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JOINT COMMISSION ON RURAL RECONSTRUCTION

Fisheries Series: No. 1

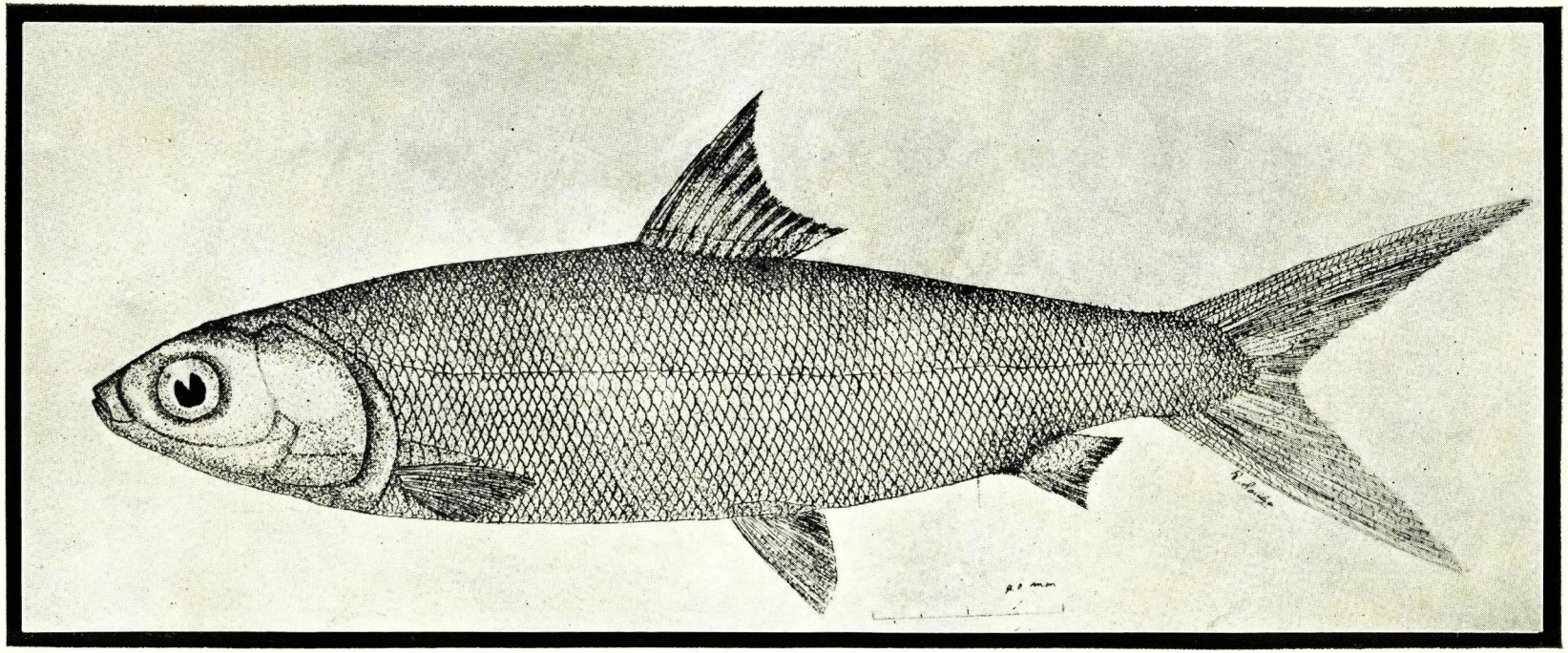
MILKFISH CULTURE IN TAIWAN

By

Tung-pai Chen

Taipei, Taiwan, China

November, 1952



THE MILKFISH, *Chanos chanos* (FORSKAL)

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FOREWORD

The milkfish is the most important pond fish of Taiwan and heads the list of food fishes of the Island. The fish farmers of Taiwan, benefited by generations of experience, have developed an unique and ingenious system of culture for this fish. To this system is due the success to reap such large fish crop from the limited pond area and to make the most of the natural fertility from the water and soil, although the growing season of the milkfish is much shorter in Taiwan than in Indonesia or the Philippines.

The astonishing thing about milkfish culture in Taiwan is that, in spite of the importance of the industry and the ingenious and intricate system of the fish culture, very little scientific study has been made on the subject. Most information on the milkfish and its culture is obtained from the research and experimental work done in Indonesia and the Philippines.

This report is a concise account of the culture of milkfish in Taiwan, although no important details have been omitted for the sake of brevity. Efforts have been made by the writer to explain the scientific principle underlying each phase of the practice. The Joint Commission undertakes the publication of this little book with the hope that it will serve as useful reference for those interested in the subject and perhaps pave the way for further study.

Chiang Monlin

Taipei, Taiwan
October, 1952.

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MILKFISH CULTURE IN TAIWAN

By T. P. Chen

Fisheries Specialist, Joint Commission on
Rural Reconstruction
Taiwan

DISTRIBUTION AND BIOLOGY OF THE MILKFISH

The milkfish, *Chanos chanos* (Forskal), is known as sabahi in Taiwan. In Indonesia, and Malaya, it is called bandeng; in the Philippines, its name is bangas; in Australia, it is variously known as salmon herring or white mullet; and in Hawaii, it is named awa-awa. It belongs to the family Chanidae, which is closely related to the herring family.

The milkfish is widely distributed in the Indian Ocean and the southern part of the Pacific, commonly found in the waters around Taiwan, Philippines, Australia, Indonesia, Malaya, Hawaii, etc. For reasons not well known, the grown fish are seldom caught in commercial fisheries. According to Schuster (1), adult Chanos are caught in the sea only in the southern part of Celebes, and a few specimens every year at the beginning of the spawning season along the Java coast. A few specimens were caught in Australia in 1950 weighing 30 lbs. each. According to G. P. Whitley, Curator of Fish of the Australia Museum (2), this fish is found in tropical Australian waters. In 1947, long lining vessels from Taiwan reported capture of one specimen weighing over 40 lbs. at Pratas Island.

The fry of the milkfish, however, are found in abundance in the coastal waters of many places, notably Indonesia, Philippines, Taiwan, and Malaya. According to Schuster (1), there is some evidence that spawning of the Chanos takes place twice a year in the neighborhood of the Spermonde Islands in the Macassar Strait. Milkfish fry of 11-13 mm. long are taken every year in April-May and September-November along shallow sandy coasts. Pelagic eggs with a diameter of 1.2 mm. have been found in the sea at points from 15 to 17 miles from the coast. From these eggs, fry of 5 mm. long are hatched after 24 hours. The age of the fry taken commercially are estimated to be 2 to 3 weeks.

Delsman (3) states that the pelagic eggs of milkfish are 1.2 mm. in diameter and the matured eggs in the ovary are 0.7 mm. in diameter. An adult female of 1.12 m. in length and 11.9 kg. in weight contains 5,700,000 eggs weighing 1,304 grams. The yolk sac of the fry is entirely absorbed 3 days after hatching. In 4 to 5 days, the fry attain length of 5 mm. When they reach 14 mm. in length, they congregate in shallow coastal waters where the salinity is comparatively low. In about a year, the fish attain a length of about 20 cm, weighing about 200 grams, and begin to live in the open sea.

Abundant milkfish fry are found along the coasts of southern Taiwan, but no milkfish with matured ovaries have been caught off the Taiwan coasts. A large milkfish of 3 ft. 8 in. in length and 13 kg. in weight caught off the southern tip of the island of Taiwan showed immature ovary with very small eggs. The Taiwan Fisheries Experiment Station, during the Japanese regime, experimented on rearing the milkfish to maturity in its experimental ponds at Tainan (4). Seven milkfish of 6 years of age, weighing about 4 kg. each, were reared for five months. On examination at the con-

clusion of this period, the ovaries were found to be about 13.5 inches in length and immature.

In 1944, 20,000 milkfish fingerlings were planted in Lake Coral in Southern Taiwan. The fish caught and sold in 1947 weighed about 4 lbs. each. This indicates that milkfish can attain fairly large size in fresh water.

ACREAGE AND PRODUCTION

Milkfish is the most important pond fish in Taiwan. The quantity produced in recent years comprises about 60% of the total production of pond fish in Taiwan. It also heads the list of food fishes in Taiwan in quantity consumed each year. The total area of milkfish ponds and yearly production for the years 1945 to 1950 are shown as follows (5):

	Total area of ponds (hectare)	Production (kilogram)
1945	6,067.25	3,007,306
1946	6,465.17	5,766,080
1947	8,697.85	8,190,088
1948	10,599.74	13,078,284
1949	11,154.22	13,348,029
1950	13,084.23	15,359,992

It is to be noted that milkfish are usually reared in association with small number of other fish, such as carp, grass carp, silver carp, mullet, and prawn. The acreages as listed above, therefore, do not represent the ponds in which milkfish are exclusively cultured.

The reasons why milkfish culture attains such popularity in Taiwan are:

1. Most milkfish ponds are located along the coast, where the soil is saline and unsuitable for farming or fresh water fish culture.

2. The unit area production of milkfish is higher than that of other salt-water or brackish-water pond fish.

3. Milkfish fry for stocking the ponds are available in Taiwan.

The acreage of milkfish ponds in Taiwan has increased considerably since the administration of the Island was turned over to the Chinese Nationalist Government in 1945 and may be further increased in the future. One of the reasons is the reduction of the area of salt fields, which are turned into milkfish ponds. Under the Japanese regime, the government encouraged the production of salt in Taiwan and maintained large areas of salt fields in order to supply salt to the Japanese islands. Since Taiwan was turned over to the Chinese Government, however, the situation has changed. No more salt is required for export, and many salt fields have been converted into fish ponds.

In Tainan, 1,000 hectares of salt fields were stocked with milkfish during the rainy season (May to September) of 1949, when salt production was impossible. To each hectare 500 fish were stocked, and no feeds or fertilizers were given during the period. At the end of the five months, from 90 to 110 kg. of fish were harvested from each hectare. The salt workers received addtional income from this enterprise, but the practice was not continued, because it caused leakage in the salt fields and affected salt production in the following season.

Because the milkfish is a tropical fish, its culture in northern Taiwan is not feasible. The greatest concentration of milkfish ponds is in the Tainan and Kaohsiung areas. Most milkfish ponds are located along the sea. The following table gives the acreage and production of milkfish ponds in various localities of Taiwan in 1949:

	Acreage (hectare)	Production (kilogram)
Taipei Hsien	10.00	9,020
Tainan Hsien	3,238.10	3,633,570
Tainan Municipality	3,972.04	5,436,800
Kaohsiung Hsien	3,240.74	3,485,900
Kaohsiung Municipality	677.84	782,709
Penghu Hsien	15.50	30
Total	11,154.22	13,348,029

It is generally believed that the culture of milkfish in Taiwan dates back to the reign of Cheng Cheng Kung (Kosinga) three hundred years ago. The Chinese fish farmers who migrated to Taiwan built dykes on the low land along the coast and stocked the ponds so formed with fry of milkfish obtained from the littoral waters. The authenticity of this story is to be questioned. According to Schuster (1), the tambaks (salt water fish ponds) for rearing milkfish were known in Java as early as the year 1400. It seems quite possible that the Dutch people who had their headquarters at Tainan introduced the culture of milkfish long before the arrival of Cheng Cheng Kung.

THE SUPPLY OF MILKFISH FRY IN TAIWAN

It can be said that the milkfish industry in Taiwan is founded on the availability of the milkfish fry. Culture of milkfish would not be developed in Taiwan if the fry were not available locally.

The milkfish fry occur both along the eastern and western coasts of southern Taiwan. They are evidently carried this way by the Kuroshio Current. The catch of the fry in 1949 according to localities is shown as follows:

Kaohsiung Hsien	26,100,000
Taitung Hsien	23,670,045
Tainan Municipality	18,390,000
Hsinchu Hsien	2,454,135
Hualien Hsien	1,892,636
Other localities	4,659,560
Total	77,166,370

The catch of milkfish fry in Taiwan fluctuates in quantity quite widely from year to year, but rarely is the supply sufficient to meet the demand. The yearly catch from 1922 to 1951 in relation to the fish pond acreage of the respective years (5 and 6) are shown as follows:

	No. of fry captured	Total area of ponds	No. of fry available for 1 ha. of pond
1922	20,217,541	6,691.35 ha.	3,022
1923	48,820,327	7,197.62 „	6,782

1924	30,070,336	6,949.20 ha.	4,327
1925	30,896,603	7,069.40 „	4,371
1926	45,067,818	7,557.26 „	5,900
1927	13,570,453	7,287.44 „	1,863
1928	27,517,150	7,375.00 „	3,731
1929	24,032,232	7,308.43 „	3,290
1930	36,413,564	7,473.19 „	4,873
1931	95,668,629	7,154.03 „	13,373
1932	118,079,477	7,648.77 „	15,438
1933	113,827,490	7,694.74 „	14,792
1934	24,298,466	8,275.53 „	2,936
1935	25,439,340	8,072.10 „	3,151
1936	25,891,419	7,955.14 „	3,255
1937	13,510,550	7,904.31 „	1,709
1938	73,911,314	7,905.95 „	9,349
1939	36,029,953	5,966.29 „	6,040
1940	35,593,833	4,500.72 „	7,910
1941	40,940,896	6,509.44 „	6,290
1942	41,135,187	9,127.21 „	4,507
1943	8,470.182	6,157 43 „	1,376
1944	16,923,727	7,883.15 „	2,147
1945	25,263,480	6.067.25 „	4,164
1946	50,441,132	6,465.17 „	7,802
1947	42,869,379	8,697.85 „	4,929
1948	72,740,600	10,599.74 „	6,862
1949	77,166,370	11,154.22 „	6,918
1950	102,078,727	13,084.23 „	7,802
1951*	30,000,000	13,106.80 „	2,289

*The complete records for 1951 are not yet available at the time of writing, but the total is estimated to be about 30,000,000.

The above record shows that only in 12 out of the 30 years were there sufficient milkfish fry to stock the ponds at the rate of 6,000 per hectare. The most serious shortage occurred in 1927, 1937, and 1943, when less than 2,000 fry were available for each hectare of milkfish pond, and in 1951, when only 2,289 fry were available for each hectare.

The smallest catch was in 1943, when the total number of fry caught was only 8,470,182. This was during the war year when the Japanese occupied the Philippines. The Japanese government sent three boats to the Philippines and brought back 4,707,519 milkfish fry for distribution to the fish farmers in Taiwan. The shortage of milkfish fry in 1943, however, was not as serious as the catch 8,470,182 seems to indicate. In the first place, the total acreage of milkfish ponds at that time was only 6,157.43 hectares as compared with 13,106.80 hectares in 1951. In the second place, distribution of all fish fry was under government control during the Japanese administration. The figure 8,470,182 represents only the number of milkfish fry collected and distributed by the government. Large number of milkfish fry were sold in black market transactions, which were not recorded.

As the common practice is to stock each hectare of pond with 6,000 to 8,000 milkfish fry each year, but in majority of the past thirty years the number of fry available for each hectare was less than 6,000, it seems that shortage of milkfish fry is the rule rather than the exception in Taiwan. There is little use to expand the fish pond acreage when there are not sufficient fish for stocking purpose. The supply of fry is therefore actually the bottleneck of the milkfish industry in Taiwan.

Fig. 1
Triangular scoop net

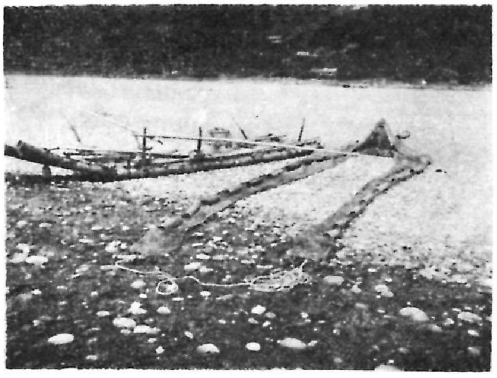

Fig. 3
A drag net and a bamboo raft

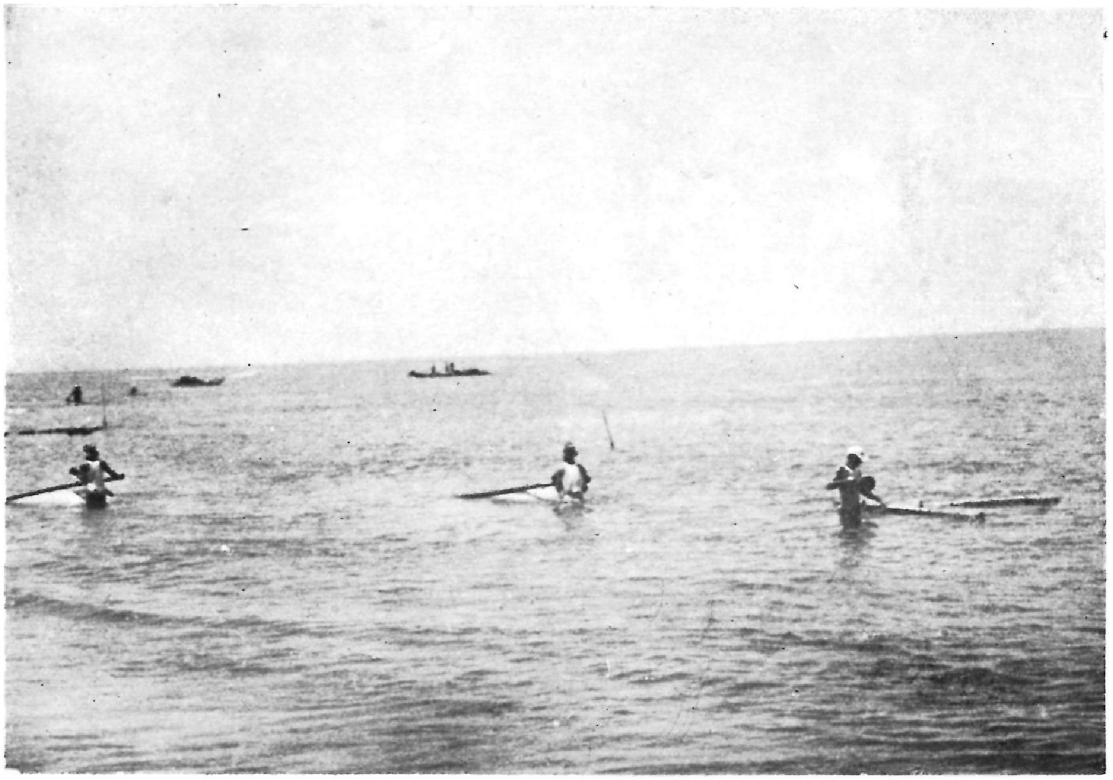

Fig. 2 Catching milkfish fry with scoop nets

CAPTURE AND HANDLING OF THE MILKFISH FRY

The milkfish fry are captured in Taiwan in the months from April to August, with the majority taken during April and May. The maximum catch occurs at every full or new moon, i.e. at the time of the spring tides. During these months, thousands of fishermen and farmers gather on the beaches and in estuaries and coves to reap their harvest of the sea. Women and children participate in the task. At the peak of the season, they often work from early in the morning to late at night.

The gear most commonly used is a triangular scoop net (Fig. 1), the web of which is made of China-grass (ramie). Two bamboo poles crossed one above the other are attached to two sides of the triangular piece of webbing. The shorter ends of the poles that portrude serve as handles with which the fisherman pushes the net forward. The poles keep the net afloat and maintain the proper size of the net opening in front. The remaining side of the triangle is the foot line of the net and is attached with lead sinkers. To the apex of the triangle at the rear is attached a cylindrical fry container, which is either the closed end of a piece of bamboo or an old tin can. The size of the net varies according to whether it is operated by an adult or a child. Usually, the width of the net at the front is four to six feet; the length of the poles varies from five to nine feet. Each net costs about sixty Taiwan dallars (equivalent of about US $ 3).

In operation, the fisherman pushes the net to and fro in shallow water. He either wades with the water chest-high or swims with the help of an inflated rubber tube around his waist. After 15 to 20 minutes of pushing, the net is raised and the fry washed into the cylindrical container at the rear of the net. From this container, they are separated from the larvae of other fish, debris, etc. and removed to a bucket for temporary holding. At some places, cement ponds are constructed on the beach or nearby places for keeping the fry alive before selling them to the dealers or collecting agents. A man or woman can usually catch from 30 to 100 fry per day and earn approximately five to fifteen Taiwan dollars (equivalent to about US $0.20 to US $0.60).

A drag net (Fig. 3) is also used in some places for capturing the milkfish fry. It is in the form of a bag, the mouth of which is kept open by floats and sinkers, and has two wings of some length. The webbing is of China-grass. With the support of a bamboo frame and base, the bunt of the net is formed into a box (Fig. 4) with an opening at the top. In operation, the net is towed by two ropes, one of which is attached to a bamboo raft and the other (beach-end) is towed by a man who walks along the shore. At intervals, the towing is stopped, and the fry collected in the box are taken out through the opening at the top by means of a dipper. Three to four people are required to operate the net and the raft, and the daily catch is normally 500 to 1,000 fry, which is equivalent to the catch of about ten people using scoop nets. At places where there are tidal currents, the drag net is sometimes anchored (Fig. 5), and the fry are carried into the net by the current. At shallow places, the drag net can also be towed by two persons, each holding on to the tip of each wing.

The drag net is evidently more efficient than the scoop net, and it saves a great deal of man power. However, it is also more expensive and often beyond the means of the average fry catchers. Usually, some rich men provide the net and raft to the fry fishermen and share the catch. To promote the use of this improved gear, the Taiwan government offers a subsidy to fishermen who want to make or procure the drag net.

The use of the drag net is mostly confined to those places where the water near shore is too deep for the use of the scoop net. Along the eastern coast of southern Taiwan, where the shore drops abruptly to considerable depth, hundreds of drag nets operate during the fry catching season. But the drag nets are seldom found on the western coast, where the beaches are gently sloping and large patches of coastal water are shallow enough for wading. There the scoop nets are generally in use.

The milkfish fry captured are sold either to dealers, who in turn sell them to the fish farmers through the fish fry shops, or occasionally directly to the fish farmers. Most fish fry shops are located at Tainan, which is the center of the milkfish industry. From the place of capture to the fish fry shops, the milkfish fry are transported in galvanized iron cans (Fig. 7) of about 1½ feet in height and 1 foot in bottom diameter. Each can holds about 3,000 fry. The cans are placed on trucks for transportation to Tainan, which requires generally from four to ten hours depending on the distance. Mortality of the fry during the trip is usually very low, from 1 to 2 per cent.

During the shipment of the fry, two changes of water are required for the longer trips. The stale water is taken out by lowering into the upper layer of water a gauze strainer, and the water inside the strainer, now free of fry, is removed by means of a wooden dipper. The volume of the water in the can is then made up by adding a solution of salt in fresh water. During the early days, sea water was carried for making changes, but the use of salt solution has been found quite satisfactory and more convenient. The fry are fed with egg yolk twice during the shipment.

At the time of writing, seven of the total of eleven milkfish fry shops in Taiwan are located in Tainan. Each shop has from 30 to 50 small cement ponds (Fig. 8), each of about ten square feet in area and capable of holding about 20,000 fry temporarily. The water in these ponds is tap water in which common salt has been added. The quantity of common salt to be added is determined by taste.

The milkfish fry are very sensitive to low temperature. The fry held in the fry shops are sometimes killed by sudden cold spells, especially during the early part of the season. Also, when the sun is hot, the cement ponds have to be covered with a bamboo screen to provide shade for the fry.

The fish fry shop is a sales agent. It gets a commission of 2% for each transaction, but has to provide board and lodging for the fish farmers who come to buy the fry.

In 1950, the price of the milkfish fry of 1½ to 2 cm. in length was Taiwan dollar 0.06 to 0.07 (equivalent to about US $ 0.003) each at the places of capture (Taitung, Hengchun, etc.) and about Taiwan dollar 0.15 (equivalent to about US $ 0.006) at the fish fry shops at Tainan. These prices are considered normal. In 1951, due to shortage of the milkfish fry, the price at Tainan went up to Taiwan dollar 0.40 (equivalent to about US $ 0.02) each. At the beginning of the 1952 season, the price was as high as Taiwan dollar 0.65 each. Later, as the fry became abundant, it dropped to Taiwan dollar 0.20 at Tainan. This shows the wide fluctuation of the price of milkfish fry as affected by supply.

For stocking the ponds, the milkfish are also available as yearlings. They are usually the late fry (fry captured after the month of May) which have been reared through the winter. In 1950, the price of milkfish yearlings of 6 cm. in length was Taiwan dollar 0.25 to 0.30 (equivalent to about US $ 0.012) each, and the price of those of 8 to 12 cm. in length was Taiwan dollar 0.40 to 0.50 (equivalent to about US $ 0.022) each.

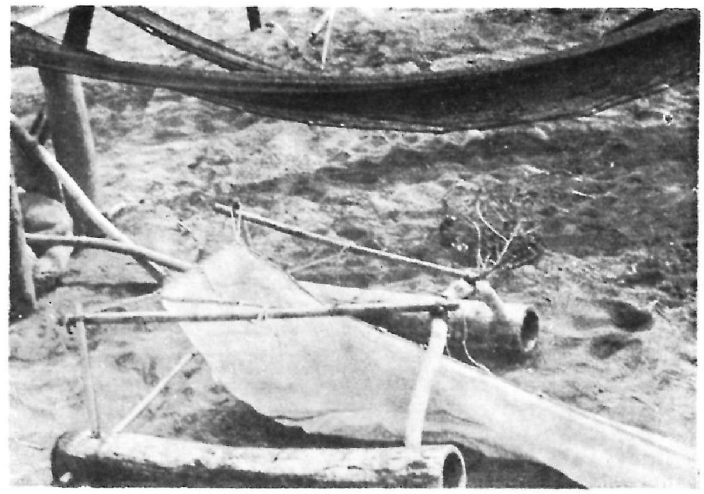

Fig. 4

Bunt of a drag net, formed into a box with opening at top.

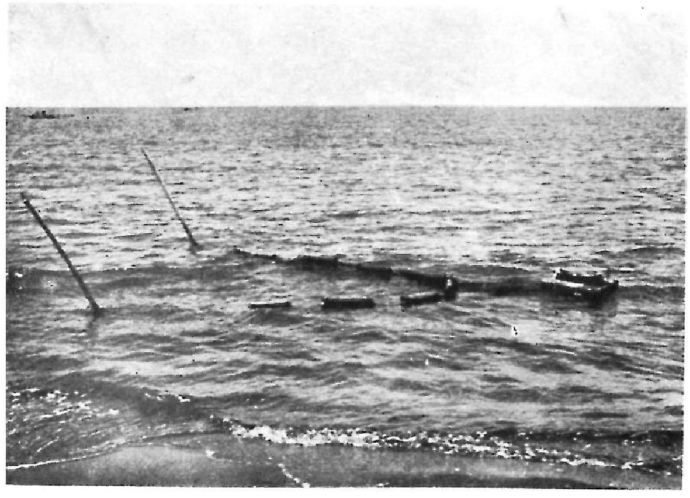

Fig. 5

The drag net is anchored at place where tidal current is present.

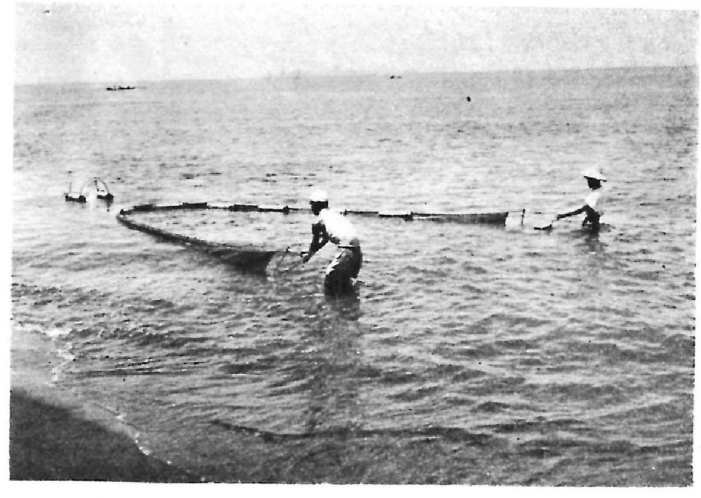

Fig. 6

At shallow places, the drag net can be towed by two persons.

Fig. 7 Fry can (center) dipper (left), and strainer (right).

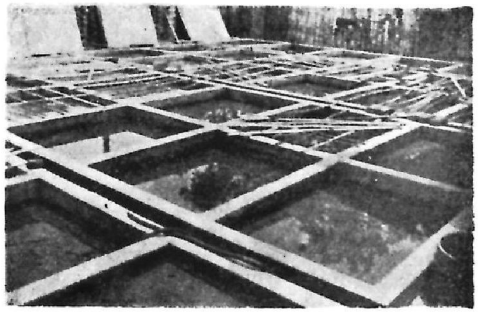

Fig. 8 Cement ponds in a milkfish fry shop.

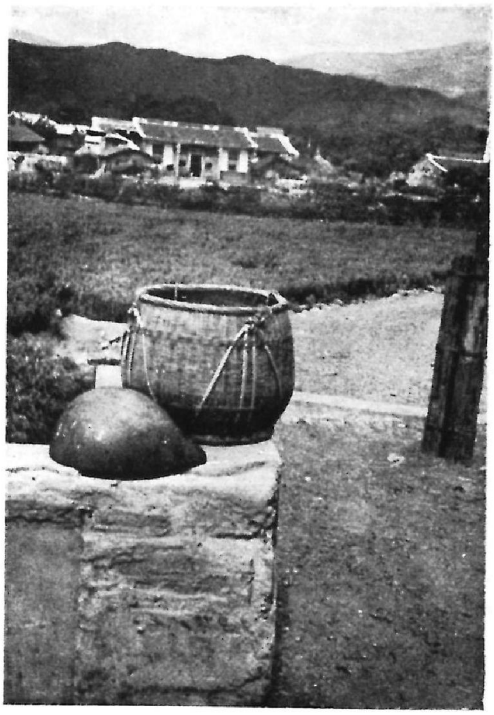

Fig. 9 A bamboo basket for transporting milkfish fry.

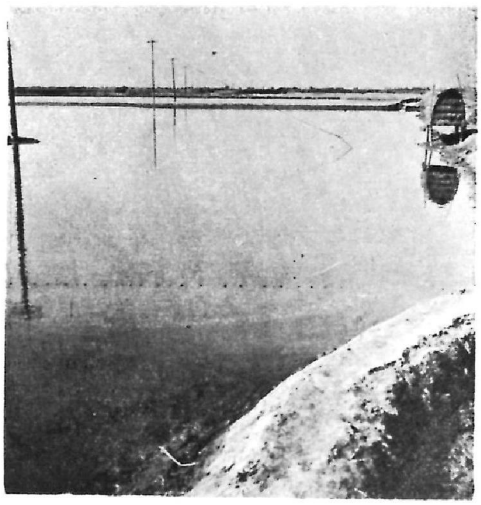

Fig. 10 A rearing pond. Watchman's shed at right.

Fig. 11 Same pond as in Fig. 10, showing wintering pond with windbreak at right.

The time-tried Chinese method of transporting the fry in bamboo baskets (Fig. 9) carried by a man with a pole that bends with each up-and-down motion is used for moving the fry at short distance. The water in the basket is thus agitated, and the supply of oxygen to the fry held in concentration increased.

THE MILKFISH PONDS

The milkfish ponds in Taiwan are known as "wun". In construction, they are more or less similar to the "tambak" in Indonesia, and different from fresh water fish ponds in that each contains a series of ponds serving various purposes. The salt water fish ponds in Kwangtung and Fukien on the China mainland and in Hongkong (7) are also known as "wun", but they are simpler in construction and consist of ponds immediately adjacent to the sea with sluice gates to admit sea water at spring tide. When sea water is thus admitted, it carries with it the youngs of mullet as well as of some other fish such as the sea-bass, sea-bream, sea-perch, and milkfish. The young fish are retained in the ponds when the gates are closed at ebb tide; and in this way the ponds are stocked. In Taiwan, the sluice gates on the sea-side are connected with the ponds through a water supply canal, and their purpose is to let in sea water and not the young fish. The construction of the wun in Taiwan is there-fore much more advanced than that on the China mainland, because it allows control over the species as well as the number of fish fry for stocking purpose, which is not possible with the wun on the China mainland.

Each wun in Taiwan consists of a series of ponds, varying in number from 3 or 4 to 20 or 30. The ponds in a wun may be classified as water supply canals, nursery ponds, rearing ponds, and wintering ponds. A brief description of each type is given as follows:

The water supply canal is of one to several meters in width and runs the length of the wun either on one side or between two rows of ponds. A sluice gate connects the canal with the sea, and other gates connect it with the ponds in the wun. In some wun of comparatively high elevation, mechanical pumps are set up on the dyke for pumping water into the ponds to maintain the proper water level.

The nursery ponds are small ponds of less than one foot in water depth. The area of each is usually 100 to 200 square meters.

The rearing ponds (Fig. 11) are small ponds of 3 to 4 feet in depth of water. They are in the shape of long ditches, with a width of about 10 to 20 feet. A bamboo windbreak is set up on the wind-ward side (northeast) toward off the cold wind during the winter.

Practically all the milkfish ponds are of rectangular shape. The arrangement of ponds in a wun varies, A typical arrangement is shown in the accompanying illustration (Figure 12).

Although milkfish can be reared in either salt or fresh water, they are known to give the best result when reared in brackish water. Sudden drop of salinity due to heavy rain often causes the death of many fish. For this reason, milkfish ponds are always located in coastal areas where sea water is accessible. At places where freshets may occur, facilities are often provided to divert the fresh water away from the ponds. Along the sea-shore, heavy dykes of sufficient height are built to protect the ponds from on-rush of water during stormy weather.

Fish farmers either own or lease their ponds. An average family operates one to two hectares of milkfish ponds. Most big wun are each operated cooperatively by a number of farmers, but one man may own and operate as many as 50 to 100 hectares of milkfish ponds. There are a few fish culture cooperative societies in Taiwan. They provide collective pumping service, ponds for collective rearing of fry, trucks for collective buying and marketing, etc. for their members.

THE SYSTEM OF POND MANAGEMENT

In Taiwan, the milkfish is reared for a period of eight months, from March to October. During these months, the milkfish remain in the rearing pond, and are given both natural and artificial feeds. All year round rearing is not possible because of low temperature in the winter months, which would cause high mortality if the milkfish are allowed to remain in the shallow rearing ponds. This is one big disadvantage of milkfish culture in Taiwan as compared with Indonesia and Philippines, where the tropical climate permits the culture of milkfish to be carried out without interruption.

Limited by the comparatively short rearing period and the season of capture of milkfish fry, the fish farmers of Taiwan have developed an ingenious system of pond management. This system is the evolution of a number of years. As a matter of fact, many of the practices mentioned in the present paper are comparatively recent innovations.

The system of milkfish culture can best be explained by presenting first the time table of the milkfish farmers of Taiwan:

November: Levelling of bottom; repair and improvement of dykes; drying of the bottom under the sun.

December: Pond is partially filled with sea water and again dried.

January: The bottom soil is allowed to rest.

February: Pond is again partially filled with water, and fertilizer is applied. Pond is dried again.

March: Pond is again fertilized. Sea water is admitted, and Camellia seed meal is applied to exterminate undesirable species of fish.
Fish from wintering pond are planted in the latter part of the month.

April: Planting of "new fry".

May: Feeding begins, usually with rice bran.

June: Harvest of first crop (fish from wintering pond). Feeding continues, usually with bran and soybean cake (or peanut meal). Late "new fry" are planted.

July: Feeding continues.

August: Feeding continues.

September: Feeding continues.
Harvest of second crop (fish planted in April). Preparation of wintering pond.

October: Feeding is discontinued.
All fish are harvested, except the late "new fry", which are removed to the wintering pond.

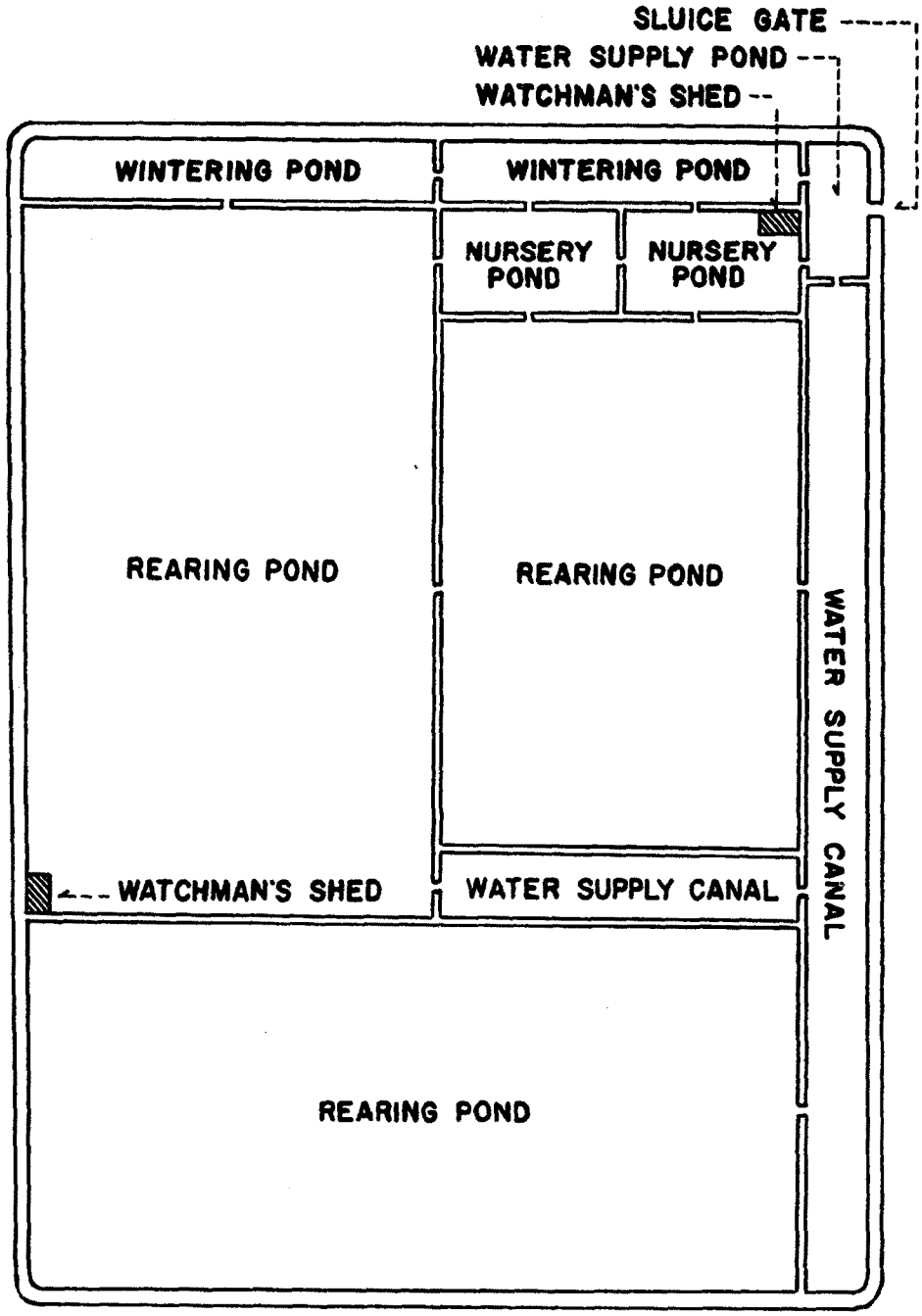

FIG. 12 TYPICAL ARRANGEMENT OF A WUN

It can be seen from the above time table that the year can be divided roughly into two periods. The first, from November to February, is the period of rest and pond preparation, during which the ponds are repaired and fertilized with the object of putting them back into condition for production. The second, from March to October, is the period of production. That the highest utilization of the ponds is obtained as far as the season and weather permit will be shown in the following chapters. Even at this moment, however, it is apparent that this system of pond management has some definite merits. First, the ponds are allowed to regain their fertility in the period when they are idle. Secondly, the carrying of the fingerlings over the winter permits an early start in the production of fish before the "new fry" are available. The two harvests of milkfish are timed to take place at the time when the catch of fish by fishing vessels is the lowest. In this way, the fish farmers get a good price for their fish crop and the supply of fish in the market is regulated.

PREPARATION OF PONDS BEFORE STOCKING

In Taiwan, a standard practice has been developed for preparing the rearing ponds before the milkfish fry are planted. This practice has gradually been improved with years, and is perhaps without parallel in the fish farming methods of various countries. The treatments as described below are universal in the Tainan and Kaohsiung areas, where majority of the milkfish ponds are located.

In about November, after the ponds have been cleared of fish, and the water drained off, the pond bottom is levelled and any necessary repair or improvement of the dykes is made. The bottom is now dried under the sun until it cracks to the sufficient extent. This generally takes about two weeks.

By this time, December probably has arrived. The sea water is let in to a depth of 3 to 5 inches and allowed to evaporate until the bottom is dry. The pond remains in this dry condition until the end of January to let the soil weather.

In February, rice bran is applied to the bottom as fertilizer. The rice bran comes in straw bags, each containing 50 to 60 lbs. of rice bran. The bags of rice bran are placed on the bottom at various points of about equal distance from each other. Then, sea water is let into the ponds to a depth of 3 to 5 inches, and the bags of bran are left to soak for one or two days. After this, the bags are opened, and the bran is spread out as evenly as possible on the bottom. In addition to the bran, sometimes straw, grass, and sugarcane leaves are dumped onto the bottom to serve as compost manure. The water is now allowed to evaporate until the bottom becomes dry.

When March arrives, rice bran is again added to the bottom. Night soil is sometimes used together with the bran, or in its place. Water is then let in to a depth of 3 to 5 inches and left undisturbed for 5 to 7 days. After this, sea water is again let in to increase the depth of the water in the ponds to 5 or 6 inches. At this time, Camellia seed meal is often added to kill the undesirable species of fish present in the ponds. The cakes of Camellia seed meal are simply broken into small pieces and cast into the water at various points. About ten days should be allowed to pass before the planting of young fish in order to prevent any poisonous effect on the fish. The ponds should be refilleed to a depth of 7 to 8 inches before stocking with fish. It will be about the end of March when all this is done, and a good layer of algae will have developed on the bottom of the ponds to serve as food for the young fish.

To fertilize the ponds as described above, about 800 kg. of rice bran is required for each hectare of pond area. In case soybean cake or night soil is used, the quantity is about 400 kg. or 14,000 kg. respectively for each hectare. Some fish farmers, for lack of money, apply fertilizer only once. The quantity of fertilizer used, in that case, would be much less than the above indicated amount. The use of chemical fertilizers is yet untried, but the Taiwan Fisheries Research Institute is planning to start an experiment to determine its feasibility.

In recent years, some of the milkfish ponds in the Tainan area are drained, dried, and fertilized once more in August, during which time the fish are temporarily held in the canals, wintering ponds, or pond specially reserved. The purpose of this is to save feeds by full utilization of natural and applied fertilizers.

It must be said that the practice mentioned above is based on very sound principle. The water let into the ponds from the sea contains nutrients. Each time this water is evaporated, a layer of organic and inorganic matters, rich in plant nutrient, is left on the bottom of the ponds. Thus, after three successive irrigations and evaporations, the pond bottom has gained a considerable quantity of natural fertilizer aside from the fertilizers applied by man.

The water in the ponds, however, has gained also in salinity as a result of the successive evaporations. If the salinity reaches 5 or 6 per cent, high mortality of the fry may result. Care must be taken, therefore, to see that the water in the ponds is properly diluted by the addition of fresh sea water, or, if necessary, by the addition of fresh water.

Many undesirable species of fish may exist in the ponds before the milkfish are introduced. These are either predators or fish which partake of the same feeds as the milkfish but are of no economical value. The most common predatory fish in the milkfish ponds of Taiwan are *Elops saurus* Linne, *Elops hawaiensis* Regan, and *Megalops cyprinoids* (Broussonet). Any fish which do not attain edible size are objectionable in fish ponds, since they do not bring any returns to the fish farmers. The Tilapia is also objectionable because it tends to disturb the growth of algae on the pond bottom.

In Taiwan, the undesirable species of fish are eradicated by the application of Camellia seed meal before the milkfish fry are planted. This is an old practice originating from Mainland China. The *Camellia sinensis* is a plant of the tea family. Its seeds are pressed to obtain the oil, which is used as food and for lighting purpose. The residue, pressed into cakes, has a high saponin content, and is used for poisoning fish as well as for hair shampoo. When applied to fish ponds, it has also fairly high fertilizer value. It could be used in place of soybean meal or peanut meal were it not for its comparatively high market price. Commonly, 180 kg. of the Camellia seed meal is used for each hectare of pond area.

STOCKING THE PONDS

It is practically a universal practice in Taiwan to raise two crops of milkfish each year. There are generally three plantings of fish: the first time in March, the second time in April or May, and the last time in June.

The fish planted in March are "old fry" or yearlings, which come from the wintering ponds and vary from 2½ to 4½ inches in length. About 3,000 fish are planted this time for each hectare of pond. They are harvested in June.

In April, when the "new fry" become available, about 5,000 fish are introduced into each hectare of pond in addition to the old fry already there. These are harvested in September.

In June, another batch of "new fry" are planted. This time, from 3,000 to 4,000 fry are placed into each hectare of pond. These are carried over the winter and saved for stocking next March.

Since the fish planted in June (third planting) are not harvested before the end of the year but carried over to the next rearing season, they are actually the stock fish for the planting in March (first planting). The ponds are therefore actually stocked only twice a year, and the number of fish planted for each hectare of pond is actually 8,000 to 9,000 (5,000 in April and 3,000 to 4,000 in June).

The number of fish in each hectare of pond in each month of the rearing season is best shown in the following table:

	No. of fish introduced	No. of fish removed	No. of fish in pond
March	3,000	——	3,000
April	5,000		8,000
May	——	——	8,000
June	3,000-4,000	3,000	8,000-9,000
July	——	——	8,000-9,000
August	——	——	8,000-9,000
September	——	5,000	3,000-4,000
October	——	——	3,000-4,000

It can be seen from the above that the number of fish in each hectare of pond is never more than 8,000 to 9,000 at any time of the year. This number should be reduced when mortality of the fish in the pond is taken into consideration.

The stocking rate of 8,000 to 9,000 to each hectare is very high as compared with the practice in Indonesia and the Philippines, and is made possible only by the intensive method of culture, which will be described in a later chapter. In Indonesia, three plantings are made each year. The number of fingerlings planted each time is about 500 per hectare (1). This would give 1,500 as the total number of fingerlings planted in each hectare of pond per year. In the Philippines, the common stocking rate is 1,000 to 2,500 fingerlings per hectare (8).

The fish farmers in Taiwan are aware of the effect of change of temperature and salinity of water on the delicate milkfish fry. Before the "new fry" are introduced into the rearing pond, they are put through a process of orientation. The fry that arrive at the pond are first placed in the fry ponds, which are made of cement or mud and about 2 square meters in area. The water in the fry pond is adjusted in temperature and salinity to approximate the water of the container in which the fry are transported. The fry are held in the fry pond for two or three days, during which they are fed with wheat flour, and water in the rearing pond is gradually added and mixed with the water in the fry pond. Finally, the water in the fry pond attains about the same temperature and salinity as those of the rearing pond, and the fry, now orientated, are removed to the latter.

Some fish farmers provide nursery ponds for rearing the fry before they are liberated into the rearing ponds. This nursery pond is an area of obout 150 square meters (the size varies greatly) temporarily partitioned off from the rearing pond by a small dyke.

The fry feed on the bottom algae and phytoplankton in the nursery pond until they attain about an inch in length. The small dyke is then broken down or removed and the fry allowed to pass into the rearing pond.

FEEDING

The feeding of milkfish in ponds in Taiwan begins in May. Before this, little or no feeds are given, because both the bottom algae and plankton food are quite abundant in the ponds and some of the fertilizers applied in the month of March may yet remain to serve as food. Feeding continues until October, when the fish are removed to the wintering ponds.

The feeds commonly used are rice bran, soybean cakes, and peanut meal. The quantity of feeds used varies as to the productivity of the ponds. Irrational as it may seem, the ponds of high productivity are given more feeds, since they are stocked with more fish; the ponds of low productivity receive less feeds, since they are stocked with less fish. The following represents the typical quantity of feeds for one hectare of milkfish pond of fairly high productivity in one year: rice bran 2,000 kg., soybean cakes 500 kg., peanut meal 36 kg.

The first part of the production or rearing period is called the "nien tou", meaning "head of the year". It is generally from March to June, and is characterized by (1) abundant natural food in the ponds, (2) comparatively dry weather and low temperature, and (3) comparatively high salinity of the pond water. The milkfish in the ponds during this stage consist of the half-grown fish from the wintering ponds and the "new fry". During this "nien tou" stage, rice bran is given as feeds almost exclusively. The reason given by the fish farmers is that most of the fish in the ponds are small and cannot take the soybean cakes or peanut meal, which is coarser and of larger particles. The fish farmers also believe that soybean cakes and peanut meal do not disintegrate easily in salt water and, therefore, should not be given at this stage.

The rainy season sets in about the end of June in southern Taiwan, and marks the end of the "nien tou" stage. The fish from the wintering ponds are also harvested at this time, leaving the smaller fish ("new fry") in the ponds. The salinity of the pond water become lower due to the rainfall, and the temperature is higher. In the ponds, the natural food is practically exhausted and the comparatively fresh water in the ponds is not suitable for the growth of algae. During this stage, soybean cakes, broken into small pieces, are given as feeds in addition to the rice bran. The fish farmers claim that the fish at this stage are large enough to partake of coarser food, and the soybean cakes, being in larger pieces, are not easily washed away by the excessive rainwater and freshets.

Peanut meal is given in August and September in addition to the rice bran and soybean cakes. The fish farmers claim that they stimulate the appetite of the fish and speed up their growth. Peanut meal is also used in place of the soybean cakes earlier in July if the price of the latter is too high.

HARVESTING AND MARKETING

Although many harvests of the milkfish may be made each year, there are mainly two harvests. The first is the harvest of the fish from the wintering ponds ("old fry"), which takes place in June; and the second is the harvest of the fish planted as "new fry"

in the early part of the rearing period, which takes place in September or October.

The fish taken out in June (1st crop) weigh 200 to 300 gm. each, and are sold entirely for human consumption. The mortality of this crop of fish from the time of planting to the time of harvest is about 8%.

The fish taken out in September and October (2nd crop) weigh about 150 gm. each. They are sold for human consumption, but the smaller fish may be used as bait for tuna long lining. The mortality of this crop of fish from the time of planting to the time of harvest is about 20%.

When the second crop of milkfish is harvested in September or October, there yet remain in the ponds the fish which are planted in June as late fry. These are too small for the market and are removed to the wintering ponds to be saved for planting in the next spring.

For more rapid turnover of investment, many fish farmers harvest their milkfish many times a year. Sometimes, fish are taken out when there is a good market demand and the price is extra high. It may be mentioned here that the frequent removal of fish from the ponds, if carried out properly, has certain advantages. It thins the fish population in the ponds to allow the remaining fish to grow more rapidly and to a larger size. It may also reduce the variation in the size of the fish in the ponds and make growth more uniform.

In some milkfish ponds, particularly those in Kaohsiung, where most of the long lining vessels for tuna are based, the fish are removed when they reach 80 to 100 gm. in weight and sold for use as baits. It is claimed that the milkfish are superior to other fish for this purpose, because of their bright silver color and better keeping quality.

The milkfish is usually harvested by use of gill-nets made of sisal hemp. The size of the mesh of the net varies with the size of the fish to be harvested. The depth of the net is from five to eight feet, varying with the depth of the pond. In operation, a number of nets, each about 14 fathoms in length, are joined together and towed across the length of the pond. As many as 12 nets may be joined together in case of large ponds. In the second harvest during September or October, the ponds are of course drained, and any fish left over are picked up. The prawns cultured in association with the milkfish are also caught when the ponds are drained.

The yearly yield per hectare of milkfish ponds, according to the Kangshan Fish Culture Cooperative, is 1,500 kg. for the average ponds and 2,000 kg. for the ponds of high productivity. These figures include the prawns which are cultured in association with the milkfish. One fish farmer in Kaohsiung gave his year's yield as 1,800 kg. per hectare. The general estimate is that each hectare of milkfish ponds produces 1,000 to 2,000 kg. of fish and the average yield is 1,500 kg. per year.

All milkfish are sold through the fish markets in the various localities. The retail price in 1952 is about Taiwan dollar 4.00 (equivalent to about US $0.17) per lb. The fish sold for baits bring a slightly higher price.

WINTERING

The milkfish, being a tropical fish, is sensitive to low temperature. According to Yamamura (9), it becomes sluggish when the water temperature drops below 15 degrees C., becomes paralized at temperature below 11 degrees C., and dies at temper-

ature about 12 degrees C. The writer must add that the above are not hard and fast rules. A great deal depends on the enviroment and condition of the fish. Milkfish may die at temperature higher than 12 degrees C. if conditions are unfavorable. Again, if the exposure to cold is prolonged, the milkfish may be affected at temperatures higher than those mentioned above.

As the winter temperature in southern Taiwan may drop as low as 2.4 degrees C. (1925 in Tainan), the milkfish could not be held over the winter unless they are protected from exposure to the critical temperature. It is necessary to hold some of the milkfish through the winter, because (1) the late fry planted after June do not reach marketabe size in October and (2) some fish should be made available for stocking the ponds early in the next rearing period as the "new fry" will not be available until April.

To hold the late fry over the winter, the milkfish farmers in Taiwan construct wintering ponds. These are ditches of 3 to 4 feet in depth and protected on the windward side by a windbreak. The windbreak is a bamboo frame thatched with straw or reeds, and placed obliquely (leaning on the pond side at angle of about 30 degrees) on the northeastern side or sides of the pond to ward off the winter monsoon. The milkfish are placed in the wintering ponds in October and held until March, when they are removed for planting in the rearing ponds. In the wintering ponds, the fish are fed with rice bran on the warmer days. On the really cold days, the fish do not take food.

As winter is the season of draught in southern Taiwan, the water in the wintering ponds tend to gain in salinity due to evaporation. It is necessary, therefore, to add fresh water to the ponds occasionally in order to maintain the proper salinity.

PRAWNS AND FISH CULTURED IN ASSOCIATION WITH MILKFISH

Prawns are stocked almost in all milkfish ponds in Taiwan. The specis stocked are the *Penaeus carinatus* Dana and the *Peneopsis monoceros* Fabricus. They bring very high market price and form a good source of income for the milkfish farmers. The *Penaeus japonicus* Bate is not reared in ponds because of the high salinity it requires.

Differing from the practice in Indonesia, where the prawn fry are admitted into the ponds with the sea water and there is no selection as to species or control as to number, the prawn fry in Taiwan are caught from the sea and brought to the fish farmers by peddlers. The fry of the Penaeus are caught mostly from Tungkang in southern Taiwan. About one-third of the Penaeus fry are caught along with the milkfish fry, and the remaining two-thirds are caught separately. To catch the Penaeus fry, bunches of seaweeds are planted in shallow bays or inlets at a distance of about 12 feet from each other. The young prawns gather among the weeds and are captured with a triangular dip net. The price of Penaeus fry in 1950 was Taiwan dollar 0.15 each of 12 mm. in length. They are planted in the ponds in May and June. After six months in the pond, they reach a weight of 40 to 50 gm. each.

The fry of the Peneopsis are also caught in southern Taiwan, and are most abundant in April to July. The eggs are hatched every time after a rain. The drag net used for catching the milkfish fry is also used for catching the Peneopsis fry, but, instead of being towed on the surface, it is allowed to scrape the bottom of the shallow sea. The Peneopsis fry are sold by carrier weight (two barrels) and not by number. Each carrier weight consists of about 8,000 fry, and the price was ten Taiwan dollars

in 1950. The rearing period is short, only two to three months. They are marketed when they reach a length of 7 to 8 cm., weighing 6 to 7 gm. each.

Fish cultured in association with milkfish are the mullet (*Mugil cephalus*), common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypophthalmichthys molitrix*), big head (*Aristichthys nobilis*), and mud carp (*Cirrhina molitorella*).

The mullet are common in the milkfish ponds of salt and brackish water in central Taiwan. They occupy a secondary position in the milkfish ponds for the reason that their feeding habit and rearing period are almost identical to those of the milkfish but their market price is usually lower than that of the milkfish. The mullet fry are captured along the coast between Taichung and Tainan by means of bag nets or by specially constructed ponds with gates to admit sea water. The price of mullet fry in 1950 was Taiwan dollar 0.15 to 0.20 each for fry of 1 inch in length.

The several species of carp as mentioned above are reared in association with milkfish only in brackish water ponds. Because of the difference in feeding habit and the longer growing period as compared with milkfish, the association of species in this case makes better utilization of the ponds and often results in larger total yield per unit area. They are often used as substitutes for milkfish for stocking the ponds when the fry of the latter are not sufficient to meet the demand.

FINANCIAL OPERATION OF THE MILKFISH FARMERS

In Taiwan, one fish farmer and his family usually operate one to two hectares of milkfish ponds. He may own his ponds or lease them from a landlord, or he may work the ponds as a hired man.

The receipts and disbursement of a milkfish farmer in Kaohsiung who operated one hectare of fish pond in 1950 is reported as follows:

Receipts from sale of fish (1,855 kg. @ Taiwan dollars 3.72)		Taiwan Dollars 6,900.00 *
Disbursements		3,880.00
Stock fish	Taiwan dollars 1,000	
Rice bran	250	
Soybean cakes	450	
Camellia seed meal	680	
Labor and equipment	1,500	
Profit:		Taiwan Dollars 3,020.00

The following is an estimate made by the Kangshan Fish Culture Cooperative in 1952 on the receipts and disbursements of its milkfish ponds calculated on the basis of one hectare:

Receipts		Taiwan Dollars 8,424.00
Sale of fish from 1st crop (540 kg. @ Taiwan $ 6.35)	Taiwan $3,429.00	
Sale of fish from 2nd crop (780 kg. @ Taiwan $ 6 00)	4,680.00	
Sale of other fish and prawns (105 kg. @ Taiwan $ 3.00)	315.00	

* SU $ 1.00 is equivalent to about 23 Taiwan dollars at the time of writing.

Disbursements		Taiwan Dollars 5,427.12
Stock fish		
(12,000 @ Taiwan $ 0.20)	Taiwan $2,400.00	
Rice bran		
(3,000 kg. @ Taiwan $ 0.60)	1,800.00	
Peanut meal		
(720 kg. @ Taiwan $ 0.85)	612.00	
Camellia seed meal		
(180 kg @ Taiwan $ 1.65)	257.00	
Depreciation of nets and gear	118.12	
Repair and improvement work	240.00	
Profit:		Taiwan Dollars 2,996.88

The above two cases do not include rentals among the items of disbursements. This item should be included if the ponds are leased. The amount of rental varies according to the productivity of the pond. For ponds of the best grade, the rental per hectare is about 160 kg. of the fish per year, but for ponds of the lowest grade, the rental may be only 30 kg. of the fish per hectare per year.

The fish farmer must also pay interest if he borrows money to pay for the stock fish and the feeds. This may be as high as 60% to 70% annually.

CONCLUSION

Since the supply of milkfish fry is the chief limiting factor of the culture of milkfish in Taiwan, all-out efforts should be made to increase the supply. Toward this end, the following measures are suggested:

1. The abundance or scarcity of the milkfish fry along the coasts of Taiwan is related to water temperature, density of water, current, prevailing wind, and other oceanographical conditions. These should be studied over a period of years. The correlation found may be useful in forecasting the probable crop of milkfish fry.

2. The horizontal and vertical distribution of the milkfish fry in coastal waters should be studied. This would supply the data necessary for the improvement of the method and gear used for catching the fry.

3. The present method and gear used for catching the milkfish fry, especially the triangular scoop net, are wasteful of man-power. The drag net is comparatively more efficient, but some improvement in its construction and use seems to be necessary.

Since the supply of milkfish fry is insufficient to meet the demand in most of the years, it is not advisable to increase the acreage of milkfish ponds any more than the present acreage. Because of the rise of the coastal land in western Taiwan, sea water is becoming less and less available to the more inland milkfish ponds, which decrease in productivity and are gradually being abandoned. On the other hand, the newly formed land on the seashore is slowly being reclaimed and, to a great extent, used for milkfish culture. The government should regulate these changes so that the proper balance may be maintained.

Increase of production in milkfish ponds can be achieved by improvement of cultural method. The government research institutions should conduct more extensive experiments and demonstrations on feeding and pond fertilization. The proper number of fish to be planted in a given area deserves extensive study, since it bears important relationship to the supply of fry. A practical system of segregating the fish of various

sizes, if such could be devised, would be very advantageous, since there is great variation in growth rate when fish of various sizes are reared in the same pond.

Many milkfish ponds along the coast are liable to inundation from the sea, which invariably results in loss of fish and fertility. The government should help the fish farmers to build proper dykes on a cooperative basis. Cooperative pumping service should also be encouraged for ponds that require mechanical irrigation and drainage.

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