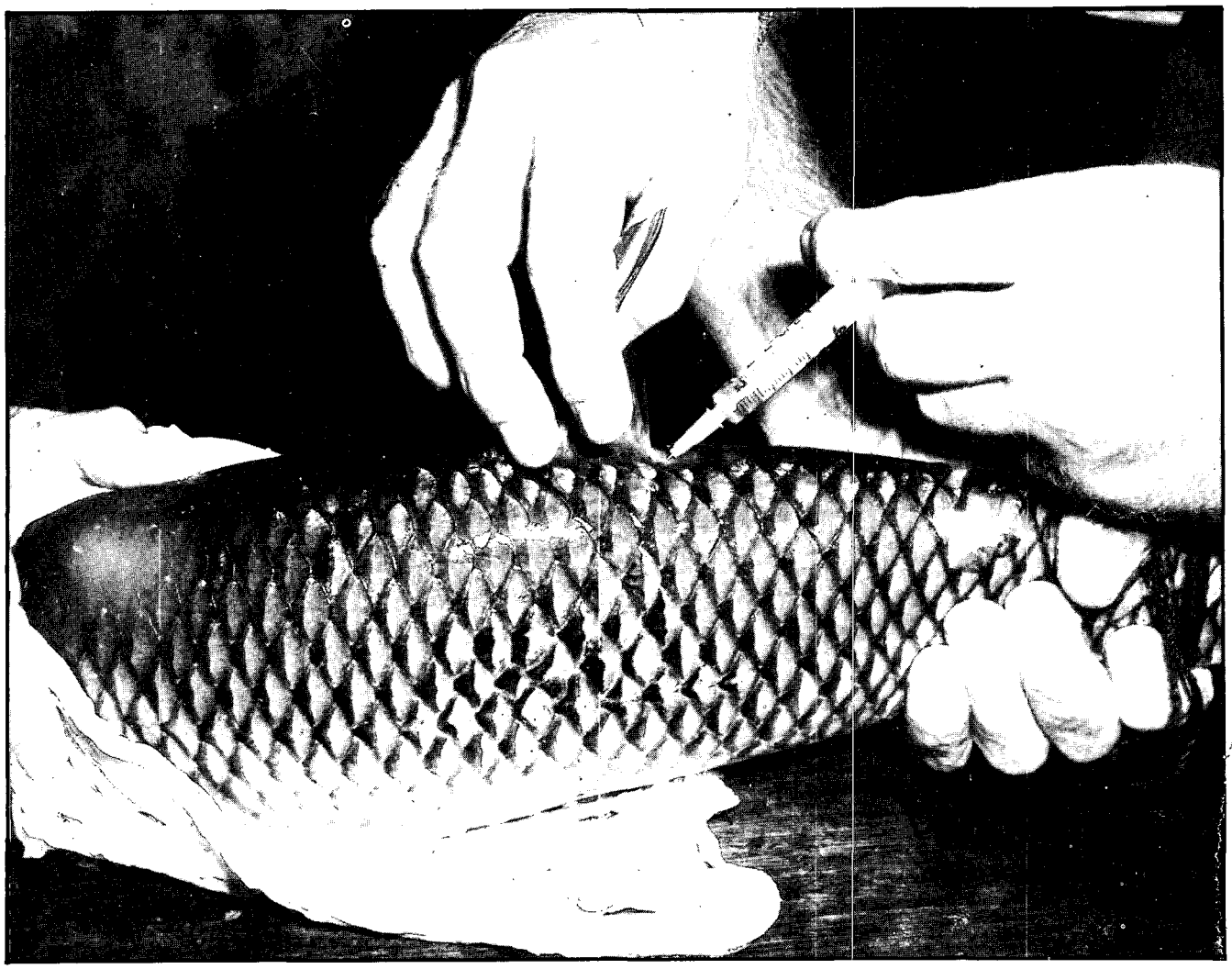

Figure 2
Intramuscular injection of HCG and PGE dosages applied by syringe at base of dorsal fin

TABLE 2
RESPONSE OF SILVER CARP TO A COMBINATION OF TREATMENTS WITH HCG AND PGE DURING THE EARLY SUMMER PERIOD OF 21—23 OCTOBER 1977

Tank No.	Sex	Fork length (cm)	Body mass (g)	HCG/pituitary gland injection time and dosage program day 1	day 2		Spawning results obtained
	F	62,5	4 000	10h00 0,5 gland/fish	14h30 0,33 gland/1 000 g	21h30 0,67 gland/1 000 g	Jumped out of tank at 22h30 on day 2. Due to fall discarded for experiment.
1							
	F	60,0	3 500	10h00 500 I.U. HCG/fish	14h30 330 I.U. HCG/ 1 000 g	21h30 0,67 gland/1 000 g	Complete spawn at 06h30 on day 3. 500 ml eggs obtained
	F	61,5	3 500	10h00 500 I.U. HCG/fish	14h30 0,33 gland/1 000 g	21h30 0,67 gland/1 000 g	Complete spawn at 23h00 on day 2. 1 000 ml eggs obtained
2							
	F	60,0	3 500	10h00 0,5 gland/fish	14h00 330 I.U. HCG/ 1 000 g	21h30 0,67 gland/1 000 g	Complete spawn at 23h00 on day 2. 400 ml eggs obtained
	M	60,0	2 750		14h30		
3	M	56,0	2 500		ALL MALES RECEIVED 1 GLAND PER FISH IRRESPECTIVE OF BODY MASS		DISTINCT THINNING RESPONSE OF SPERM OBSERVED IN THE CASE OF ALL MALES AS A RESULT OF INJECTION WITH PITUITARY GLAND
	M	56,0	3 000				
	M	58,0	3 000				
4	M	57,0	2 500				
	M	58,0	2 500				

TABLE 3
RESPONSE OF GRASS CARP TO A COMBINATION OF TREATMENTS WITH HCG AND PGE DURING THE SUMMER PERIOD OF 1—3 NOVEMBER 1977

Tank No.	Sex	Fork length (cm)	Body mass (g)	HCG/pituitary gland injection time and dosage program day 1	day 2		Spawning results obtained on day 3
	F	86,0	9 000	11h00 500 I.U. HCG/fish	16h00 0,75 gland/1 000 g		No spawn at 10h00. Returned to pond.
1							
	F	65,0	3 500	11h00 500 I.U. HCG/fish	15h00 750 I.U./1 000 g		Complete spawn obtained at 10h00. 300 ml eggs obtained
	F	52,0	2 250	11h00 500 I.U. HCG/fish	16h00 0,75 gland/1 000 g		No spawn at 10h00. Returned to pond.
	F	64,5	3 750	11h00 500 I.U. HCG/fish	16h00 750 I.U. HCG/ 1 000 g	23h00 All females received 0,67 gland/kg body mass	Complete spawn obtained at 10h00. 1 100 ml eggs obtained
2							
	F	53,0	2 750	11h00 500 I.U. HCG/fish	16h00 0,75 gland/1 000 g		No spawn at 10h00. Returned to pond
	F	55,5	2 000	11h00 500 I.U. HCG/fish	16h00 750 I.U. HCG/ 1 000 g		Complete spawn obtained at 10h00. Spawned partially in tank
	M	59,0	2 750				
3	M	53,0	2 250				
	M	54,0	2 750		16h00		SPERM FREE RUNNING AT ONSET OF EXPERIMENT. DISTINCT THINNING RESPONSE OBSERVED IN SPERM AT TIME OF SPAWNING
	M	56,0	3 000		ALL MALES RECEIVED ONE GLAND PER FISH IRRESPECTIVE OF BODY MASS		
4	M	52,0	1 500				
	M	53,0	2 000				
	M	53,0	2 000				

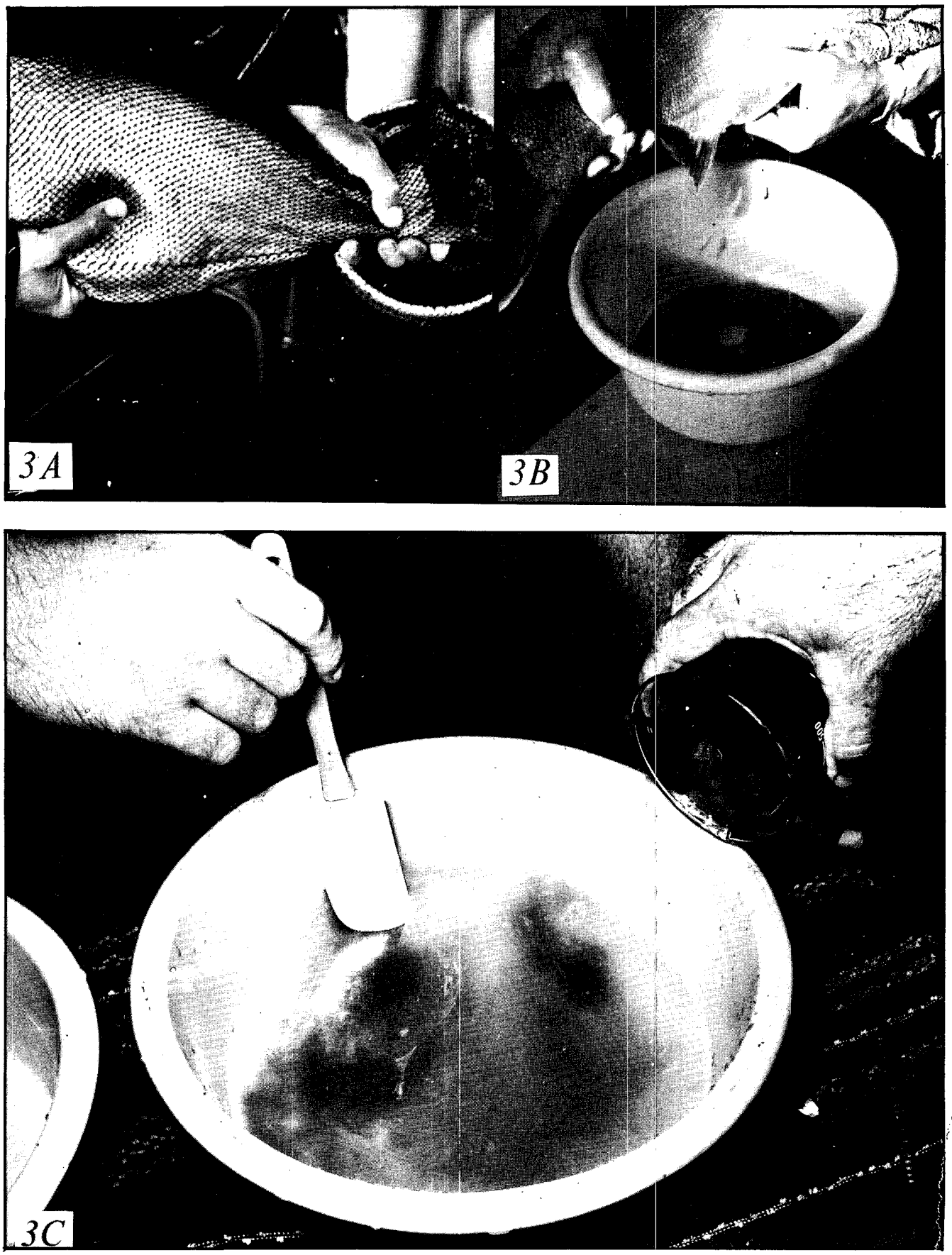

Figure 3
Induced spawning of silver carp. 3A. Stripping of eggs by stroking abdomen of female gently in direction of genital opening. 3B. Stripping of milt over eggs. 3C. Rinsing of fertilized eggs first with 0,8% saline and then with tap water

gland or 330 I.U. of HCG per 1 000 g of female spawner. Seven hours later all female spawners received 0,67 pituitary gland per 1 000 g of fish. Immediately after the last injection, one female which received only PGE jumped out of the tank and, despite the fact that a partial spawn was obtained later on, was not considered further for the experiment. Of the rest, all female silver carp spawned completely (Table 2).

The results on induced spawning of the silver carp suggest that for successful spawn, the first two injections (starter and the first fraction of the main dosage) can consist of either PGE or HCG, provided that the last (third) dosage is PGE. As the aim of the present study was also to be less dependent on pituitary gland for the induced spawning of fish, it was therefore decided that the starter injection in the case of the grass carp was to be HCG only (Table 3). The first fractional injection of the grass carp, which followed on the starter injection of 500 I.U. of HCG, was either 0,75 pituitary gland or 750 I.U. HCG per 1 000 g of spawner. Seven hours later, the last injection for all females consists of 0,67 pituitary gland per 1 000 g of spawner.

From Table 3 it can be seen that only those grass carp females which received HCG during the first two injections, actually spawned. Where the second injection comprised PGE, no spawn was obtained and the fish were returned to the ponds. From these findings it appears that the induced spawning requirements of female silver carp may be less specific compared to those of the grass carp females. These findings also confirm the results of similar work done in Israel during their summer season of 1977 (Schoonbee *et al.*, 1978) namely that in the case of the grass carp, HCG may play an important role in the maturation process of eggs and that the function of the PGE in the final dosage is largely for the loosening and subsequent discharge of the eggs. According to Cardeilhac (1976) the FSH hormone in mammalian gonadotrophin can speed up the oöcyte maturation in fish.

It is worthwhile mentioning that at the fish farm of the Kibbutz Gan Shmuel complete spawn of the grass carp by the sole use of PGE was obtained late in their spawning season when the eggs possibly were fully developed.

Stripping of Eggs and Milt and Fertilization Procedures

The fish were ready to spawn within 2—9 hours (silver carp) or approximately 11 hours (grass carp) after the last injection. When the females of both species were ready to spawn they became more active in the tanks. Upon handling, such fish may release a stream of eggs by means of contraction of their abdominal muscles. Males, being very active, were usually anaesthetised in 200 mg/*l* of MS 222 (Sandoz). In the case of the females, which receive HCG during the first two injections, the eggs were devoid of any blood clots, which is not necessarily the case when PGE is used in the first and/or second injections.

Eggs were handstripped into plastic bowls by stroking the sides of the abdomen of the female spawners in the direction of the genital opening (Fig. 3a). Similarly milt from males was discharged over the eggs (Fig. 3b). Sperm and eggs were then gently mixed with a soft rubber tipped cake spoon for 4 minutes (Fig. 3c). Approximately 1 m*l* of milt appears to be sufficient to fertilize 1 litre of eggs. In cases where insufficient milt was obtained, a second male was used. Diluted 0,8% saline was used to wash the eggs 4 or 5 times in order to clear them of substances such as coelomic fluid and vitelline from broken eggs (Fig. 3d). After rinsing, the volume of the eggs was determined in a transparent graduated beaker. In the case of the silver carp the respective volumes of eggs obtained ranged from 400 to 1 000 m*l*. At a later spawn in November 1977 a volume of 1750 m*l* of silver carp eggs was obtained. The best spawn amongst the grass carp females yielded 1 100 m*l* of eggs. According to Antalfi & Tölg (1971) the approximate number of eggs per 100 m*l* in volume is 100 000 for the silver carp and 80 000 for the grass carp.

Incubation of Eggs and Care of Larvae in Hatchery

After fertilization, the eggs were transferred to breeding funnels of which two types were used (Fig. 4), namely glass hatching jars of 7 000 m*l* capacity and P.V.C. plastic funnels of 70 *l* capacity. Water flow through the glass funnels averaged 0,78 *l*/min and in the plastic funnels the flow was regulated to vary between 1,2 and 6,1 *l*/min. Experience showed that the glass and plastic funnels used could not handle more than 100 cc and 500 cc of eggs respectively. Hourly measurements of water temperature and oxygen in the funnels during the two spawning trials showed that in the case of the silver carp, temperatures ranged between 22 and 25°C. Oxygen concentrations still varied between 74 and 78% saturation after the water had flowed through the eggs. A similar situation was found with the spawning of the grass carp but with water temperatures on the average 1—2°C higher.

The highest mortalities of developing eggs usually took place within the first 6 hours after spawning, with the critical period occurring during the first twelve hours. Thereafter egg mortality declined sharply.

Hatching of the eggs in both species commenced in less than 24 hours after spawning (Fig. 5). During a later spawn in November, hatching again took place in less than 24 hours. Hatched larvae were transferred direct from the funnels to the holding tanks with connecting pipes. The swimming bladder of the larvae developed within 2 days after which food in the form of hard boiled egg yolk was given. This was followed on the 4th day by a mixture of finely ground trout starter pellets and soybean meal supplemented with egg yolk. From the sixth day onwards, the fry received water rich in phytoplankton. The fry of both carp species were transferred to earthen ponds after 8 days.

Major Points of Interest

From the experience with both the silver and grass carp in the present and a follow-up breeding experiment, the following facets appear to be of importance:

1. Spawners in particular should be selected at the ponds. The softness and the swelling of the female fish belly can be taken as a good sign of gonadal maturation.

2. The condition of the spawners used in the present experiment was good, as both species of fish were kept in low densities in earthen ponds rich in phytoplankton and water weeds.

3. The results confirmed the findings of research workers overseas in connection with the collection of pituitary glands which preferably should be from female common carp donors collected at the onset of the spawning season i.e. during early spring.

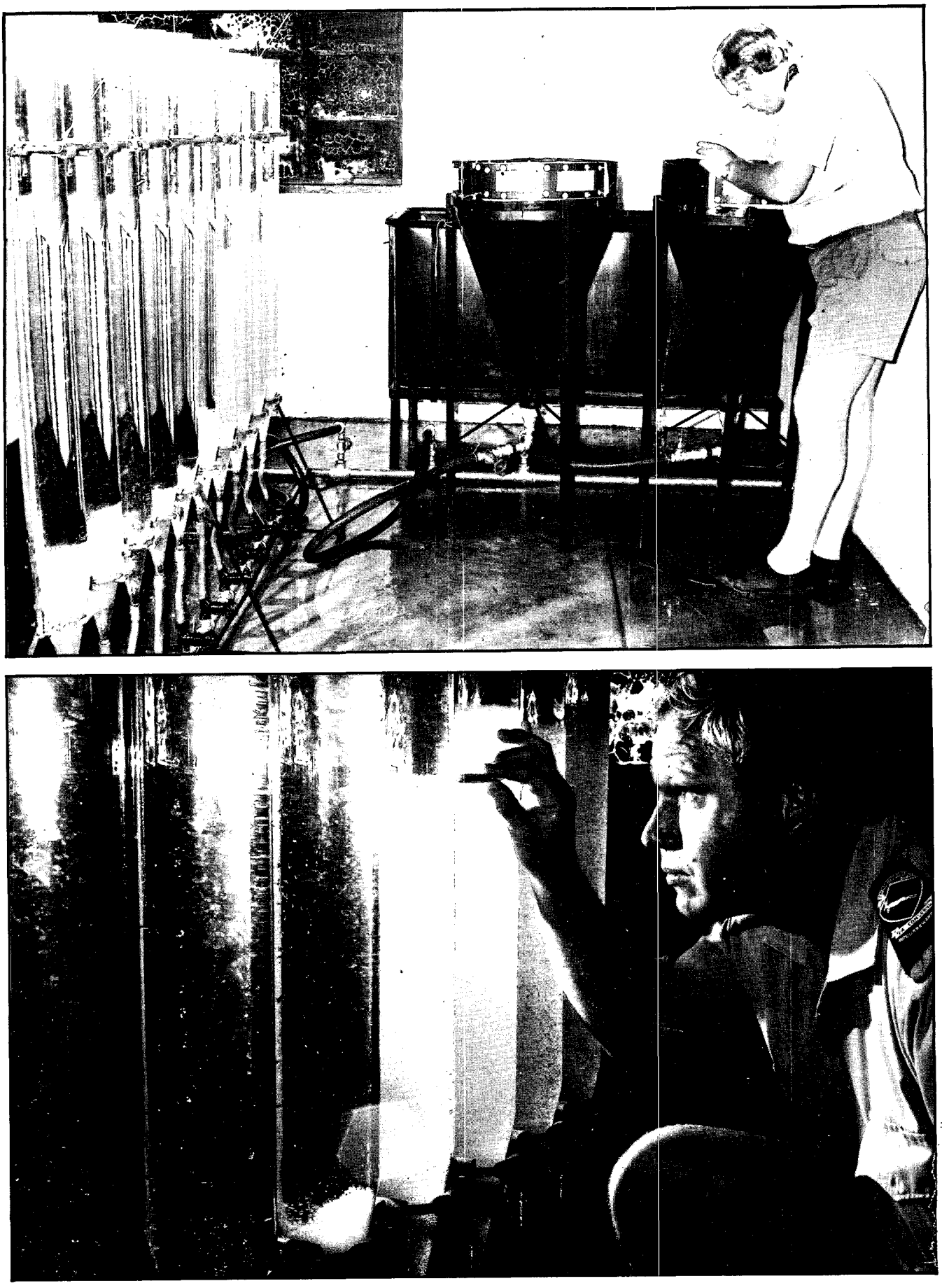

Figure 4
Glass hatching jars and plastic funnels used in the incubation
of the grass and silver carp

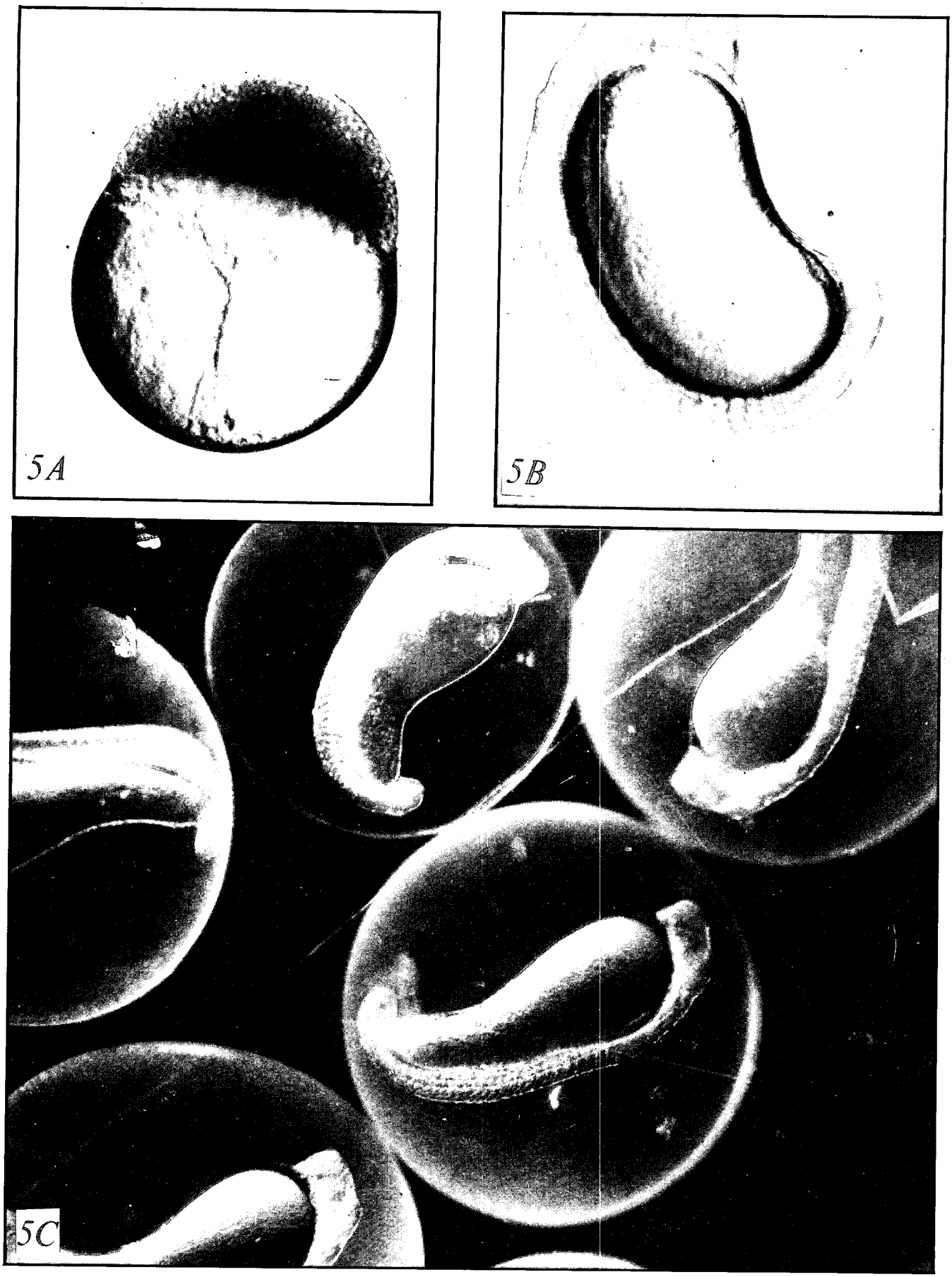

Figure 5
Developmental stages of the grass carp. 5A: 4—5 hours stage, 5B: 14 hour stage, 5C: 16 hour stage. Hatching occurs in both species less than 24 hours after fertilisation

4. The glass breeding jars used in the present study are narrow and can therefore only take a relatively small quantity of eggs. Otherwise satisfactory results were obtained. The black plastic funnels used made it impossible to observe egg movement so that the control of the correct flow of water through the funnels was extremely difficult to manipulate. It was also not possible to spot dead areas in the funnels. Perspex funnels such as those being used in Europe and Israel will give better results.

5. The HCG Pregnyl appears to be a good substitute for carp pituitary extracts when used in the first two of the three dosages. The last dosage must always be pituitary gland extract. The fact that HCG can be used as a substitute during the first two injections also means that fewer mature common carp females need to be sacrificed for pituitary glands.

Discussion

Since Ramaswami and Sundararaj (1957) first succeeded in spawning the Indian catfish *Clarias batrachus* with the aid of human chorionic gonadotrophins (HCG), enough progress has been made, especially with the Chinese carp species, for HCG to be used in addition to pituitary gland hormones in the commercial production of various freshwater fish species. The initial use of HCG in China and Japan as part of the treatment in induced spawning of the grass and silver carp is recorded by Tang *et al.* (1964), Lin (1965) and Hickling (1966). Lin (1965) and his associate research workers found that HCG, sold under the trade name Synahorin, can be used as a booster for the common carp pituitary gland extract (PGE), in the spawning of both the grass and common carp species. The latter author also found the best results when HCG is used together with PGE on female spawners when injected as two fractions, 6 hours apart. In the United States, Bailey and Boyd (1970) and Lin (1974) also obtained the best result, in induced spawning trials with the grass carp when HCG is administered first, followed by common carp pituitary extract.

Today it is generally accepted that HCG can play an important role in the maturation of the eggs of fishs. In other words, it has some Follicle Stimulating Hormone (FSH) function, whilst PGE with its Luteinising Hormone (LH) properties, provides the trigger for the release of the eggs.

The use of HCG in the process of induced spawning of freshwater fish for commercial purposes must be seen as only the first step in an attempt to replace completely the PGE mainly because of the difficulty to ascertain the gonadotrophic potency of each gland (Yashouv *et al.*, 1968). The lack of available common carp donors as well as the problem that the pituitary glands must be removed from donor fish at the onset of the breeding season, pose a further stumbling block in the use of PGE as an aid in the large scale production of fish.

The findings of the present study generally confirm those of authors such as of Bailey & Boyd (1970) and Lin (1974) where the use of HCG is recommended as a booster for the PGE in the spawning of the Chinese grass and silver carp species.

Experience in South Africa and elsewhere in the world has shown that the control of noxious aquatic weeds in rivers and impoundments through the use of herbicides or mechanical removal can be very costly and may well be a continuing method of combating this problem (Sneed, 1971; Baker, *et al.* 1974). Although future attempts towards the biological control of aquatic weeds in local rivers, impoundments and irrigation canals may be equally indecisive, the use of phytophagous fish species such as the Chinese grass and silver carp, *C. idella* and *H. molitrix*, may at least contribute towards a lessening of this problem in a relatively inexpensive way. It has already been shown in other parts of the world that the grass carp can control water weeds such as *Potamogeton* and *Najas* in ponds, at stocking densities of one hundred 0,11—0,23 kg fish per acre, and that several of the genera of water weeds such as *Elodea, Myriophyllum, Typha* and *Phragmitis*, which also cause problems in some of the local water bodies, are grazed by this fish species. (Sneed, 1971.)

Laboratory observations on the food habits of young 4—9 g grass carp kept in aquaria at the Rand Afrikaans University and at the Fisheries Research Station at Marble Hall, have shown this species to devour large quantities of filamentous algae, *Potamogeton pectinatus* and especially species of *Lagarosiphon*. Observations on their food habits have also shown the fingerlings to crop the aquatic roots of both *Eichhornia crassipes* and *Salvinia molesta* successfully. Baker, *et al.* (1974) have found that larger specimens of the grass carp can control the water hyacinth by eating its leaves and petioles and that it is particularly successful in controlling the number of new daughter plants.

It has been pointed out by authors such as Stanley (1976) that the grass carp can reproduce naturally in some areas outside its native range, such as Cuba, Japan, Taiwan and the Philippines, and although Vinogradov and Zolotova (1974) have shown that in Russia, where this fish can spawn freely, it has been responsible for the disappearance of perch and pike in lakes where it was introduced, no evidence exists so far that this has happened in the other countries mentioned above. If the grass carp is used in the control of weeds in South Africa and it can be shown that it can in fact spawn naturally in local waters, then it is suggested that sexually mature fish which can easily be separated into males and females be used, and that only the members of one sex be stocked into such bodies of water where the control of excessive aquatic weeds may be required. In this way the number of fish introduced into impoundments, canals, etc., will be known.

Much research will have to be done in South Africa before the general release of the grass carp in river systems can be considered. The large scale induced spawning of this species at the Marble Hall Fisheries Research Station during the present series of experiments provided sufficient offspring for several research projects intended to evaluate the grass carp as a biological means of control of certain noxious aquatic weeds in impoundments in the Transvaal.

As a result of its very specific phytoplankton diet, the silver carp can equally well be used to benefit from algal blooms in impoundments caused by eutrophication. Here again further research on the possible effects of this species upon other fish species present in such water bodies needs to be carried out before its general release in impoundments.

The potential of both Chinese carp species in freshwater fish polyculture has already been shown in countries like Israel. The silver carp in particular lends itself to a semi-intensive and extensive type of fish production and investigations into the possible role of this species for local fish production should receive a high priority.

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