CHINESE-AMERICAN

JOINT COMMISSION ON RURAL RECONSTRUCTION

Fisheries Series: No. 2

THE CULTURE OF TILAPIA IN RICE PADDIES IN TAIWAN

By

Tung-Pai Chen

Fisheries Specialist

TAIPEI, TAIWAN, CHINA

First Printing August, 1953

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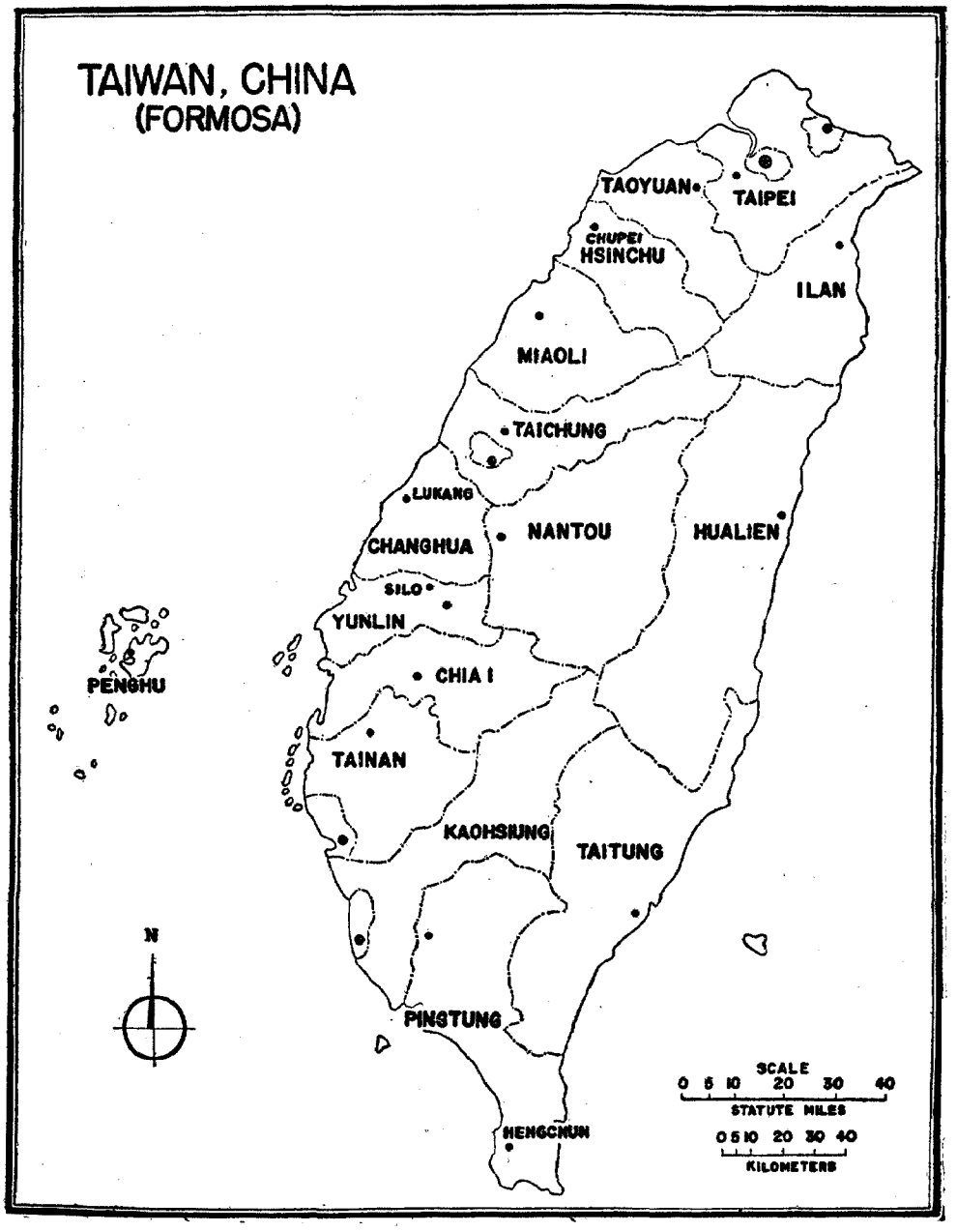
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Acknowledgement

Thanks are due to Messrs. Yun-An Tang and Tsing-Chi Chou of the Taiwan Fisheries Research Institute for supplying most of the information on the habit of the Tilapia and the method of paddy culture, and to Mr. Chih-Shiu Cheng of the Taiwan Fisheries Bureau for furnishing the data on the Tilapia extension project. Mr. Chou also furnished most of the photographs used for illustration in this report.

The Culture of Tilapia in Rice Paddies in Taiwan

By T. P. Chen

Fisheries Specialist, Joint Commission on Rural Reconstruction, Taiwan

The Culture of Tilapia in Other Countries and Its Introduction into Taiwan

South Africa. - The *Tilapia mossambica* Peters, with which this report is concerned, is one of the several species of the genus Tilapia belonging to the big family of Cichlidae. According to Hey (1), this group is represented by five species (*Tilapia mossambica* Peters, *Tilapia melanopleura* Dum., *Tilapia sparrmanii* A. Smith, *Serranochromis thumbergi* Cast., and *Haplochromis moffatii* Cast.) in South Africa, where they are commonly known as "kurpurs". The *Tilapia mossambica* is the most common and best known of the group. They are widely distributed throughout the inland waters and even found below the tidal limits in rivers. In South Africa, the *Tilapia mossambica* is amenable to culture in dams. It grows to 5 lbs. with the average in the vicinity of 2½ lbs., and is considered a fish of high table quality.

Indonesia. - The spread of *Tilapia mossambica* to southwestern Asia probably began with Indonesia. According to Schuster (2), it is not known how the fish reached Indonesia. The first fish were caught in Java in the middle of 1939 by the fishery foreman Pak Mudjair, whose name was later given to the fish. He planted the fish in his own ponds. Within a short time, the fish multiplied and spread on a large scale. Schuster also said that, during the Japanese occupation, the Tilapia was taken from Java to Sumatra, Malacca, Siam and Burma. The Japanese occupation army made

* The information contained in this report has been brought up to date in the second printing.

wide distribution of this fish to the fish farmers when the milkfish fry became difficult to obtain due to stopping of coastal shipping during the War, and the Tilapia became firmly established in many parts of Java. The fish now makes up a great part of the fish production from Central Java swamps, which were formerly practically non-productive (Rawa Besar 1946-48 : average 140,000 kg. a year, Rawa Gunung Rowo 1947 : 12,000 kg., Rawa Gembong 1947 : 15,000 kg.).

The Tilapia grows to a weight of one pound or more in eight months in the milkfish ponds in Java (3). The highest yield per unit area in the milkfish ponds of Heemraad in 1947 was 262 lbs. per acre (294 kg. per ha.). The people of Java have learned to like this fish, although it is still priced considerably lower than the milkfish.

Malaya.- The *Tilapia mossambica* was introduced into Malaya from Java by the Japanese during the latter part of the occupation period (4). The fish is now eaten by all classes of people and is generally considered a second grade food fish.

The best growth rate for this fish was recorded in brackish water ponds in Singapore, where fish up to 30 oz. in weight and not more than one year in age have been captured. The maximum size in ponds is 33 cm., and the usual size is 22 cm. Under ideal conditions, the fish attains a size of 15 to 20 cm. in six months. In experimental ponds run by the Fisheries Department, a yield of 1,065 lbs. per acre (1,173 kg. per ha.) annually has been recorded. In another experiment in which hog manure was run into a pond stocked with Tilapia, a yield of about 2,500 lbs. per acre (2,807 kg. per ha.) per year was obtained.

The common practice in Malaya is to rear the Tilapia in company with imported Chinese carp (*Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix* and *Aristichthys nobilis*). The Fisheries Department also carried out experimental rearing of the fish in rice fields. In this respect, the main difficulty was said to be the presence of predators such as *Ophiocephalus striatus*, *Clarius batrachus* and *Anabas testudineus*.

Philippine Islands.- The *Tilapia mossambica* was introduced into the Philippines from Bangkok, Thailand, in May, 1950, through the initiation

of the Director of Fisheries, D. V. Villadolid (5). The imported stock was first reared in the Dagat-dagatan Pondfish Experiment Station, where they spawned in three months. Since then, the fish has been transplanted to several government hatcheries and private fish ponds, which now distribute the fry. It is considered a good table fish in the Philippines, and attains table size in three months if placed in spaceous ponds with enough food.

Thailand. - Two hundred Tilapia were imported to Thailand from Indonesia by the United Nations Food and Agriculture Organization in 1950, according to Oscar Ochs (6). They have become very popular and well liked by the native people. It was reported that the hatcheries at Thailand were producing 100,000 Tilapia fingerlings monthly for distribution to farmers, and might increase the production to 250,000 a month very soon. The fry are shipped by air in fish-seed containers provided with oxygen.

West Indies. - *Tilapia mossambica* was first introduced into St-Lucia, British West Indies, from Malaya in 1950 (7). In the same year, about 400 of them were shipped by air from St-Lucia to Jamaica, where they established themselves and thrived. In June, 1951, 103 Tilapia were introduced from Jamaica to Haiti under the Fish Culture Project assisted by the United Nations Food and Agriculture Organization. The fish grew rapidly and multiplied by hundreds at the end of August in the same year.

Taiwan. - It was reported that actually the Tilapia was introduced into Taiwan from Indonesia by the Japanese in 1944, when both Taiwan and Indonesia were under Japanese occupation. The fish were planted in the fresh water ponds in Pingtung, which is the southernmost prefecture of the Island. But they did not spread to the other areas, and were not given much publicity. In 1946, Wu Chen-huei (吳振輝) and Kuo Chi-chang (郭啓彰), two Taiwan Chinese returning from Singapore, brought thirteen Tilapia to Kaohsiung, also a prefecture in southern Taiwan. They placed the fish in their own ponds, and the Tilapia multiplied and spread until they are now a common fish in all parts of the Island.

The Taiwan Fisheries Research Institute took up the study of the feeding and spawning habit of Tilapia in 1950, and conducted an experiment

on the paddy culture of the fish in 1951 (8). Encouraged by the results, the Government launched an extensive extension project on the culture of Tilapia both in ponds and paddy fields in 1952. This project was continued with greater effort in 1953.

The culture of Tilapia in Taiwan faces a most formidable difficulty, i. e., the unfavorable climate. Being a tropical fish, the Tilapia has been found to be a very hardy fish in all the countries mentioned above, where the year-round high temperature is favorable to the fish. The success of the culture of this fish is so phenomenal and its achievement so effortless in Thailand, Oscar Ochs, a FAO staff writer, said: "All a farmer has to do is pour a can of Tilapia fingerlings into his pond and he is in the business - as a fish farmer." He also said "The fish eats like mad, grows like mad and spawns like mad" (6).

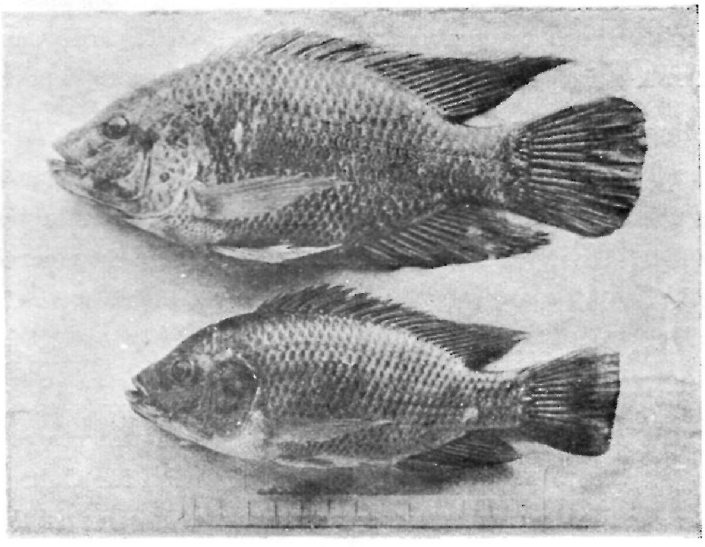
In Taiwan, the climatic factor has made this picture much less rosy. The fish is killed by the low winter temperature in natural waters in most part of Taiwan. The spawning and growing season is limited to about seven months in most of the areas. Consequently, the supply of the fry and the preparation and management of the ponds and fields are all problems that the fish culturist has to face.

The Habit of Tilapia Mossambica

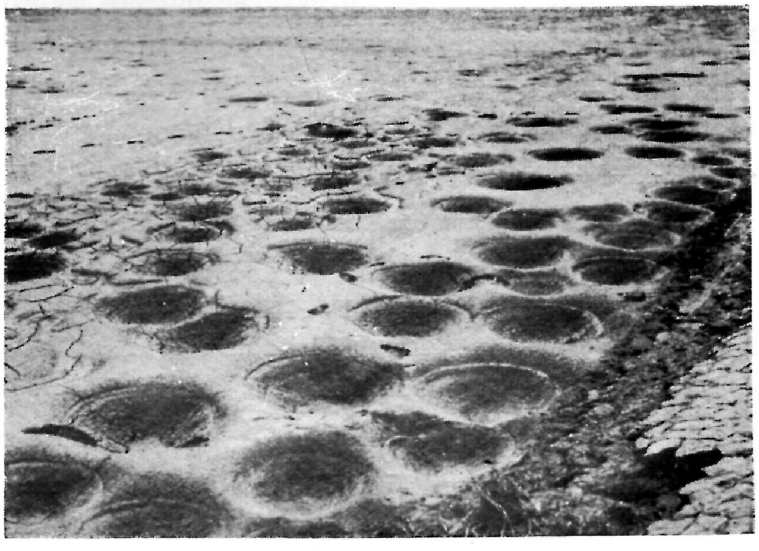
Tilapia mossambica Peters (Synonyms: *T. vorax*, *T. natalensis*, *T. arnoldi*) is one of the African cichlids known commonly as mouthbreeders. It grows to fairly large size in its native country, reaching a length of 360 mm. (9). In Malaya, the usual size is 220 mm., which it attains in about eight months. In Taiwan, due to over-crowding in the ponds and the shorter growing period, the fish rarely attains 200 mm. in length. The largest specimen seen by the writer was about 18 oz. in weight.

It is a fresh water fish, but also occurs in brackish water, even that of fairly high salinity. According to the observation of Hofstede (10), the *Tilapia mossambica* was not affected by salinity as high as 6.9%, and spawning occurred in water of salinity ranging from 3 to 4.8%. Being a tropical

Plate I



a. *Tilapia mossambica.* Upper, male; lower, female.



b. Saucer-shaped nests made by the spawning Tilapia for deposition of eggs.

fish, the minimum temperature it tolerates is reported to be approximately 10° C. (11). It has been experienced in Taiwan, however, that prolonged exposure to cold, even at temperature above 14° C., will cause heavy mortality of the fish in ponds.

The most interesting thing about the fish is its breeding habit, which causes it to be known as a mouthbreeder. The spawning season of the fish in southern Taiwan is from March to November, extending sometimes to early December, during which period the temperature is generally above 23° C.

In Taiwan, the fish are ready to spawn when they reach the age of three months. According to a report of the Taiwan Fisheries Research Institute (12), the number of eggs from each spawning increases with the size and age of the fish. The records of the Chupei Fish Culture Station of the Institute show that each spawner of about 8 cm. in length (3 to 4 months old) produces 100 to 150 eggs at each spawning, as compared to 200 to 250 eggs from fish of about 11 cm. in length (about 6 months old). The records of the Lukang Fish Culture Station show that the first spawning of a fish produces less than 100 eggs; the number increases with each successive spawning and may exceed 1,000 eggs with a spawner of over six months old (about 70 gm. in weight). Tang of Taiwan Fisheries Research Institure counted over 800 hatched fry that emerged from the mouth of a large female.

The sexes of the *Tilapia mossambica* can easily be differentiated by the genitalia (3 orifices in the female and 2 orifices in the male). The males are also distinguished from the females by the darker body color and the deep red of the fins as compared with the dull olive color of the females (Plate I. a). The males are also much larger in size. The proper sex ratio for propagation purpose is one male to each female.

It is observed in the Tainan Fish Culture Station of the Taiwan Fisheries Research Institute that, before spawning, the pair of parent fish make a saucer-shaped depression on the pond bottom by digging with their mouths. The bottom soil is taken into the mouths by the pair of fish and is deposited just outside the depression by expelling through the gill-slits.

Then the floor of the depression is leveled wiith the pectoral fins. The depressions vary in diameter length from 30 to 90 cm. and in depth from 10 to 30 cm., depending on the size of the fish and the nature of the bottom. (Plate I. b) The digging of holes, however, is not absolutely necessary for spawning to take place. The writer has seen Tilapia spawning successfully in a garden pond with conerete bottom.

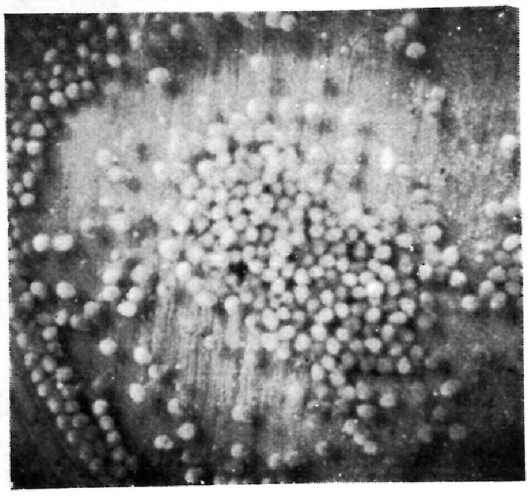
Spawning usually takes place at dawn or early in the morning of a calm day. The female fish swims around and above the depression to drop its eggs, closely followed by the male, which turns its belly upward and ejects the sperm. The fertilization act thus completed, the female fans up the eggs with its pectoral fins and picks them up in its capacious mouth. The eggs are heavier than water and non-adhesive. They are shaped like hen's eggs, about 2.5 mm. in the long diameter, and of a beautiful yellow color (Plate II. a). In the mouth of the female fish, the eggs are hatched in about 60 hours at 28° C.

The larvae just hatched are about 4 mm. in total length. They are feeble, and remain in the protection of the mouth of the female fish during the entire larval stage. This larval period lasts 3 to 5 days, at the end of which the yolk is completely absorbed and the total body length attains 8 mm. In another 2 or 3 days, the fry become stronger and swim out from the mouth of the female fish (Plate II. b).

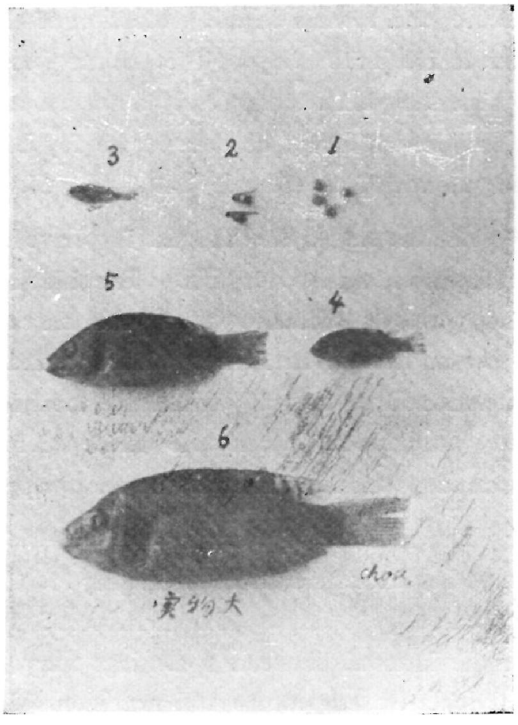
At this stage, the Tilapia fry have many enemies, such as frogs, eel, snake-head, and other fish. The black coloration of the body begins to fade; two faint black spots remain on the dorsal fin and darken as the fish grow in size. When the total length reaches 17 mm., the body assumes a greenish silver color. When the total length of 40 to 50 mm. is attained, the young fish assume the shape, color, and habit of the adults, and secondary sexual characters begin to appear (Plate II. b).

The number of spawnings by one fish in one year is observed to be 6 to 16 in southern Taiwan, averaging 11. The interval between two spawnings is generally 22 days. The number of spawnings each year and the length of the interval between spawnings vary, of course, with the enviroment, particularly tempeature and nutrition. It is observed in the Tainan Fish

Plate II



a. The eggs are shaped like hen's eggs, about 2.5 mm. in the longer diameter.



b. Development of the *Tilapia mossambica*: (1) Eggs, (2) Fry wth yolksacs, (3) 1 week after hatchig, (4) 2 weeks after hatching, (5) 4 weeks after hatching, (6) 6 weeks after hatching.

Culture Station that, without sufficient feeding, the spawning is very light, and sometimes there is no spawning at all.

The optimum temperature for propagation of the Tilapia seems to range from 20° C. to 35° C. It was observed at the Chupei Fish Culture Station that spawning was very light in the months of July and August when the water* temperature was as high as 38° to 40° C. at mid-day. The fish appeared to be in a state of discomfort at the above stated temperatures. This condition may be due to the insufficient supply of oxygen in the water at such temperatures, or it may merely be due to the high salinity of the pond water in mid-summer when there was very little rainfall.

Salinity has been found to be an important factor when the propagation of Tilapia is carried out in brackish water. It has been found in the Tainan Fish Culture Station that brackish water of 1.02 or 1.03 in specific gravity is suitable for propagation of the fish. In water with specific gravity of 1.08, spawning was also observed, but no larvae were obtained—the eggs probably failed to hatch.

The Tilapia is not strictly herbivorous although its food is mainly vegetable. It feeds on plankton, algae, decomposed vegetable matter, rice bran, soybean meal, chopped meat and fish, etc., but it has been observed to reject live food which is readily taken by the carp. It is not a ferocious fish, as its appearance seems to suggest. In an aquarium, a few young Tilapia have been observed to live peacefully with several species of Cyprinids of the same size. In the fish pond, they are therefore not predators, but are liable to rob the other fish of their food.

The cannibalistic tendency of the Tilapia when the youngs are placed in the same pond with the larger fish has been studied by the Taiwan Fisheries Research Innstitute. The conclusions reached are:

1. The youngs of Tilapia of less than $1\frac{1}{4}$ inches in length are liable to be eaten by the older fish. The liability increases with the decrease in the size of the young fish.

2. All Tilapia above 3/4 inch in length are capable of eating the

younger fish, but not when the disparity in size is too small. It was observed that Tilapia of 7 inches long were capable of eating the youngs up to $1\frac{1}{4}$ inches in length; fish of 3 to 6 inches in length were capable of eating the youngs up to $\frac{1}{2}$ inch in length; and fish of 3/4 inch in length were capable of eating the youngs up to 3/8 inch in length.

3. Cannibalism increases when no feeds are given.

The above study indicates that Tilapia should be at least $1\frac{1}{4}$ inches in total length when being planted in paddy fields, where natural enemies are present.

It has been observed in Taiwan that the growth rate of the female Tilapia slows down considerably after it starts on its spawning activities, and there is a growing disparity in the size between the male and female fish in the same pond. The segregation of sexes has been proposed to eliminate reproduction so as to increase the growth rate of the female. This would also enable the control over the population of the fish in the pond, making it unnecessary to thin the stock from time to time. The difficulty is, of course, the differentiation of the sex of the pre-mature fish by inexperienced fish farmers.

The Culture of Fish in Rice Paddies

The utilization of rice paddies for the production of fish has long been tried on the China mainland and has attained considerable success in Japan. In both countries, the common carp is the fish cultured in most cases. In mainland China, the practice has met with little success, except in isolated instances because (a) most of the rice fields are not provided with adequate irrigation facilities, (b) the growth of the common carp is slow, especially in the cooler regions, and (c) it is difficult to prevent poaching in a country where most of the population live in dire poverty. It may be said that the paddy culture of fish in mainland China has never been practiced on any significant scale although much effort has been made to promote it.

According to McKernon (13), the culture of carp in rice paddies in

Japan began to flourish after about 1919. In certain areas of Japan, the rice paddy culture of carp has become an established practice, and the land yields three crops - wheat through the winter and spring and rice and carp in the summer and fall. According to the Japan Fisheries Agency (14), the total area of paddy fields utilized for fish production in 1949 reached 226,186 acres, with a total production of 937.5 metrie tons of fish. This is roughly 3.23% of the total rice paddy acreage in Japan.

The advantages of culture of fish in rice paddies generally claimed are:

1. The most economical utilization of land is achieved, since the same land is used for production of rice and fish.

2. The farmer can take care of the fish at the same time he takes care of the rice crop. Therefore, very little extra labor is required. He is also compensated by the saving of labor due to elimination of weeding to a certain extent.

3. The quantity of feeds, if any are given, is less than when the fish are cultured in ponds.

4. The rice yield is increased due to less insect pests and increase of organic fertilizer.

There seems to be little doubt that paddy culture of fish gives the farmers an additional source of income. McKernon (13) cited an experiment by the Nagano Prefecture Experimental Station in Japan in 1947, in which the yield of carp varied from 127 to 220 lbs. per acre when no feeds were given other than the usual fertilization of the rice fields. It is estimated that as much as 1,500 lbs. can be produced per acre when the carp are fed.

The adverse effects of paddy culture of fish on the rice crop are:

1. The deeper water required for fish, 4 inches or more, is not beneficial to rice, which requires shallower water.

2. If the fish are introduced when the rice plants are too small, they may cause injury to the young plants.

The general opinion is that only selected types of rice should be planted

in fields in which fish are to be reared. Furthermore, only rice fields with adequate irrigation and good drainage facilities should be used for fish culture. Otherwise, drying up of the field or flooding may cause total or partial loss of the fish.

The culture of Tilapia in rice paddies has opened up new possibilities. First, the Tilapia grows more rapidly than the carp and is marketable in smaller size. Secondly, it tolerates nearly all kinds of conditions in shallow water and small ditches. Finally, it is an indiscriminate feeder and is more voracious than the carp.

The culture of Tilapia is not possible in Japan or the China mainland due to the comparatively cold climate in these countries. However, the paddy culture of Tilapia is being practiced in a number of countries in Southeast Asia, although not to the extent as in Taiwan.

The Method of Paddy Culture of Tilapia

In 1951, the Taiwan Fisheries Research Institute carried out experiments on the paddy culture of Tilapia at Silo (Yunlin Prefecture) and Hsinchu. As a result, a practical method of paddy culture was developed, and has been followed by fish farmers with satisfactory result. To promote the paddy culture of Tilapia and to acquaint the farmers with the proper method thus developed, the Joint Commission on on Rural Reconstruction published in February, 1952, a pamphlet in the Chinese language entitled "How to Rear Tilapia in Rice Paddies" (15) for distribution to interested farmers and various farmers' associations and fishermen's associations. The following paragraphs are mostly translation from this pamphlet, which was prepared by the writer in collaboration with the Taiwan Fisheries Research Institute.

Selection of Rice Paddies for Tilapia Culture.- Because the Tilapia is a tropical fish, the rice fields in southern Taiwan are more suitable than those in northern Taiwan for the culture of this fish. Not only are the fry of Tilapia more easily available in the South, but the growing period of the fish is considerably longer there. To be suitable for Tilapia culture,

the rice paddies should have the following qualifications:

1. Where two crops of rice are cultivated;
2. Where there are adequate irrigation and good drainage facilities and where drought and flood do not frequently occur;
3. Where there is little seepage of water.

Preferably, the fields should be in close proximity to the farm houses, so the farmers can give them close supervision and guard them against poaching. It is also desirable for the fields to have a gentle slope so as to facilitate drainage and harvest of the fish.

Preparation of the Field. - It is necessary to dig a ditch circling the entire field (or on all four sides of a square field); but, in case of a field less than half hectare in area, a ditch around half of the field (or on two sides of a square field) would be sufficient (Fig. 1). The width and depth of the ditch depend on the size of the fish to be reared. To rear the fish to an average weight of $2\frac{1}{2}$ oz. each, a depth of 2 to 3 feet and a width of 4 to 6 feet are recommended. To rear the fish to a larger size, the depth and width of the ditch should be increased. If the area of the field exceeds one hectare, it may be necessary to dig an additional ditch of six inches in depth and one foot in width across the center of the field running parallel to the slope. The earth from the excavation should be piled on the levee to increase its height to about two feet to prevent the escape of fish as well as inundation in case of flood. Any surplus earth may be used to increase the width of the levee, on which vegetable crops may be grown.

Some farmers, instead of the above arrangement, dig the ditch across the center of the field perpendicular to the bordering foot path. In case of a large field, a number of ditches parallel to one another may be dug. The farmers claim that this arrangement makes the stealing of fish more difficult.

The purpose of the ditch is to provide a place for the fish to stay in when the field is drained of water during transplantation, application of fertilizers, and harvesting. It also serves as a place of breeding and to hold the fish during an emergency. The ditch is very important and must not be omitted. It has been found on some fields where the ditches were

too small that the rice plants were injured by digging of nests or depressions by the fish during spawning.

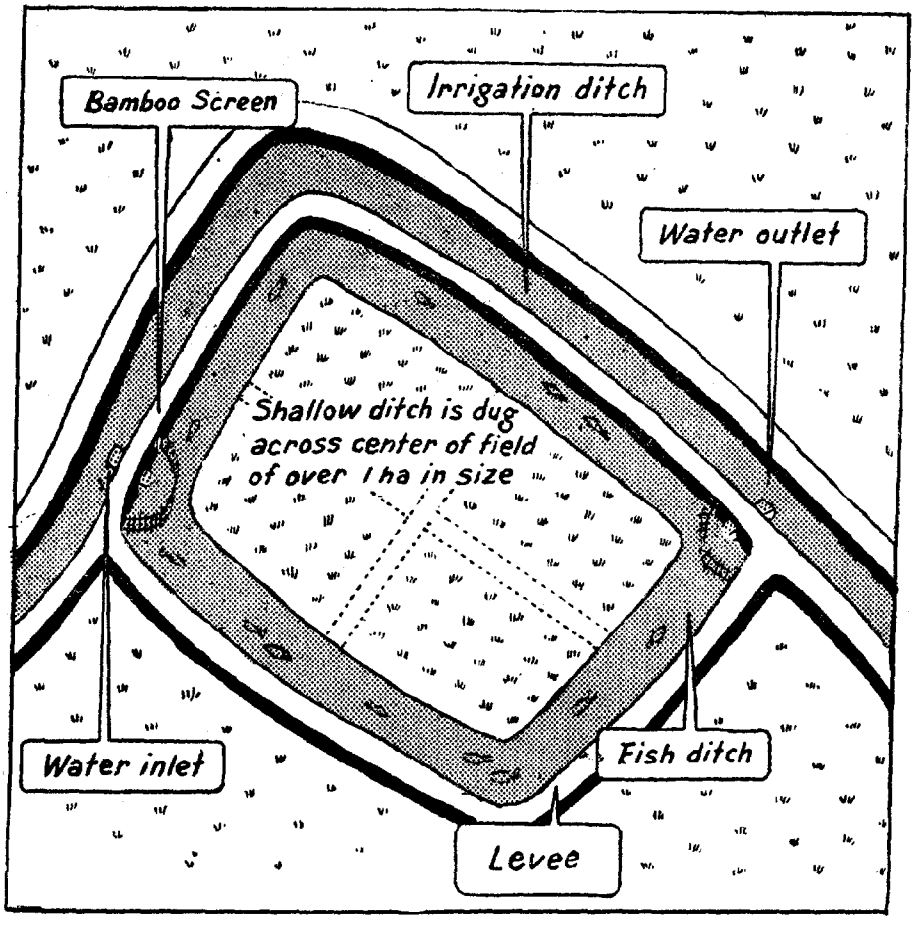


Fig. 1 Preparation of Paddy Field for Tilapia Culture

Water inlets and outlets should be provided at the higher and lower sides of the rice fields respectively. Wooden sluice gates, provided with sliding boards to regulate the flow and wire screens to prevent the escape of fish, are ideal but may be too expensive. For simplicity and cheapness, a bamboo or clay pipe may be inserted in the levee at the proper level to serve as the inlet or outlet. The pipe is stoppered with a wooden plug. When water is let in or out, the plug is removed and a bamboo screen set up to prevent the fish from escaping.

Fertilizing the Field. - When a rice field is to be stocked with fish, more fertilizer is required than when no fish are to be planted. The quantity of fertilizer used should be 50% to 100% more than in common practice on rice fields. All kinds of fertilizers commonly used in Taiwan may be applied, except calcium cyanimide, which is poisonous to the fish. However, compost, green manure, and night soil are preferred, since they are also consumed by the fish as feeds. The way of application is the same as in common practice, but it is not necessary to fertilize the ditch, as sufficient fertilizer will be washed into it when the field is being flooded.

Planting the Fish. - The time of planting the fish varies as to locality, but, as a rule, the Tilapia should only be planted when the water temperature has gone above 15° C. and is not liable to drop much below. Furthermore, the Tilapia fry should not be planted until about ten days after the rice seedlings have been transplanted to avoid any damage that the fish may cause to the rice plants; and, if the fish are of fingerling size, they should not be introduced until about three weeks after transplantation of the seedlings. The number of Tilapia fry to be planted in each hectare of rice field is 7,000 to 8,000. If fish of fingerling size are planted, 120 to 180 kg. to each hectare are recommended.

Field Management. - During the first month after planting the fish, there is an abundant supply of natural food in the rice field, and feeding is not necessary, but it would be advantageous to put in any unconsumed food or surplus compost that the farmer may have on hand. As much water as the rice plants will tolerate should be allowed to stand in the field. A minimum of three inches of water is considered necessary. Change or leakge of water means loss of fertility and should be avoided as much as possible.

In the second month, some fertilizer should be applied as top dressing. Generally about 2,000 kg. of compost or 3,500 kg. of night soil may be applied to each hectare. If chemical fertilizers are used, sufficient water should be drawn off to expose planted area and drive the fish into the ditch before applying the fertilizers on the exposed surface. After 2 or 3 days have elapsed, the field may be flooded again (Plate III, a).

It is also necessary to feed the fish with rice bran, soybean meal, etc. during this second month. The amount of feeds to be given depends on the number and size of the fish. For 100 kg. of fish, 2 to 3 kg. of feeds should be given daily. In this case, 10 to 20 kg. of feeds given daily should be sufficient for each hectare of rice field.

The first and second weedings should be carried out as in common practice on rice fields, but the third weeding may be omitted.

To prepare for the harvest of the first rice crop, the water in the field is drained off and the fish are held in the ditch. During the time when the fish are confined in the ditch, feeding should not be discontinued but the quantity of feeds may be cut down.

By this time, a number of the fish will have reached the individual weight of 2 oz. and may have spawned. If large number of fry are discovered, the larger fish should be removed to thin the stock and make room for growth. This is the first fish crop, and may be marketed or consumed by the family.

After the first rice crop is harvested and when the fish are still in the ditch, fertilizers should be immediately applied to the field as in common practice. Then, after a lapse of 2 to 3 days, the field is flooded with water up to a few inches from the top of the levee. For fields which do not hold water well, the water should be replenished from time to time to maintain the high water level.

The rice field at this stage is comparable to a fish pond. The fish are given plenty of room to move about. The rice stalks that remain in the field are allowed to rot in the water to serve directly as food of the fish and as nutrient for the plankton organisms. The most rapid growth of the fish is therefore expected during this period.

During the transplanting of the rice seedlings of the second crop, the water in the field is again drained off, and the fish are collected in the ditch. A small mud dike of 18 inches high and 12 inches wide is thrown up between the ditch and the exposed surface of the field to prevent the fish from invading the planted area (Fig. 2 and Plate III. b). Sufficient

Plate III

a. Paddy at Yunlin Prefecture with first crop of rice, showing ditch.

b. Paddy with Tilapia just after transplanting of seedlings of second crop of rice, showing ditch and mud dike to prevent invasion of fish into the planted area.

time is allowed to elapse for the rice seedlings to become firmly rooted, before the field is again flooded and the fish allowed to enter the planted area.

The temporary mud dyke should be removed at this time to allow free passage of the fish between the planted area and the ditch.

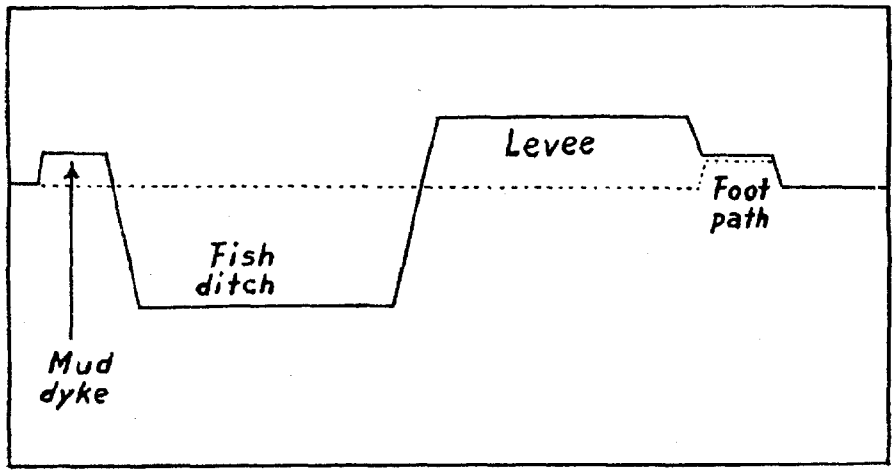


Fig. 2 Cross Section of Paddy Field for Tilapia Culture. Dotted line indicates cross section before re-arrangement.

The first weeding in this second crop season should be carried out as in common practice, but the second and third weedings may be omitted.

Harvesting the Fish. - After the second crop of rice is harvested, a deep pool of 6'×6' in area and 4' in depth is dug at a point near the water outlet to serve as a place for collecting the fish. The water in the ditch is now drained off to as low a level as possible, and the fish are driven to the deep pool to be taken out by dip nets. The fish thus captured may be marketed or consumed by the farmers themselves. The harvesting of the fish must not be delayed too long, especially in northern Taiwan, as a cold spell may set in and kill all the fish.

Experiment on Paddy Culture of Tilapia

In 1951, the Taiwan Fisheries Research Institute contracted with three

farmers at Silo (Yunlin Prefecture) to conduct an experiment on the paddy culture of Tilapia with the object to find out the feasibility of this practice and the proper method of field preparation and management. The results of this experiment are tabulated as follows:

	Field No. 1	Field No. 2	Field No. 3
Area	1.0 ha.	1.0 ha.	1.2 ha.
Rice varieties			
1st Crop	Horai, Kaohsiung #10	Horai #150; Native, high stalk; Native, low stalk	Horai, Taichung #65
2nd Crop	Horai, Chianan #8	Native, white non-glutinous	Native, Mintun
Number of fish planted	12,080	8,140	7,000
Size of fish planted	3 - 8 cm.	3 - 8 cm.	8-25 cm.
Feeds given,			
Rice bran	374 kg.	204 kg.	228 kg.
Peanut meal	99 kg.	---	186 kg.
Fish harvested	484 kg.	239 kg.	222 kg.
Rice harvested			
1st Crop	4,020 kg.	3,600 kg.	3,600 kg.
2nd Crop	2,880 kg.	2,700 kg.	3,300 kg.
Rice harvested in previous year			
1st Crop	4,200 kg.	3,900 kg.	4,032 kg.
2nd Crop	3,300 kg.	3,150 kg.	3,240 kg.

The preparation and management of the paddy fields were in accordance with the method described in the chapter "The Method of Paddy Culture of Tilapia" with some small deviations. The fish were reared in the rice fields throughout the first and second rice crop seasons. The quantities of harvested fish listed in the above table do not include the fish which were too small for the market or for consumption.

Some of the conclusions reached from this experiment are:

1. Almost any varieties of rice may be planted with fish in the first rice crop season, but varieties with strong, short stalks are preferred for the second crop, for the reason that the soil at the time of planting the second crop is softer and the fish are larger and more active.

2. There was slight decrease in the rice crop when fish were reared in rice fields due to the fact that 5 to 7% of the area of the fields was turned into ditches.

3. Half of the labor of weeding was saved when Tilapia were reared in rice fields.

4. The average yield of Tilapia per hectare of rice fields was 303 kg.

5. The total yield of paddy rice in the three fields under experimentation was 20,100 kg., or 6,281 kg. per hectare. The total yield from these fields in the previous year when no fish were planted was 21,822 kg., or 6,819 kg. per hectare. The loss in yield was therefore 538 kg. of paddy rice per hectare. This is compensated by an average yield per hectare of 303 kg. of fish which were sold or eaten and a large number of small fish which were held over for planting in the next year or used as poultry feed.

Extension of Paddy Culture of Tilapia in Taiwan

The program on extension of paddy culture of Tilapia in Taiwan was initiated by the Taiwan Provincial Government in 1953 with the aim of increasing fish production to meet the civilian and military need. The target set for 1952 was 5,080 hectares of paddy fields and fish ponds. According to the unpublished report of the Taiwan Fisheries Bureau, the actual acreage stocked with Tilapia in 1952 was 3,438 hectares of paddy fields and 1,906 hectares of fish ponds. The total production of Tilapia in that year is estimated as 3,446 metric tons. The total number of Tilapia fry distributed was 55,064,863, of which 21,644,439 were released by the Taiwan Fisheries Resarch Institute.

The target for 1953 is 8,400 hectares (inclucing paddy fields and

ponds). The number of Tilapia required was 67,200,000 (8,000 to each hectare). The total fish production expected was 5,000 metric tons. According to unofficial report, about 6,000 hectares of rice fields and ponds were stocked with Tilapia in 1953 (3,000 hectares of rice paddies and 3,000 hectares of ponds). The total production of Tilapia in 1953 was 6,300 metric tons, of which 2,165 metric tons were from rice paddies.

Under this program, two kinds of work were undertaken by the Government: (a) the propagation and distribution of Tilapia fry, and (b) the construction of wintering ponds. A brief account of the work is given as follows:

Propagation of Tilapia - In order to supply the Tilapia fry needed for this program, large-scale propagation work was carried out by the Taiwan Fisheries Research Institute at three propagation centers, i. e. the Tainan Fish Culture Station, the Lukang Fish Culture Station, and the Chupei Fish Culture Station. In addition, a number of prefectural and municipal governments and farmers' associations also carried out propagation work themselves. The work of the three propagation centers of the Fisheries Research Institute in 1952 is shown in the following table:

	Pond area (hectares)	Number of stock fish	Number of Tilapia fry released
Tainan Station	31.08	179,372	14,843,400
Lukang Station	3.86	64,160	4,753,789
Chupei Station	1.17	30,000	2,047,250
Total	36.11	273,532	21,644,439

As the target set for the three propagation centers was a total of 50,000,000 fry, the total of 21,644,439 fry released was far short of the number expected. This was due to many reasons, one of which was the very small number of fry obtained from each stock fish (regardless of sex) during the entire period—74 at Tainan and Lukang and 68 at Chupei. Under normal condition, it is believed possible to obtain 1,500 to 2,000 eggs from each pair of spawners in a year.

According to the Fisheries Research Institute, many difficulties, most of them relative to management, were encountered in carrying out the propagation and distribution work. These may be enumerated as follows:

1. Late starting - Because the stock fish were purchased from fish farmers, they were not obtained until March, and spawning did not take place until April.

2. Delay in appropriation of fund has caused delay in some important work, such as preparation of ponds and purchase of feeds.

3. Insufficient fund has resulted in insufficient feeding, which affected the frequency and size of the spawning.

4. Delay in taking delivery of the fry. - Most of the prefectural and municipal governments failed to take delivery of the fry at the time when they received the notification of the Institute. This had two detrimental results: (a) The nursery ponds of the Institute became over-stocked, resulting in heavy mortality of the fry held, and (b) The fry became too large, resulting in heavy loss during transportation.

5. Careless handling of the fry. - The fry were distributed free of charge at most places. Because they cost nothing, the men in charge of transportation and distribution did not handle them with sufficient care.

Construction of Wintering Ponds. - In 1953, the Taiwan Fisheries Bureau started a project on the construction of wintering ponds for Tilapia. The object was to make the fry of Tilapia available in all parts of Taiwan instead of from a few supply centers as in the previous year. A total of 42 wintering ponds were constructed at various localities north of the line of Tropic of Cancer, in addition to the wintering ponds of the Fish Culture Stations at Chupei, Lukang and Tainan. Their location, area, water condition, and the survival rate of the fish are shown in the following table:

	No. of Ponds	Total Area	No. of Fish Held	Survival Rate	Source of Water	Temperature of Water
Yilan Prefecture	2	0.12 ha	120,400	83%	Spring	
Taipei Pefecture	3	0.26 ha	50,450	34%	Spring & surface	
Taoyuen Prefecture	12	0.68 ha	225,000	30%	Mostly surface	
Chupei Fish Culture Sta.	1	0.60 ha	30,890	91%	Spring	20°-24°C.
Hsinchu Prefecture	10	0.60 ha	256,000	20%	Mostly surface	
Miaoli Prefecture	4	0.20 ha	114,445	75%	Spring & surface	
Taichung Prefecture	7	0.26 ha	115,516	83%	Surface	
Nantou Prefecture	2	0.13 ha	53,385	85%	Surface	
Lukang Fish Culture Sta.	2	0.13 ha	30,860	50%	Surface & well	18°-20°C.
Changhua Prefecture	2	0.28 ha	152,160	80%	Surface & well	20°C.
Tainan Fish Culture Sta.	5	0.77 ha	274,937	90%	Surface	15°-27°C.

The fish held in the above ponds were generally 8 to 15 cm. in length at the start, and were held for about 150 days. Feeds were given on warm days.

The wintering ponds in southern Taiwan, e. g., in Tainan, were similar to the wintering ponds for milkfish. They were about four feet in depth and protected on the windward side by a windbreak. They have been found to be quite adequate in southern Taiwan. The experience is, during a cold spell, the milkfish die before the Tilapia.

In northern Taiwan, the wintering ponds for Tilapia should be supplied with spring water, which has a temperature several degrees higher than that of the surface water. The wintering ponds of the Chupei Fish Culture Station has an abundant supply of spring water, and has given the best result. When the fish were being recovered from this pond in April, a large number of Tilapia fry were found, indicating that the fish had spawned in the pond.

Propagation of Tilapia in ponds fed with hot spring water has proved successful in northern Taiwan, where Tilapia ordinarily do not spawn until April or May. In the early part of 1954, the Joint Commission on Rural Reconstruction and the Taiwan Fisheries Bureau gave joint assistance to the Ilan Prefectural Fishermen's Association to construct a number of ponds at Chiaochi, where hot spring water is piped into the ponds to obtain a more or less constant temperature of 25 degrees Centigrade. Tnese ponds were ready for use in the early part of April, and nearly two million fingerlings were obtained before the end of May.

In 1954, the target area for the Tilapia extension program is 8,000 hectares of rice paddies with an estimated production of 2,400 metric tons of fish. The program also includes a project on the demonstration of Tilapia culture in rice paddies, which is largely assisted by the Joint Commission on Rural Reconstruction both technically and financially. Under this project, 88 hectares of selected rice paddies distributed in 11 prefectures are to serve as demonstration centers. The demonstration farmers are required to (1) prepare and manage the fields strictly according to the prescribed methods, (2) provide for each hectare of paddy fields at least 180 kg. of rice bran for feeds and about 5,000 kg. of night soil for fertilizer, and (3) keep records of the weight of the fish at the time of planting and harvest, the yield of rice, etc. In return, the demonstration farmer receives, for each hectare of paddy fields, 6,000 Tilapia fry of not less than one inch in length and a cash subsidy of 910 Taiwan dollars (equivalent to about US$ 34). It is expected that this demonstration will yield more accurate information on the economical return of paddy culture of Tilapia and show the farmers the proper cultural method.

Evaluation of Results of Paddy Culture of Tilapia in 1952

In order to get more accurate information and to find out if the culture of Tilapia in rice paddies was feasible, a number of questionnaires were sent out by the Joint Commission on Rural Reconstruction to various prefectural and municipal governments in Taiwan in March, 1953. Replies to the questionnaires were received from 13 prefectural and 2 municipal governments.

According to these replies, the 15 localities may be divided into three groups: (a) areas where fish production was affected by flood, consisting of 3 localities, (b) areas where fish production was affected by late distribution of fry - fish not planted until after the first crop of rice, consisting of 6 localites, and (c) areas where the condition was more or less normal, consisting of 6 localities. The production of paddy rice and fish in the areas under each group is tabulated as follows:

	Acreage of paddies with fish (ha.)	Average fish production (kg/ha)	Average rice production in fields with fish (kg/ha)	Average rice production in fields without fish (kg/ha)
Areas affected by flood	1,253.0	185	4,857	5,067
Areas affected by late stocking	600.9	263	4,012	4,005
Normal areas	1,178.9	275	5,699	5,988
All areas	3,032.8	235	5,005	5,214

According to the above data, one hectare of rice field produced on an average 235 kg. of fish at the sacrifice of 209 kg. of paddy rice in 1952. Since the price of fish is at least twice that of paddy rice, there is little doubt that the paddy culture of Tilapia has been profitable to the farmers, even when more than 60 per cent of the culture areas were affected by flood and late planting of fish.

It is interesting to note from the returns that the highest fish yield per hectare was 1,492 kg. in Pingtung Prefecture, where the temperature is the highest and the growing season the longest. It indicates what might be expected of the yield of Tilapia in rice paddies where conditions are

good.

In reference to comparison of rice yield between fields with Tilapia and fields without Tilapia, three localities reported no decrease of rice yield in fields with Tilapia. It was observed by the field inspectors of the Fisheries Bureau and some prefectural governments that most farmers who reared Tilapia did not apply extra fertilizers to the fields or give sufficient feeds to the fish. This undoubtedly accounts for the lower yield of rice in fields with Tilapia in a number of cases.

No returns have been received from four localities, which are estimated to have a total of 111.3 hectares of rice fields stocked with Tilapia. The total acreage of rice paddies with Tilapia in 1952 was therefore approximately 3,144 hectares (3,032.8 plus 111.3). Calculated at the average yield of 235 kg. of fish per hectare, the total production of Tilapia from rice fields in Taiwan in 1952 would be about 740 metric tons, which is quite significant as compared with 937.5 metric tons of fish produced from rice fields in all Japan in 1949.

Discussions

Perhaps the most important factor toward the successful culture of Tilapia in rice paddies is an early start in the season. A sufficiently early start will enable the fish to have a longer period of growth, say about seven months, and to attain good marketable size at the end of the period. In Pingtung, the southernmost prefecture of Taiwan, this condition is easily obtained, because Tilapia fry are available there for planting in the rice paddies at any time of the year. The average lowest monthly temperature in Hengchun, a town in the Pingtung Prefecture, from 1897 to 1945 was 17.4°C. in February (16). This is comfortably above the minimum temperature for Tilapia. Therefore, the Tilapia spawn in Pingtung practically the year round.

In areas north of Chiayi, however, spawning of Tilapia does not occur until April or May and the fry will not be ready for distribution until May or June. This means that the Tilapia in the rice paddies would

have a growing period of only four to five months, which is not sufficient for the fish to attain good table size. This is exactly what happened in 1952 and 1953 under the extension program of the Taiwan Provincial Government. Some prefectures did not receive their quota of the Tilapia fry as late as July.

In order that the farmers in all parts of Taiwan may receive the Tilapia fry at the time of the planting of the first crop of rice, it seems necessary to make radical change in the Government's system of propagation and distribution. The proposal is to have the propagation centers located in Pingtung and have the fry shipped to various localities north according to the planting schedule of the rice crop. This necessitates the establishment of new centers of propagation in the deep south and improvement of the facilities for transporting the fry. It certainly is worthwhile for the Government to think and plan along this line.

There have not been sufficient experimentation and demonstration on the paddy culture of Tilapia in Taiwan. The experiment at Silo and another at Hsinchu done by the Fisheries Research Institute and the experiments done by a few Regional Agricultural Improvement Stations served as the only demonstrations of the paddy culture of this fish. The result is that many farmers were mislead. They plunged into the venture with too high hope and became disappointed later. Many also did not follow the proper methods of field preparation and management, with the result that the yields were disappointing. Such is the case with the farmers at Silo. The three contract farmers of Silo in the experiment of 1951 made good profit not only from the fish they sold for consumption but also from the Tilapia fry they sold as planting stock. Their neighbors saw the result and rushed into the business, but they became disappointed because: (a) trying to save feeds and fertilizers, they did not get the expected yield of fish or rice, (b) holding the fish too long in the ditches, many of them lost their entire fish crop in the winter, and (c) they could not find market for the Tilapia fry. Thus, many farmers became discouraged and did not want to try again.

If this same thing happened in all the other localities, the farmers

would soon lose their confidence in Tilapia culture and would not have the fish in their paddies even when the Tilapia were given to them free of charge.

The opinion of the writer is that the Goverment should not rush into the extension of the Tilapia in rice paddies without sufficient experimentation, planning and demonstration. A number of places should be selected as demonstration centers where the paddy culture of Tilapia will be under close technical supervision and observation. The success of the demonstration farmers and government assistance in the supply of fish for stocking purpose will be sufficient impetus to put the extension over. The writer is happy to report that, with the financial and technical assistance of the Joint Commission on Rural Reconstruction, the Taiwan Fisheries Bureau has initiated a demonstration project in 1954.

At present, the Tilapia is not accepted as first class table fish in Taiwan, chiefly because of the small size in which it is marketed. Its acceptability would be much improved if the fish is given a longer growing period and made to reach a larger size before it is sold. Hence, the importance of an early start in the year in the culture of Tilapia cannot be over-emphasized.

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