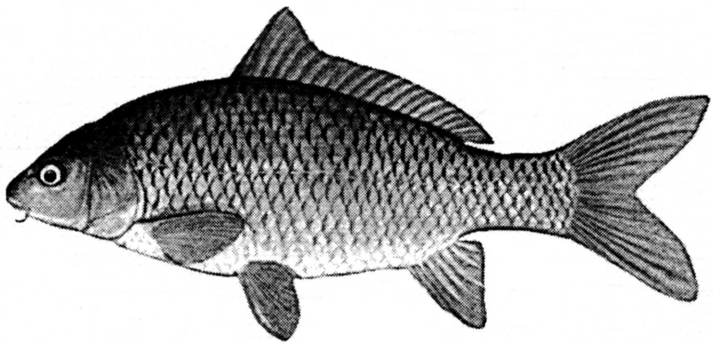
Seed Production of Carp in Zambia



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) EXPERTS

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CONTENTS

I . Background to Carp culture in Zambia

Carp is thought to have originated in Central Asia; a Chinese book on fish culture written 2400 years ago describes Carp culture techniques. Later, during the Greek and Roman eras, Carp was transferred into Europe. It is known that Carp culture was taking place in Austria in 1227, that the species was transferred into Germany and France in 1258, and that by the 17th century Carp culture has spread into Scandinavia.

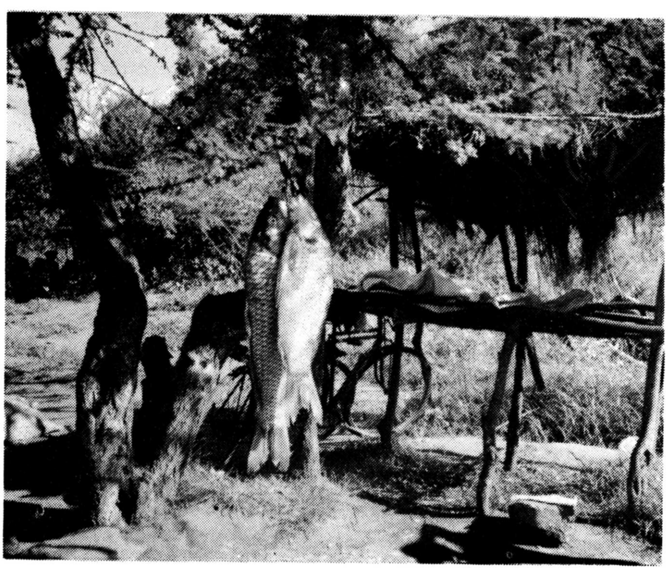
Fig. 1. Distribution of Carp in Southern Africa

From Freshwater Fishes of Southern Africa

Introduction of the fish by the Chinese into Southern Africa (specifically at the time into what was the Cape Colony) took place during the 18th century, Today, Carp and Chinese Carp (Silver Carp, Grass Carp etc.) are found throughout Southern Africa, Carp being particularly widely distributed. **(See Fig 1.)**

The "Eat More Fish " campaign carried out by the FAO in East, Central, and Southern Africa in the 1960s and 70s, resulted in farmers in these areas being introduced to Carp and Tilapia culture. In Kenya in 1992, a total of 470 tons of Carp were cropped from fish farms or caught from the adjacent waters of the Tana River. Nowadays, Carp being sold at the side of the road along the Tana River near the town of Sagana is a common sight. **(See photo I)**

Photo. I Sale of Carp at the side of raod in Kenya



There are at least two types of Carp in East and Southern Africa: the German type and the Yamato type from Japan. The Carp in the Tana River and its adjacent waters was introduced into the Sagana Fisheries Station in 1969 by request of the Kenyan government. Artificial seed production has been carried out at this same station since 1971, and during this period many dams along the Tana River have been constructed. These two activities have resulted in the establishment of Carp in the Tana River system. Although the German type (Mirror Carp) was introduced before the Yamato type into the Sagana Station, there is little sign of the German type in the Tana River today.

Mirror Carp were introduced into Malawi in the mid-1970s, and artificial seed production was first carried out in 1978 at the Domasi Fish Farming Station. In October of 1980, two hundred of the Mirror Carp fingerlings produced at the Domasi Station were imported by the Zambian government and introduced into the Chilanga Fish Culture Station. At around the same time, Chilanga had also obtained some Scaled Carp (one of the German types) from Czechoslovakia. Seed production of these fish was attempted, but due to a worsening in the water condition at Chilanga, a decision was taken in 1981 to transfer some of the Mirror Carp and Scaled Carp to Mwekera Fish Farm in the Copperbelt.

Over recent years Mwekera Fish Farm has received technical aid from FAO, JICA and other international organizations. Since 1981, JICA expert and volunteer co-operation has largely focussed on Carp seed production at Mwekera. During this period Carp seed has not only been distributed to the Copperbelt region, but also nationwide. As a result of the wide distribution, one can now see cultured Carp for sale in the shops and markets at cities and towns such as Lusaka, Kitwe, etc.

Although seed was widely distributed, the actual amount available for distribution was insufficient to meet the demand. The main reason for this shortfall was that seed production could only be carried out by the very small number of fisheries stations in which the hormone injection method using the pituitary body of *Syprinida* species could be applied. In response to this situation, and with the objective of establishing the technique of the mass production of seed, the Zambian government, in technical co-operation with JICA, set up a Mini-type technical project in August 1994. This project ended in July, 1997.

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II . Varieties of Carp

The numerous types of Carp (German Carp, Yamato Carp, Nishiki Koi, etc.) all belong to the same species: *Cyprinus carpio Linnaeus*. It is from this one species, by artificial selection, that people in Japan and Europe have developed the many varieties, which are different in terms of morphology, habits, colour etc.

The different German varieties are identified principally by the location of scales on their bodies: the Scaled Carp has the whole body apart from the head covered with scales; the Mirror Carp has scales only on the dorsal region and part of the caudal peduncle; the Line Carp has scales along the lateral line only; and the Leather Carp has no scales at all.

In Japan, the Scaled Carp which is spindle shaped and black in colour is called Makoi (generally termed Common Carp and including Yamato Koi and Shinshu Koi), and is cooked for the table. The coloured Iro–Koi is not usually eaten; selective breeding of this variety has produced Nishiki–Koi with red, black, gold, silver etc. colours.

Morphological variation is produced by the employment of different rearing methods and the presence of differing local environments. The different varieties are given local names.

A comparison of Mirror Carp and Common Carp shows a number of differences: the gill rakers of Mirror Carp are longer and more numerous than those of Common Carp; in addition, the Mirror Carp has a longer intestine. It seems that Mirror Carp has become adapted to feed on plankton rather than on benthos (the original food of carp). Carp have no teeth in the mouth, but the pharyngeal molar teeth present in the throat can crush food a little. Carp, unlike Tilapia, have no stomach.

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III. Management of the parent fish

III– 1. Selection

Before parent fish can be selected, it is necessary to ascertain the phenotype required in the offspring: whether, for example, the consumers require large numbers of small fish rather than fewer numbers of large fish; whether they want fish with or without scales etc. The method of fish culture being used will also affect the choice of parent fish.

Fig. Ⅲ-1. **Genotype and Phenotype of Scale on Carp**

♀ \ ♂	NS	Ns	nS	ns
NS	NNSS	NNSs	NnSS	NnSs
Ns	NNSs	NNss	NnSs	Nnss
nS	NnSS	NnSs	nnSS	nnSs
ns	NnSs	Nnss	nnSs	nnss
	Line Carp	Leather Carp	Scaled Carp	Mirror Carp

Lethal gene

At present, Mwekera stocks mainly Mirror Carp and Scaled Carp. Mirror Carp has irregular scales but grows comparatively fast. Scaled Carp, having a similar appearance to the domestic species as a result of its spindle shape, appears familiar to the local population and is therefore easily accepted as a source of food.

Scale presence and location on the body of Carp is genetically determined and follows Mendel's laws of heredity as shown in Fig III-1. The characteristic for scale appearance can be represented by S, and that for the non-appearance by N. S is dominant over N. The genotypes of the different varieties are therefore as follows: Scaled Carp, nnSS or nnSs; Line carp, NnSS and NnSs; Leather Carp, Nnss; and Mirror Carp, nnss. Combinations NNss, NNSs and NNss are lethal, and organisms with such cannot survive. Of these four types of carp, the Mirror and Scaled varieties appear to have faster growth rates and also higher survival rates.

In situations where Carp is being produced for human consumption, market demands and profitability under the chosen culture method must be taken into account. High growth rates and good body shape are therefore important considerations when selecting parent fish.

Ⅲ -2. Rearing the parent fish

In temperate regions such as Japan, female carp mature at four years of age, male carp at three years. For the following twenty years the fish can respectively spawn and ejaculate on a continuous basis. The healthiest eggs seem to be produced between the ages of five and ten years.

In contrast, at Mwekera located in a tropical region, earlier maturation has been observed with females reaching maturity between the ages of two and three years, and males maturing between the ages of one and two. The most suitable size of fish in terms of handling weighs between 1.5 and 4.0 kg. Fish bigger and heavier than this are difficult to handle and attempting to do so can result in an increased risk of accidents such as dropping the fish.

Sufficient food should be given to the parent fish but over-feeding should be avoided especially as the breeding season draws near. This will prevent fat deposits from accumulating in the ovaries and ensure the production of healthy eggs. The rearing density of female parent fish is kept at half of that used for production. The depth of the rearing pond must be more than 1m. It is thought in China that the carrying capacity of the female rearing pond should not exceed 150 kg per 660 m^2 under manuring culture.

At Mwekera, a high hatching rate of fertilized eggs was obtained when about 300 kg female fish had been reared in a pond of 2,000 m^2. These females had been fed on locally produced artificial feeds, and manure had been added to the pond regularly. The male Carp is a little easier to rear than the female. If the male fish are receiving sufficient food, production of sperm will not be affected by density. At Mwekera, sperm production has been observed to occur from early July.

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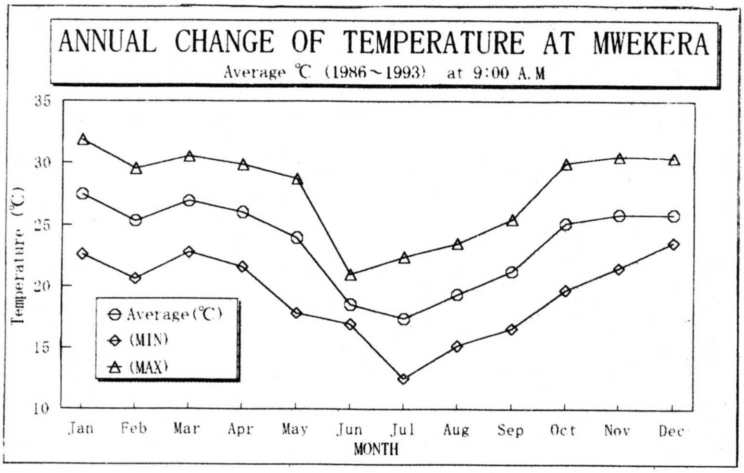
Ⅳ. Spawning and hatching

Ⅳ-1. Change in water temperature and the optimum spawning period at Mwekera

The changes in water temperature through the year at Mwekera are shown in **Fig. Ⅳ-1-1.** The temperature starts to drop in March, reaches it's lowest point in July and starts to rise again rapidly in August.

As shown in **Fig.** Ⅳ**-1-2,** from July to September there is a rise in temperature from 16

Fig. Ⅳ－1－1.

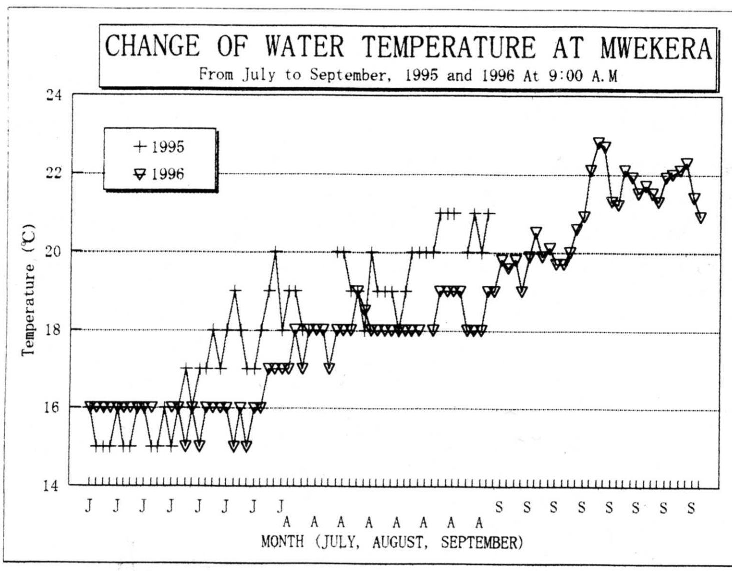


℃ to 22 ℃. The 1995 pattern is repeated in 1996, but occurs about ten days later.

There is quite a long season, from the end of July to December, during which fertilized eggs may be collected at Mwekera.

In 1987 fertilized eggs were collected each month continuously from August to December. This might, however, have occurred because the carp had only recently been introduced into Zambia and had not had sufficient time to adapt to the environment at Mwekera.

Fig. Ⅳ－1－2.



The recent spawning results indicate that the spawning period is from the mid－August to September. During this period the temperature of the water taken at 9:00a.m. rose from 18 ℃ to 22 ℃. Around 18th September, when natural spawning was taking place, the water temperature was between 21 ℃ and 22 ℃. The optimum water temperature at Mwekera for spawning is therefore considered to be at such time as the temperature has risen to between 20 ℃ and 22 ℃ at 9:00 a.m.; in this case between the end of August and middle of September.

IV−2. Sorting of the parent fish, fecundity, and changes in body weight during the pawning period

It is the general view that male and female carp should be separated one to two months prior to the spawning period. Since it is not easy to identify the different sexes, it is advisable to repeat the sorting process just before spawning.

TABLE. IV -2.
HOLDING NUMBER OF EGGS BY SIZE AND WEIGHT
COMMON CARP

T. length (cm)	B. weight (kg)	Number of eggs	Number / kg
	1.96	443,930	226,494
	2.25	600,000	266,666
	4.60	643,680	139,930
42	1.50	109,800	73,200
51	2.66	267,260	100,474
46	1.28	230,000	179,688
47	2.81	385,464	137,176

During the actual spawning period males can be easily identified by the expulsion of milt when slight pressure is applied to the lower abdomen.. The mature female can usually be identified by the presence of an enlarged abdomen which becomes very soft when spawning is near. However, careful observation is necessary when selecting females since male Mirror Carp can also display enlarged abdomens making the two sexes difficult to distinguish. Males can be used two or three times in the breeding period providing that they are well fed.

When fry are both hatched and reared in the same pond it is necessary to estimate the number of eggs spawned. This can be done with reference to length and weight of the female parent. This relationship is shown in Table IV−2. There is a wide variation in the number of eggs per kg of female, ranging from 70,000 to 260,000 eggs per kg.

Osaka Freshwater Fisheries Experimental Station has adopted the following formula for the estimation of spawned number of eggs:

$$\text{Estimated number of eggs} = (a-b) \times 500$$

where a = body weight before spawning (g) b = body weight after spawning (g) and 500 is the number of eggs per gram.

On spawning completely the females' body weight decreased by 13 ~ 16% as shown in Table IV−3−2. At Mwekera the number of eggs per gram varied according to the variety of carp. It seems scaled Carp produced smaller eggs than Mirror Carp. Therefore, it may be advisable to count the number of eggs per gram before the estimation at Mwekera.

Although it is the general opinion that the males and females of any pair should be of the same size, when a male to female size ratio of 1:4 was used at Osaka Furitsu Fisheries

Station in Japan, no detrimental effect on hatching rate was observed.

Ⅳ－3. Collection of fertilized eggs

3－1. Hormone injection

Hormone injection has been an important method of seed production since carp was introduced into Africa, and indeed has been used in many other part of the world. In this method, either fresh or dried pituitary glands of the *Cyprinid* species are used, and the glands are usually preserved in alcohol or acetone. The pituitaries are ground using a mortar and pestle, and an injectable solution is prepared by mixing with 0.6－0.9% saline solution. The dosage used depends on the body weight of the fish to be injected. Generally speaking, the total body weight of the donor of the pituitary gland is 1 ～ 3 times that of the recipient. The injection is administered through the dorsal muscle or peduncle or through the base of the pelvic or pectoral fin.

At Mwekera, good spawning results were obtained using double injections (ie. primary and main injections). When using Silver Carp pituitary glands, a primary dose of 0.09 to 0.20 pieces of pituitary material dissolved in 0.5cc saline solution was given per kg of fish. However, a dosage of 0.125 pieces per kg may be considered as a standard concentration for the primary injection. The main dosage was prepared by dissolving 0.5 to 1.0 pieces per kg in 0.5 cc saline solution. The interval between the primary injection and the main injection depends on the temperature. Under August water temperature conditions at Mwekera, good results were obtained when the main injection was given 20 hours after the primary injection. The average weight of one Silver Carp pituitary gland in powder form is 14.8 mg, and the activity (IU) of one mg of the powder is 0.10.

3－2. Natural spawning (Group and individual spawning)

Although natural spawning has been observed on several occasions at Mwekera, very few of the females spawn at once. For this reason natural spawning in ponds was not utilized for the mass production of fingerlings.

Generally, the spawning method of Carp in the pond involves several females together with two or three times the number of males; this is called group spawning.

It has been observed at Mwekera, however, that in this situation usually only one female spawns, the other females either spawning partially or not at all. In response to this problem, individual females were placed in cages together with males.

Table. IV-3-2

THE CHANGE OF BODY WEIGHT OF FEMALES, BEFORE AND AFTER SPAWNING IN TRIALS OF NATURAL SPAWNING BETWEEN INDIVIDUAL AND GROUP SPAWNING

Individual Spawning

	17/09/96		18/09/96			
Cage. No	B. W(g)	Spawning	B. W(g)	Difference(g)	%	Species
1	1,325	Yes	1,153	- 172	- 13	S. C
2	2,477	Yes	2,142	- 335	- 14	M. C
3	3,867	Yes	3,326	- 541	- 14	M. C
4	2,093	Yes	1,800	- 293	- 14	M. C
5	2,159	Yes	Escaped	-	-	M. C
6	1,743	Yes	1,606	- 137	- 8	S. C
7	2,012	Yes	1,742	- 270	- 13	M. C
8	1,769	Yes	1,485	- 284	- 16	M. C

Group Spawning

	17/09/96		18/09/96			
Pond. No	B. W(g)	Spawning	B. W(g)	Difference(g)	%	Species
A2	1,932	Yes	1,638	- 294	-15	M. C
A2	1,860	No	1,812	- 48	-3	M. C
A2	1,529	No	1,506	- 23	-2	M. C
A2	1,943		1,861	- 82	-4	M. C
A3	1,575		1,514	- 61	-4	S. C
A3	1,323	No	1,305	- 18	-1	S. C
A3	1,549	Yes	1,354	- 195	-13	S. C

The results of this are shown in Table IV-3-2. When setting up the spawning cages, it is advisable to place them within 1m of each other so that fish in one cage can see and hear the activities of fish in the neighbouring cages. For production purposes one female to two males in each cage is satisfactory. When carrying out selection experiments, only one male and one female should be used, each having the desired characteristics.

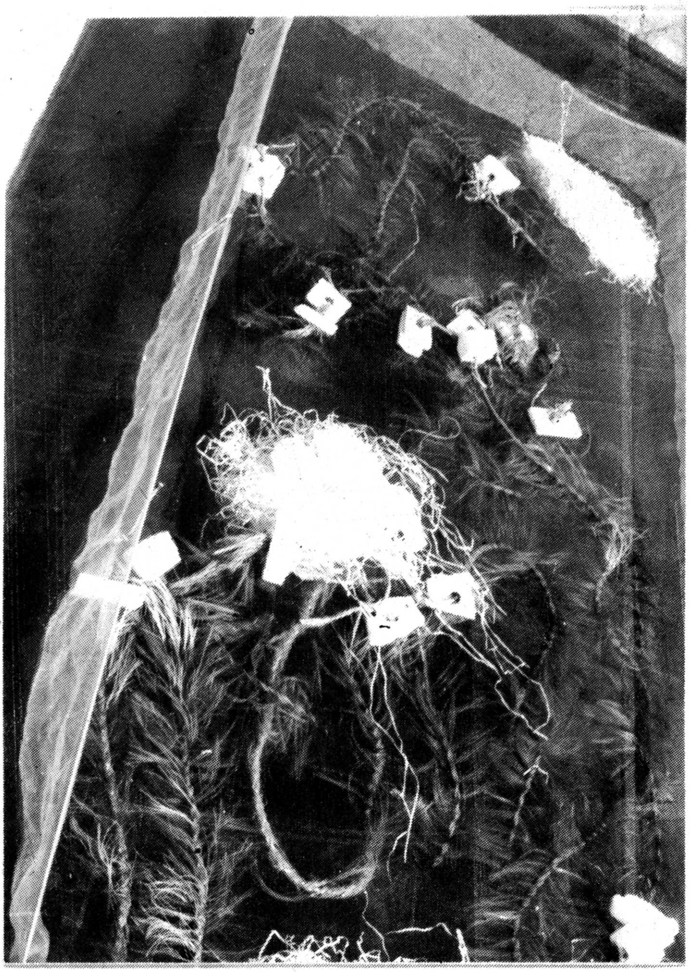
At Mwekera, the individual spawning method in cages was found to be more efficient and easier to control than the group spawning situation.

3-3. Nests, cage nets and pond for spawning

Carp start to spawn at dawn and will sometimes continue until the afternoon. After spawning, either the nests or the parent fish must be taken out of the spawning pond to prevent the eggs from being eaten by the parents. If the parent fish are removed, then the pond can be used for hatching the eggs. The use of a cage net for spawning makes the collection and disinfection of eggs easier. If the spawning cage is situated in a manured pond, it can be left there after the removal of the parent fish, and subsequently taken out after the eggs have hatched. In this way handling of hatched fry is minimized and fry can be left to grow to a desired size without disturbance.

The nylon mesh used to make the cage nets is available in the shops. This material is suitable since it does not rot easily and it is soft enough not to injure the spawning fish. The

Photo. IV-3-3. Cage net and Nest for Spawning



mesh size of the material should be big enough to let water pass through but small enough to keep the spawned eggs inside (about 1.2–2mm bar length).

Eggs which have just been spawned are very soft, and some may be pushed out through the meshes of the cage net by any turbulence caused by the movements of spawning fish. In order to collect the eggs which passed out the cage, another net is spread on the bottom of the pond around the cage. The greater the weight of the spawners, the larger the size of cage required. For fish of 2 ～ 4 kg in weight, a cage of dimensions 1.5m x 1.5m x 0.8m is suitable. A water depth of 0.5 m is sufficient. A variety of materials such as sisal fibre, mealie meal bags etc, can be used for making the nests. These materials, however, should be boiled in water for at least 20 minutes before use. The nesting material has floaters attached to it so that it does not sink in the spawning cage (See photo–IV–3–3).

IV–4. Disinfection, hatching water, and hatching rate of fertilized eggs

The incubation period of fertilized eggs is significantly affected by water temperature. A difference in water temperature between the surface and bottom of a pond results in a difference in incubation period between eggs in these two regions. To ensure uniform temperature distribution, aeration or other mixing methods should be applied. Development

Table. IV-4-1

Water temperature and required days for hatching (Commom carp)

Water Temp(℃)	15	20	25	30
Days Required	6.0	4.2	3.0	2.1

From: CARP. Youshoku-kouza 1979

of a thermocline can also be avoided by making the pond shallow. The relationship between water temperature and the incubation periods is shown in table IV-4-1. Fertilized eggs can be hatched in temperatures ranging from 15 ℃ to 30 ℃ as long as there is no drastic change in water temperature during the incubation period. A better hatching rate was observed when the temperature had risen to around 22 ℃ at Mwekera as shown in table IV-4-2. Generally the highest hatching rate is obtained at the temperature between 20 ℃ and 30 ℃. Individual hatching rates for individual spawners do, however, show a wide variation ranging from 30% to 90% at Mwekera and from 26% to 70% in Japan.

Table. IV-4-2. HATCHING RATE OF EGG

cage No.	16 ~ 21/Aug/96 Haching rate (%)	25 ~ 30/Aug/96 Haching rate (%)	6 ~ 9/Sep/96 Haching rate (%)	18 ~ 21/Sep/96 Hatching rate (%)
1	75	69	60	66
2	49	67	85	78
3		64	70	99
4	50	57	77	62
5	68	54	47	68
6	18	59	65	38
7	25		74	89
8	33		60	88
Average	47.2%	61.1%	65.0%	74.0%
Water Temp(℃)	16 ~ 18.9	16 ~ 18.6	18.3 ~ 20.5	20.0 ~ 23.0

Dead and unfertilized eggs, if left on nest without being disinfected are rapidly attacked by aquatic fungi. The fungi spread quickly and in doing so can cover the fertilized eggs which in turn get killed. In order to protect them against fungal attack, the eggs are bathed in a solution of zinc-free malachite green before they are incubated in the hatching pond. A concentration of 10 ppm malachite green is generally used, and the eggs are bathed for 15 minutes. However, if aeration is available and a water current is maintained in the incubation tank, eggs can be bathed in a 1 ~ 3 ppm solution for 3 to 5 minutes and good results still obtained.

Malachite green is poisonous to both the fish and the eggs, therefore great care must be taken during treatment. Since the sensitivity of fish to malachite green is much higher than eggs, the dosage to treat fungal infection of fish have to be much lower than that used for the eggs.

In Northern Europe incubation of carp eggs is carried out in Zong jars after the adhesion on eggs has been removed. This method also prevents fungal attack. The removal of adhesion on the eggs makes it possible to fertilize and incubate eggs artificially; selection experiments are thus possible with this method. In tropical regions where the incubation period is shorter and the purpose of fertilization is to produce fingerlings, use of malachite green is sufficient.

Table. IV -5. USED FEMALES & FRY PRODUCTION N.A.R.D.C. 1996
(From 12 / Aug to 24 / Sep)

DATE	Spawned female	Body Weight	Transferred Hatched Fry	Production /Female	Production / kg
12 Aug	20	46.8Kg	1,140,000	57,000	24,359.0
22 Aug	20	49.3Kg	1,547,000	77,350	31,379.3
04 Sep			485,000		
24 Sep			563,000		
TOTAL			3,735,000		

IV-5. Production and handling of hatched fry

Newly hatched fry are transparent, inactive, and cling to the nesting material, tank wall or drop to the bottom. They are about 5 ~ 6 mm in total length and carry a yolk sac. Two to three days after hatching, the yolk sac reduces in size and the fry start to swim along the wall of the tank. This is the best time to transfer the fry to the nursery pond. The bodies of the fry are very delicate at this stage, so handling must always be done in water. To reduce the risk of injury, fry can be transferred using a hosepipe or through a channel. Hatcheries or hatching ponds are designed to be at a higher level than the nurseries thus facilitating the easy flow of water and fry into the nurseries. Sometimes the hatchery is situated at the centre of the nursery pond so that after hatching, the fry can be released with a minimum of handling.

On a commercial scale in Japan, the average number of fry produced from a female of weight between 1.5 and 3kg is 80,000; in Mwekera as shown in Table IV-5, it varied between 57,000 and 77,000.

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V. Rearing the hatched fry

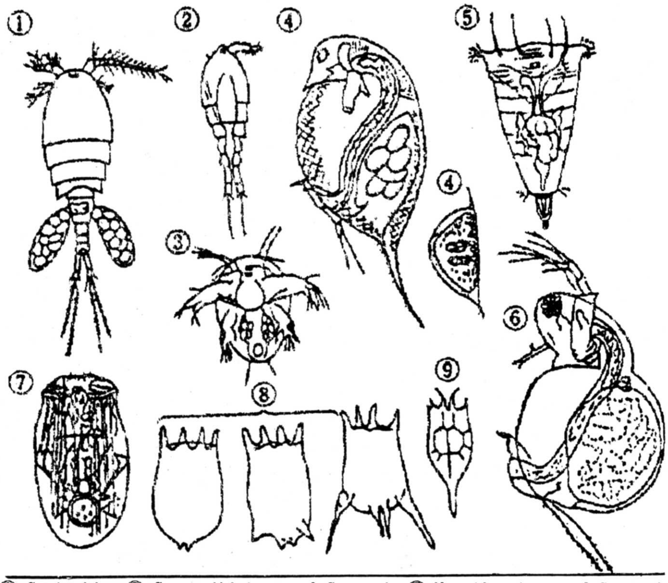
V-1. First feed

By the time the fry have been hatched for two or three days, about 70% of the yolk will have been absorbed. The fry now start to ingest external food such as Moina larvae, Rotifers and other small zooplankton. Between one and two weeks after hatching the fry start to feed on larger zooplankton. If no food is ingested during the first week, most of the fry die.

Zooplankton must therefore be propagated before fry are stocked in the nursery pond. The phytoplankton and bacteria upon which zooplankton feed are easily developed by manuring the ponds, but zooplankton doesn't appear easily when there are not enough number of seed (resting eggs) in the pond. Thus, when new earthen ponds or concrete ponds are used for nurseries, they must be stocked with zooplankton or mud from old ponds which contains enough resting eggs. In Japan, an old fish culture pond holds about 590,000 resting eggs per m^2 while a natural or reservoir holds about 350,000 per m^2.

Observations made in East and Southern Africa show that small zooplankton such as Rotifers and Bosmina appear soon after manuring whereas larger zooplankton such as Moina and Daphnia hardly occur at all. As a result it has been found necessary to stock nursery ponds with the seed of the larger zooplankton in order to propagate them in sufficient

Fig. Ⅴ -1. Zooplanktons



①. Cyclopidae ②. Copepodid larva of Copepoda ③. Nauplius larva of Copepoda ④. Daphniaand resting egg ⑤. Synchaetidae ⑥. Moina ⑦. Asplanchnidae ⑧. ⑨. Brachionidae

numbers.

Daphnia and Moina reproduce in three main ways. One method involves the female carrying out haploid parthenogenesis. The second method is by sexual reproduction producing resting eggs able to survive during unfavourable environmental conditions. In the third method, both previously mentioned types of offspring are produced at the same time by the same individual. Which one of these reproductive methods is in operation at any particular time depends on environmental conditions such as pH, temperature, availability of food, density, etc. A pH of 7 ~ 8 combined with a temperature of 15 ~ 25 ℃ provides optimum conditions for haploid parthenogenesis. When the temperature is above 37 ℃ and pH rises above 10 or falls below 4, propagation is inhibited. After November at Mwekera, when temperatures are high, mass production of Moina has not been observed. The keys to successful fry production are a sustained high density of zooplankton and the maintenance of good water quality in the nurseries. When plankton is cultured outside, water temperature, illumination, water quality and quantity, pond size, quality and quantity of manure and method of manuring must all be closely monitored. If there is not enough plankton in the pond, then chicken egg yolk and liver, strained through a plankton net and sprayed onto the water is given to the fry. Particular attention must be paid to the change in water quality when using such artificial feeds.

Although micro–diets such as MED (Micro–encapsulated diet), MBD (Micro–bound diet) and MCD (Micro–coated diet) have been manufactured and are available, for economic reasons, the production of fry at Mwekera still depends on plankton culture.

V −2. Zooplankton culture in earthen ponds

2−1. Manuring

Earthen ponds must be kept dry for minimum of 2 weeks (ideally for 5 weeks) prior to liming and manuring. This kills any pathogens that may have remained from the previous stocking (See photo V−2−1). Exposure of the pond bottom to direct sunlight also helps in the breakdown of organic matter and release of nutrients.

Photo. V -2-1 Liming in fish pond

It has been found that manuring will fail to propagate the useful plankton if the water hardness or total alkalinity is less than 10 mg/*l*. Between 10 and 20 mg/*l*, the effect of manure cannot be reliably predicted. Manuring only becomes effective in producing plankton when water total alkalinity is above 20mg/ *l*. Liming the pond therefore very important since it increases the total alkalinity of the water in preparation for manuring culture. Quick lime kills frogs thus reducing the number of tadpoles which compete with young fish for food and space. When ponds are manured in order to produce plankton, frogs reproduce prolifically and soon the pond is filled with tadpoles which can out−compete the young fry at the time of stocking. For this reason it is necessary to kill all the frogs before the ponds are filled with water. The quantity of lime depends on the type and pH of the soil; clay soil usually requires more lime than sandy soil.

Quick lime humifies organic fertilizers and reacts with inorganic manure such as urea and ammonium sulphate, this reactivity being lost after a period of two weeks. It is therefore important to add quick lime two weeks before the addition of manure or inorganic fertilizes. Slacked lime, however, which is not very reactive, can be added at the same time as the fertilizers.

After liming, the pond is fertilized with manure or inorganic fertilizers in order to propagate the bacteria, protozoa and phytoplankton which are food for the zooplankton. Although inorganic fertilizers dissolve quickly in the water, their effect does not last long. Organic manure, because it releases nutrients slowly, has a longer lasting effect.

At Mwekera, chicken manure has been used although both cow and goat manure are also obtainable. Other organic materials such as beer waste, maize husks and soybean cake can also be purchased and used.

Chicken manure is applied to nursery ponds at a quantity of 200–500g/ m² which is equivalent to 2 ~ 5 ton/ha. The quantity of manure applied depends on the amount of organic matter on the pond bottom and also on the rate at which water is lost from the pond. For example, a pond of depth 60cm with a clay soil bottom can be fertilized with 0.58kg/ m² Soya source waste and 0.12kg/ m² chicken manure. If compost manure is used, 1,500kg may be applied to 1,000 m² of pond. In the case of inorganic fertilizers used for production of phytoplankton such as *Scenedesmus sp,* the ratio of nitrogen to phosphorus is 7 : 1 which is equivalent to 7g N and 1g P in 1,000 litres of water. Table V 2–1 Shows the nitrogen and phosphorus components available when inorganic fertilizers and organic manures are applied to the pond. This table can be used to calculate the amounts of fertilizer and manure.

Table: V **2-1 .**

Contents of Nitrogen (N) and Phosphate (P) in Each Manure

Name of Manure	Convertion & Content(%)	
Chiken dung		N : 1. 2%~3. 6%
		P : 0. 7%~6. 6%
Cow dung		N : 0. 94%
		P : 0. 19%
UREA	2.2g of urea = 1 g of N	N : 46. 0%
P_2O_5		P : 44%
N of Animal Crude protein	N = Animal Crud Protein / 6.25	

Zooplankton production is affected by temperature, the peak density being reached more quickly at higher temperatures. The propagated peak density is directly proportional to the quantity of manure applied. The upper limit in the case of chicken manure is 500 kg–N/ha.

Conditions must however be kept favourable for both plankton and fry in the nursery pond.

A very high density of plankton can result in oxygen depletion and lead to fry mortality. One way of avoiding this is to rear plankton in a separate pond, collecting it to feed to fry in a different pond as required.

2−2. Zooplankton production in nursery ponds

When a manured pond is filled with water to a depth of 10 ~ 15cm, the water colour becomes brown, turning green after 5 ~ 7 days. This green colour is caused by the production of phytoplankton, and it is at this point that more water is added to slightly increase the depth. At about this time *Rotifer spp* such as *Branchionus spp* start to appear. Larger Zooplankton start to develop after the *Rotifer spp*.

Fig 2−2−1.

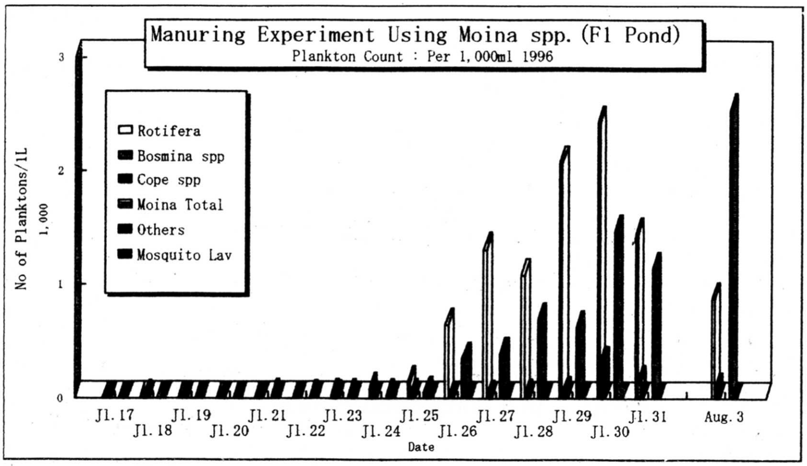
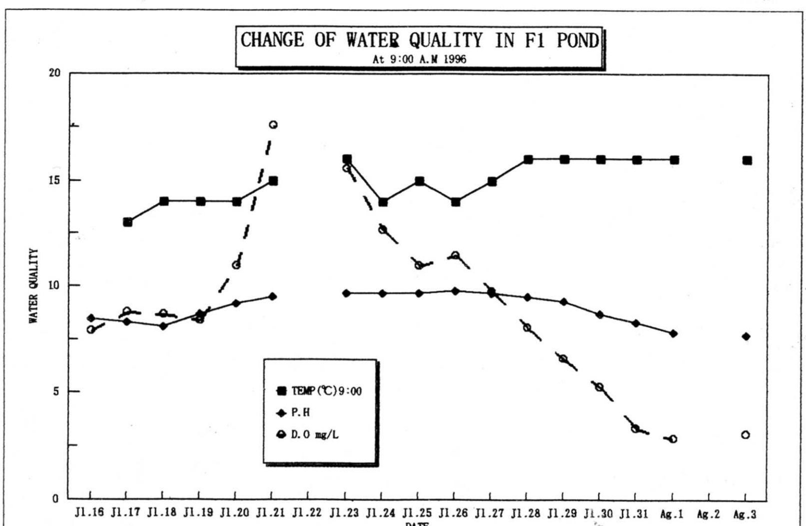


Fig 2−2−2



If larger zooplankton fail to appear in the natural successions, the seed can be stocked into the pond when it is being filled with water. Fig 2−2−1 shows the succession of zooplankton after Moina seed was stocked. The initial stocking density was 200 Moina per ㎡. Initially, 3 ton manure per ha was added, and after 14 days manure was added at a rate of 500 kg/ha. Fig 2−2−1 also shows changes in the density of Moina, the highest being 2,500

Moina per litre. When Moina or Daphnia seed are used, an initial stocking of 200 ~ 300 Moina per m^2 is sufficient. It is convenient to have a stock of Moina multiplying by feeding on raw yeast in 1 ton tank for stocking into pond during the season of spawning.

Additional manure sustains the plankton population for a longer time. It is difficult to determine the quantity of additional manure and the time when it should be added because so many other factors such as weather, number of plankton, quantity of manure etc,. have to be considered. Generally, 10 ~ 20% of the initial quantity of manure is added 14 days after the pond is filled with water. Thereafter, this quantity of manure is added every after seven days. Manure can be heaped in the corners of the pond or spread all over the pond. However, frequent spreading of small quantities of manure is more efficient than heaping the manure; though it requires more labour and time. It should be borne in mind that heaping is safer in that it is less risky to cause of rapid change in water quality.

As shown in FigV 2−2−1 and FigV 2−2−2., the development of a high density of larger size zooplankton is quickly followed by a drastic decrease in dissolved oxygen levels. The oxygen in the pond water is obtained from surface mixing and planktonic photosynthesis. In this situation however, since most of phytoplankton are consumed by zooplankton, almost all the oxygen has to come from surface mixing. As a consequence, only the top layer of water in the pond will contain dissolved oxygen. Therefore, in order to minimize this oxygen level difference, the water in a rearing pond of fry fish should be as shallow as possible bearing in mind that the shalow water, open pond can be subject to sharp temperature changes that can damage the fry fish and result in high mortality.

2−3. Moina culture in tanks

Moina seed, in the form of resting eggs, was brought to Mwekera from Japan in 1994. Since then, the species has been maintained and used as natural fry food in nurseries.

①. Hatching and propagation of Moina sp.

With the temperature range 18 ~ 20 ℃, and in continuously aerated water(about 1.5 litres), Moina eggs can be hatched in a 2 litre flask. At this temperature it takes about one week from the time they are placed in the flask for the eggs to hatch. After hatching the young Moina are fed on raw yeast suspended in water. About 3 ~ 4 days after hatching, the density of Moina increases and they can be transferred to a bigger container such as a 30 litre tank. The size of the container can be further increased as required.

In the case of *Moina affinis*, one female can produces 5 ~ 6 times during its lifetime. (The maximum recorded is 7 times). The frequency of and interval between production at temperature of 24 ~ 26 ℃ is shown in Table V 2-3. Moina start producing within 56-66 hours from hatching.

Table. V 2-3 Required Hours for Moina Larvae Production from Hatching Stage

Production	Required hours from hatching	Produced number of Larvae
1st	58 - 66	6
2nd	88 - 93	5
3rd	118 - 121	7
4th	148 - 154	10
5th	186 - 188	8
6th	221 - 223	8
7th	255 - 262	6

(SHIROTA et al, 1966)

②. Moina culture

Moina cultured in manured ponds generally feeds on bacteria, protozoa and phytoplankton. Providing there is sufficient food, a high density of Moina can be produced. In some cases, densities as high as 8,000 ~ 10,000 Moina/litre can be obtained.

Moina can also be cultured in tanks and fed exclusively on yeast. At Mwekera, raw baker's yeast was fed to Moina at a rate of 1g per 10,000 Moina per a day. The 1g of yeast was diluted in 1 litre of water and used to provide two daily feeds. Using this method 800 ~ 1,000 Moina/L could be produced.

③. Preservation of resting eggs

During unfavourable conditions (drastic change in water temperature, lack of food, high population density, influx of muddy water etc,) Moina reproduces sexually to produce resting eggs. If the objective is to produce the resting eggs, Moina is first propagated by feeding it not only on yeast but also on phytoplankton such as *Scenedesmus sp*. When the density has reached its peak, feeding and aeration is stopped. The tank is left as it is for some days; during this time the resting eggs are produced which settle on the sediment at bottom of the tank. These eggs can be sorted later using different sized of strainers (from 60 ~ 120 μ). The eggs collected should be kept in a dark and cold place. They can be stored in a bottle of water or in dry form in a plastic bag. Preserved eggs remain viable for years and can be used to start the artificial culture of Moina at any time.

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VI. Seed production by manuring method

VI-1. Production of advanced fry

If well fed, early fry grow to a size of 1g, within 20 to 30 days after hatching. The stocking rate of hatched fry and the cropping rate of advanced fry depend on the quantity and density of Zooplankton in the rearing pond and also on the method of rearing fry fish adopted (e.g manuring, feeding or a consideration of the two). A manured rearing pond with an adequate supply of zooplankton is stocked with hatched fry. When the zooplankton have been consumed, the fry are given artificial feed. Generally speaking, a 1,000 m² nursery pond stocked with 300,000 hatched fry can be expected to produce about 100,000 advanced fry of about 1g in size. If artificial balanced feeds are available and the water quality is well managed, it is possible to obtain some 100,000 advanced fry from single female. The survival rate of eggs through to the advanced fry stage on a commercial basis in Japan is shown in table VI-1-1.

Table. VI -1-1.

An Example of Survival of Seed Production in Business

Parent Fish →	Spawning →	Fertilized egg →	Hatched Fry →	1g Fingerling
3 ♀ x 10 ♂	500,000	300,000	250,000	100,000

It is advisable to grade the fry once or twice during their time in nursery pond, particularly when only manuring is being employed. Grading helps to maintain a fast growth rate and uniform size of fry in the nursery pond.

Table. VI -1-2

The Growth of Hatched Fry (Common Carp) in Different Densities By Manuring Culture in China

Pond No.	Area (m²)	Depth Av. (m)	Day of Stock	Stocked No of Fry fish	Cropped Day	Cropped No of Fry Fish	Survival (%)	Total Body Length (cm)	Body Weight (mg)
14	673.2	0.54	18/Apr	115,840	10/May	110,500	95.4	1.96	87
10	462.0	0.59	20/Apr	133,444	8/May	118,400	77.17	1.81	73
15	640.2	0.62	20/Apr	204,444	5/May	119,600	58.5	1.83	72
2-10	521.4	0.69	17/Apr	298,388	18/May	80,400	26.9	1.77	61
3	660.0	0.51	18/Apr	527,136	10/May	164,600	31.2	—	—

In China where 150,000 hatched fry per 660 m² is considered a suitable stocking level, fry are graded when their body weight reaches 60 ~ 90 mg. After the first sorting, fry are grown to 0.1 ~ 0.5 g, the size at which they are first sold. With frequent grading, it is possible to produce 1g fry within 30 days by the manuring method only.

Plastic products produced in Zambia and available in the local shops can be used as sorting boxes. During sorting, the fry must be handled with great care, the fry have to be kept in sufficient and well moving water in a cage. High mortality rates can result from the mishandling of fry during grading.

VI-2. Production of fingerlings.

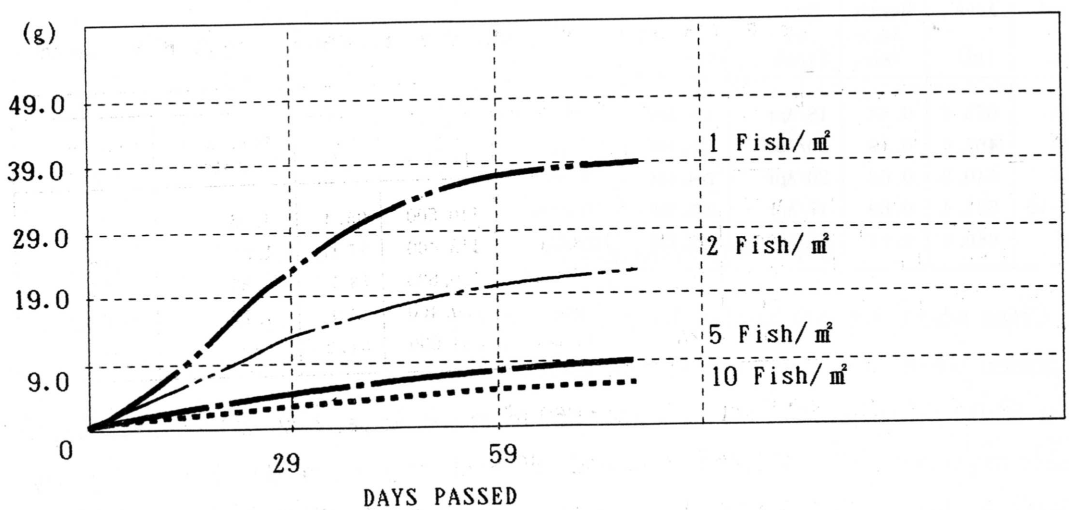
Fingerlings in the range of 50 ~ 150 g are used for the production of table sized carp in Japan. A number of different rearing methods are available for the production of fingerlings:

manuring culture; manuring combined with supplementary feeds; feeding culture using balanced artificial feeds; running, semi–running or stagnant water. Normally 1,000 ～ 1,500 advanced fry (about 1 g in size) are stocked per 1,000 m².

When manuring culture is used, the growth of the fish largely depends on the stocking density. Fig VI–2 shows the growth of fingerlings stocked at different densities and reared by manuring at Mwekera. The fish were reared for about 60 days after which their size was measured. The average size of fish in different ponds varied from about 9 g for those stocked at a density of 10 fish/ m² to about 40 g in the density of 1 fish/ m². The pond with lowest density produced the fastest growth rate. In Lot.1 (1 fish/ m²) and Lot.2 (2 fish/ m²), the growth rate began to decline after 30 days. At Mwekera, it is therefore advisable that fingerlings being reared by manuring culture should be sorted after the first 30 days.

Fig. VI-2.

THE GROWTH OF FRY FISH IN DIFFERENT DENSITIES



Normally in carp culture, grading is a routine process. Table VI –2 shows the numbers of the different stages of fingerlings stocked. By adjusting the stocking densities it is possible to produce the size of fingerlings required for the market. At Mwekera, water temperature drops below 20 ℃ from May to August, and during this period of low temperature fish growth slows down. However, since hatched fry can be produced from August, it is possible to produce table– size carp (500 ～ 1,000g) within one year, unlike in Japan and Europe.

Table. VI -2 Stocking Number Of Fish By Month Stage

Month from Hatching	1	2	3	4
Number of fish / 3.3 m²	5,000～1,000	300～100	100～30	10 ～ 5

References:

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VII . Manufacturing artificial feed

VII－1. Combined feed at Mwekera

Locally available raw materials including agricultural waste, food processing waste, trash fish, Lake Tanganyika shrimp and Kapenta are used to manufacture artificial feeds at Mwekera. The formulation of balanced artificial feed is still at experimental level. The vitamin and mineral pre－mix for trout used in the trials is imported from South Africa.

1－1. Manufacturing of Handy－Type Micro－Diet Feeds(H.T.－M.D.F.)

When fry have eaten all the plankton in the nursery pond, they are usually fed on micro－diets which are generally prepared according to the following method:

1. Chicken eggs are separated into the yolk and the albumen (egg white).
2. The yolk is mixed with skimmed milk, raw yeast, and vitamin and mineral premix. This step is carried out as quickly as possible to prevent fermentation.
3. Albumen and cooking gelatin are added to the mixture in step 2 and are mixed thoroughly.
4. The mixture is then steamed for 10 minutes and left to cool.
5. The cooled material is then wrapped in a plankton net, strained, and washed several times.

The remaining mixture is suspended in water and fed to the fry.

1–2. Production of feed for fingerlings

Fingerlings are fed on crumbs produced by crushing dried pellets. Pellets can be made using different types of machines. If dry pellets are not available, moist pellet can also be used. Moist pellts are made by mixing about 35% water to a quantity of raw materials. The pellets are then produced by passing the mixture through a mincing machine. The moist pellet, however, be dried before they can be crushed into crumbs. The pellets should be dried in the room since their exposure to direct sun light leads to the breakdown of vitamins by ultra–violet radiation, and in well–ventilated place to avoid rotting.

VII – 2. Feeding hatched and advance fry

2–1. Feeding of Handy–Type Micro Binding Feed (H.T–M.B.F.)

Egg Yolk and H.T–M.B.F. are used as first external feed for hatched fry during the first 2 to 3 days. At Mwekera, about 70% of survival rate of hatched fry were achieved by feeding of M.B.F alone for 10 days, although a slight reduction on growth rate is observed.

2–2. Feeding advanced fry

Artificial feed has to be supplied before natural feed in the pond has been completely consumed. The feeding is begun using paste feed. The paste is placed on hanging dishes from where the fry eat it. Sometimes the feed is moulded into balls and placed on the dishes. Crumbs are fed to fry after they have got accustomed to artificial feed. The protein requirement of young fish is high such that a protein content of 42% ~ 46% is necessary in the artificial feed. Another important factor in maintaining the quality of the feed is prevention of oxidation. Vitamin E, ethoxiquine etc, can be used for this purpose. Ethoxiquine can be present in quantities up to 150 ppm in feed.

By paying careful attention to the feed at Mwekera, a survival rate of 74.7 % between hatching and advanced stage was achieved.

VII – 3. Feed for fingerlings

It is generally thought that the required protein content in carp feed is rather lower than other species. However, the result of trials at Mwekera indicate this requirement is rather higher than normal. The composition of the artificial feed and its protein content are shown in Table Ⅶ −3−1 and Ⅶ −3−2. Using the Feed 1, a survival rate of 85% can be expected, with the fingerlings growing to 54.2 g from 1 g after 105 days application in an earthen pond.

The quantity of feed given to the fish depends on the temperature of water and the size of fish. The daily quantity of feed required can be estimated using the feeding rate table. As an example, the table for Carp feeding produced by Nagano fisheries station in Japan is shown in Table Ⅶ −3−3.

Table . Ⅶ -3-1

Composition and Protein Content of Feed 1 and Feed 2.

	Feed 1		Feed 2.	
	%	Protein Content %	%	Protein Content %
Shrimp	40	25. 40	25	15. 875
Kapenta	5	3. 325	5	3. 325
Soya Bean*	10	5. 556	20	9. 96
Soya Meal	7	3. 241	−	−
Rice Bran	5	0. 790	8	1. 128
Maize Bran	5	0. 5	15	1. 50
Wheat Bran	5	0. 79	15	2. 37
Wheat Flour	5	0. 78	5	0. 78
Bone Meal	5	0. 50	5	0. 50
Salad Oil	2	−	−	−
Vitamin Mix	2	−	1	−
Mineral Mix	2	−	1	−
Beer Waste	5	0. 85		−
Total	100	41. 732	100	34. 738

Table. Ⅶ -3-2.

The Growth of Carp by Feed 1 and Feed 2.

	Average Body Weight(g)	
Reared Days	Feed 1	Feed 2
0	1. 0	1. 0
15	3. 21	2. 82
30	4. 62	3. 75
45	4. 62	8. 87
60	10. 4	11. 3
75	13. 1	20. 27
90	22. 09	23. 46
105	24. 50	25. 21
120	30. 19	25. 61
135	46. 32	28. 4
150	47. 7	31. 0
165	51. 6	33. 1
180	65. 8	37. 1
195	78. 5	42. 1

Table. Ⅶ-3-3

Feeding Table of Carp

BW (g) / Wt(℃)	2.5~5.0	5.0~10.0	10.0~20.0	20.0~30.0	30.0~40.0	40.0~50.0	50.0~100.0
15	4.9	4.1	3.3	3.1	2.7	2.2	2.4
16	5.2	4.4	3.5	3.3	2.9	2.3	2.6
17	5.5	4.7	3.7	3.6	3.1	2.5	2.8
18	5.8	5.0	4.0	3.9	3.4	2.7	3.0
19	6.3	5.4	4.4	4.2	3.7	2.9	3.2
20	6.9	5.9	4.9	4.6	4.0	3.2	3.4
21	7.3	6.4	5.2	4.9	4.3	3.4	3.6
22	8.1	6.9	5.6	5.3	4.5	3.6	3.9
23	8.7	7.4	6.0	5.6	4.9	3.9	4.2
24	9.2	7.9	6.4	6.0	5.1	4.1	4.5
25	9.8	8.2	6.7	6.2	5.4	4.4	4.8
26	10.4	8.8	7.0	6.6	5.8	4.6	5.2
27	11.0	9.4	7.5	7.2	6.2	5.0	5.5
28	11.6	10.0	8.1	7.8	6.8	5.4	5.9
29	12.6	10.8	8.9	8.4	7.4	5.8	6.3
30	13.8	11.8	9.8	9.2	8.0	6.4	6.8

References:

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Ⅷ. Fingerling production with supplementary feed

Manuring culture is very commonly used in fish production from pond in Zambia. By this method fish can be produced at low cast and with little labour. However, the productivity levels are low when compared with those methods using artificial balanced feed.

One way to improve production at relatively low cost is to use a combination of manuring and supplementary feed. The materials used as feed are normally by-products of agricultural production such as maze husks, wheat bran, rice bran, beer waste etc,; they are not usually processed.

At Mwekera, an inexpensive method and cheap materials were used to make the combined feed (See. Table Ⅷ – 1). The result were compared with other culture methods. Lot 1.(Manuring + Maze Bran) and Lot 2 (Manuring + Combined Feed) resulted in higher growth rate than Lot 3. (Manuring only). See Table Ⅷ – 2.

This area requires further research since the economic aspects of commercial fish culture are of vital importance.

Table. Ⅷ -1

Composition of Home Made Supplementary Combined Feed

	%	C.Protein(%)	C.Fat(%)	Fiber(%)	Ash(%)	Value Kwacha/kg
Beer Waste	45	10.89	3.96	6.57	1.98	3.15
Wheat Bran	34	5.372	1.462	2.958	1.70	17.0
Soya bean (Oil extract)	5	2.315	0.065	0.25	0.305	20.0
Rice Bran	10	1.000	0.670	0.41	0.25	10.0
Maize meal	4	0.580	0.692	0.3	0.348	2.0
Bone Meal	1	0.503	0.113	0.011	0.306	4.5
Salad Oil	1	-	-	-	-	18.4
Total	100	20.660	6.962	10.499	4.889	75.050

Table. Ⅷ -2

The Growth of Fish in Each Lot

	Initial Weight	Average Weight After 60 Days	Average Increment/One
Lot 1.	12.4g	50.8g	38.4g
Lot 2.	12.4g	61.0g	48.6g
Lot 3.	12.4g	24.6g	12.2g

Lot 1.= Manure + Maze Bran, Lot 2.= Manure + Combined Feed, Lot 3.= Manure only.