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REPORT OF
FISHCULTURAL INVESTIGATIONS
IN TAIWAN

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REPORT OF FISHCULTURAL INVESTIGATIONS IN TAIWAN[1]

USAID-Auburn University Project (AID/csd-1581) Increasing Fish Production by Improved Fishcultures - Phase I

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June 17, 1969

Introduction

We arrived in Taipei, Taiwan about 2 p.m. on October 12, where we were met by Mr. S. Y. Lin and Mr. J. K. Liang, both former students at Auburn. Our trip and transportation in Taiwan was arranged by Mr. T. P. Chen, Chief of Fisheries, in the Joint Committee for Rural Reconstruction (JCRR). This committee is composed of several members from USAID and an equal number of Chinese. This arrangement resulted in a particularly effective program which has allowed Taiwan to become a developed country.

A trip to Taiwan is necessary for all Auburn personnel who will work abroad. It is especially valuable to see how the people have made the best of things already available. Practically every square foot of available soil is presently in cultivation. Even the terraces grow useful plants, such as sweet potatoes, instead of weeds. The refuse from agricultural crops is put to good use. Even rice straw is used for the production of paper and also for the culture of mushrooms.

The most noticeable thing about Taiwan is the ability of the Chinese to work very hard and to use to good advantage all of the facilities they have. As a matter of fact,

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1. This report is based on a survey made October 12 to October 18, 1967.

they may work entirely too hard as men and women are busy in their fields and businesses from sunup until sundown, seven days a week. The constant hardwork of the Chinese probably should be reduced to a certain extent because the present lack of time from work does not lead to careful planning for future development.

Another very noticeable condition in Taiwan is the tremendous number of young children present everywhere. The rate of increase in the population is somewhat in excess of 3 percent per year, which will result in a doubling of the population in about 22 years. Already practically all of the agricultural land has been pressed into use and is producing at relatively high rates. Consequently, in this country, the problem is how to prepare for this increase in population. The majority of these young people appears to be between the ages of 5 and 10. This obviously will place quite a strain upon the economy as each adult must support approximately 5 to 7 people.

Importance of Fisheries in Taiwan

The importance of fishery resources in Taiwan, which has a land area of approximately 8.8 million acres and a population of 13 million people, can be seen from the following fishery statistics:[1]

Type Fishery	Total Production (metric tons)
Deep-sea	169,260
Inshore and coastal	197,506
Culture	58,511

1. Taiwan Fisheries Yearbook, 1966. Taiwan Fisheries Bureau, Department of Agriculture and Forestry. 232 p.

The total production of 425,277 metric tons was valued at $96,635,125.00.

Fish Cultures

Fish cultured in brackish and fresh waters makes up only 16 percent of the total annual fishery product of Taiwan--58,511 metric tons from fish cultures as compared to 366,766 metric tons from deep-sea and coastal fisheries. Production from fish cultures is quite important however, because the principal species cultured are carps and milkfish, which have long been favorite foods of the Chinese.

The production by species and value of fish and other aquatic organisms produced in 1966 are summarized below:

Species	Production (MT)	Value (U.S. $)
Common carp	895	305,800
Crucian carp	627	174,500
Grass carp	1,354	635,450
Silver carp	2,520	894,575
Tilapia	8,271	1,626,500
Eel	175	286,350
Milkfish	29,093	12,577,250
Mullet	1,296	509,050
Shrimp	297	255,225
Crab	160	122,200
Oyster	10,332	1,606,500
Clam	1,559	288,150
Gracilaria	277	6,925
Other	1,655	14,630
Totals	58,511	19,288,475

Of the total of 58,511 metric tons of fish and other cultured aquatic organisms, 31,415 metric tons were produced in 15,587 hectares of brackishwater ponds while 10,740 metric tons were produced in 5,336 hectares of freshwater ponds. Production of fry of common and Chinese carps amounted to 224,687,000 for 1966.

On October 13, accompanied by Mr. S. Y. Lin and Mr. Liang, we traveled by car to Tainan where we first visited a private fish farm owned by Mr. Tsai.

Tsai Fish Farm

This operator has several ponds ranging up to one hectare in size. These ponds are entirely supplied by runoff water and the water is carefully saved when a pond is drained by pumping it into an adjacent pond. After the crop of fish is harvested, the bottom of the pond is allowed to dry for one week before water is pumped back into the pond and fish stocked--stocking rates will be given later.

The rates of fertilization and feeding were not obtained, but chicken and pig manure and night soil apparently were used at heavy rates. In addition, supplementary feeds such as rice bran, peanut cake, soybean cake, legume seed, brewery wastes and soybean wastes were used. The ponds had a very deep green color and appeared to be full of plankton. At times, the water became so low in oxygen that fish became distressed. The owner stated that he merely harvested the fish if they did not look as if they would recover. All species of fish stocked did not die as some were more resistant to low dissolved oxygen than others.

Most of the growth of fish was obtained from May until fall, but very little growth occurred after November. Consequently, the ponds were usually drained shortly thereafter. Fish were harvested at intervals from July until draining whenever they were found in the seine and were large enough to sell.

Stocking rates and approximate yields for the various species are presented below:

Species	Stocking rate (no. /ha)	Harvest (kg/ha)
Mullet	3,000	1,000
Silver carp	1,000	800
Grass carp	300	400
Bighead carp	200	350
Common carp	3,000	600
Goldfish (brood)*	few	300
Tilapia**	30,000	5,000
Totals	37,500	8,450

* Only brood goldfish were added. These reproduced in the pond and the young were harvested.

**Tilapia stocked had an average weight of 20 grams and were from a previous draining of a pond.

The total weight of fish harvested during and at the end of a growing season generally exceeded 8,000 kg/ha. The owner stated that in some years, production ranged up to 10,000 kg/ha. The owner summarized the economics of his fishcultural operations on a per hectare basis as follows: cost of feed and fertilizer, $1,000; temporary labor, $250; sales of fish, $2,000. Return to the owner for his investment and profit was $750 per hectare.

Reclaimed Intertidal Pond Areas

This 1,500-hectare area was visited October 14. Here, the area between high and low tides was walled off with a strong dike facing the sea. This project was sponsored by the Taiwan government. The area was divided into 30- to 50-hectare blocks. These 30- to 50-hectare farms were sold to private fish farm operators for 1,500 U. S. dollars per hectare, although the cost to the government for acquisition of land and construction of the main water supply canal and water control structures was $2,000. The loss was considered justified because this system allowed production of a large amount of additional fish for use by the country.

Farmers buying these fish farms built the interior dams themselves and divided them up into smaller pond areas suitable for culturing milkfish. Part of the uplands located above high tide was also divided into fish farms. Water is pumped from the high-tide level to the upper pond area. The central or main canal is engineered to take the normal river flow in addition to water resulting from heavy rains. These waters pass into the sea through a large sea-gate. In Taiwan, a total of 9,827 hectares of reclaimed tidal lands is in fish production at the present time, and it is possible to reclaim an additional 50,000 hectares of similar tidal lands to be utilized in brackish-water fish cultures.

Tsen-Wen Fishery Research Station

The Fisheries Division, under the Department of Agriculture and Forestry, was allotted approximately 80 hectares of this reclaimed intertidal pond area to develop into

a research station. Part of the dams and 20 hectares of ponds had already been constructed. The outside dam along the main water supply channel had a 6 to 1 slope. Most of the ponds had brick-lined sides extending from the pond bottom to about one-third meter above the normal water level.

The cost of bricks, mortar, and labor for lining the sides of the ponds was $1.20 per meter of pond dam (about $400 per hectare for ponds 4 to 5 hectares in size). Although costly, this is a very effective method of preventing damage to dams by wave action. The cost of the concrete gates with four slots for boards was $125.00 each. Pumping of the sea water from high-tide level to the upper pond area, a lift of approximately 2 feet, was accomplished with a 5 hp diesel pump. This pump used approximately 100 liters of fuel per 24 hours and pumped 85 gallons of water per minute.

Research at the Tsen-Wen Research Station was directed toward developing methods of culturing shrimp. Penaeus monodon was the species cultured. This species is called grass shrimp in Taiwan and "supo" in the Philippines. It is a very rapid grower and reaches a size of from 8 to 10 inches in length when fully grown. The post larvae, approximately 1 inch in length, were seined from the estaurine areas. These small shrimp sell for about one cent each. The young shrimp were stocked in small nursery ponds at the rate of 100,000 per hectare and were fed lightly, but frequently, with finely ground peanut meal for one to two weeks. After the shrimp attained a size of 2 inches, they were stocked into production ponds at the rate of 6,000 per hectare, and fed ground trash fish. This is the first year of the shrimp culture experiment, so no results were available.

The biologist at Tainan Fisheries Research Station in charge of the shrimp culture project received training on culturing shrimp in Japan. The species cultured in Japan is Penaeus japonica. The spawners are caught at sea while trawling for shrimp for the market. The sexually mature shrimp are allowed to spawn. After hatching, the nauplius stage larvae are not fed, but the succeeding zoea stages are fed a pure culture of diatoms, principally Skeletonema. The mysis stage is fed for 3 days on small brine shrimp. Post larvae shrimp are fed brine shrimp and crushed clam muscle. Sometimes crushed oysters are also used. Approximately 20 days are required for the shrimp to reach the juvenile stage, at which they are stocked into production ponds. Production of shrimp was reported at 2 to 5 tons per hectare per 7-month growing period--May through October. Harvest size was 30 grams. Using ground trash fish as the primary food source, the conversion rate was 15 to 1, a very poor conversion figure.

A portion of the intertidal area was devoted to the culture of Gracilaria, especially those ponds which had sandy bottom soils with little organic matter. This aquatic plant is utilized in production of agar-agar. Bamboo fences were placed at intervals across the pond to break up the action of the wind, as this is detrimental to the culture of this seaweed. Small clumps of Gracilaria, 2 to 3 inches in diameter, were planted at the rate of 2,000 kg per hectare. This was done in July and August as this plant grows best during spring and autumn, but it grows very slowly during extremely cold and rainy weather. A salinity of 25 ppt is required for good growth. Water in the pond is exchanged once per week, but no fertilization is practiced. Each

small clump of Gracilaria grows rapidly, increasing its area approximately 10 times in 30 to 40 days. The first harvest is 4 to 6 weeks after planting and periodically thereafter, whenever the plant grows sufficiently to warrant harvesting. Gracilaria is sold air-dry. In drying, it loses 90 percent of its weight. Production per hectare is 10,000 kg, and sale price is 12.5 cents per kg or equivalent to $1,250 per hectare. Although this is a new business in the area, this culture is spreading. No one in Taiwan apparently cultures the edible types of seaweed, but these are collected from coastal waters.

Tainan Fish Culture Station

This research station has an area of 50 hectares, with 40 hectares in water. There were 13 rearing ponds, 2 to 4 hectares each; 12 experimental ponds, .3 to .5 hectare each and 4 wintering ponds. Principal work at this station was on research on the culture of milkfish, feeds for milkfish and the culture of various types of algae. The Taiwan method of milkfish culture is an advanced method, which consists of raising in the same pond, 3 to 4 sizes of milkfish and harvesting at various times during the growing period. The success of this method depends upon being able to raise benthic algae or various mixtures of blue-green algae and diatoms. Plankton algae are considered to be a nuisance as they shade out and prevent growth of these bottom forms. FAO papers prepared by Mr. Tang give much of the background for the Taiwan method; hence, only the basic procedure is outlined on the next page.

December to January	Drain pond and dry thoroughly.
January	Fertilize pond bottom using organic and inorganic fertilizers. Reflood pond a few inches and dry again.
February	Fertilize the second time using 500 kg/ha rice bran. Chicken manure is also used.
March	Kill wild fish with tea-seed cake or tobacco-stem powder.
April	Stock over-wintered fish. These are fish removed from ponds the preceding November and carried over winter in ponds protected against the cold winds sweeping through this area. Usually two sizes are stocked: large fingerlings, 2,000/ha and medium, 2,000/ha. Also 2,000 fry, 1-inch long, recently caught from the ocean, are added.
June	An additional 2,000 fry are added. First harvest of the over-wintered larger fingerlings, now of marketable size, is made.
July	Second harvest of milkfish is accomplished. This consists of the smaller over-wintered fish, and also, part of the fry which were added in April.
August	Algae beds on bottom are examined; if they have been depleted, the fish are often shifted to another pond previously prepared, or fish may be fed on rice bran. (Third harvest).
October	The final harvest is made and fish of marketable size are sold. Smaller fish are stocked in over-wintering ponds for stocking the following spring.

The larger milkfish are principally harvested by the use of gill nets, which was demonstrated by personnel of the station. Before the fish were caught, a large mesh

nylon net was slowly dragged through the pond. As the fish approached the net, they jumped in tremendous numbers, and continued for sometime thereafter. This "scare netting" was repeated three times during which time the fish expelled feces and cleared their digestive tract. Another gill net with a 2-inch mesh was then dragged through the pond. This net also reached from one side of the pond to the other and from top to bottom of the pond. The smaller fish passed through the mesh of the net, but most of the larger fish were gilled and subsequently were removed rapidly by the workers. The fish then were arranged in circular baskets, tail down and head up, in an orderly manner. Each basket contained approximately 30 kg of fish. In this manner, five men were able to harvest 90 kg of milkfish from a 3/5-hectare pond in about 30 minutes. The rapidity of this method of harvest makes its consideration for use in fishculture elsewhere desirable where the fish do not have to be kept alive to send to market.

Milkfish ponds produced an average of 1,968 kg/ha in 1964 and 1,860 kg/ha in 1966. Maximum production is 2,500 kg/ha. Mr. Lin gave the following statistics for milk fish culture in Taiwan:

	U.S. $ per hectare	
Total sales		825
Cost of production		
feed & fertilizers	217.50	
labor	100.00	
rent	75.00	
fish for stocking	290.00	
		682.50
Net profit		142.50

Mr. S. Y. Lin, in a manuscript summarizing research on milkfish culture in Taiwan, points out much information that is important to fish culturists. According to his paper, milkfish can be changed from water containing 34 parts per thousand salinity immediately into freshwater without loss. But they cannot be placed directly from freshwater into sea water. In this case, they must be gradually acclimated to increase in salinity. Milkfish can tolerate up to 120 parts per thousand total salinity; however, after the salinity approaches 70 parts per thousand, the fish grow very slowly in ponds. The best temperature range for growth of this species is between 20 and 33° C. They become sluggish at 20 to 15° C, and die at 12° C. He also reports the digestability of protein and various types of food stuffs by milkfish. This work was done by Lai. The digestability in percent for powdered algae was 46.7; for rice bran, 33; for peanut cake, 53; flax seed cake, 69; fish meal, 66; fish solubles, 41.8 and commercially mixed dry feeds, 67.0.

One staff member of the Tainan Fish Culture Station is working on a project to develop pure cultures of various species of benthic algae fed upon by milkfish. These are then tested as food for milkfish to determine their digestability and value as feeds. Another one is working on the feeding ecology of milkfish. The fish are caught from the ponds every three hours during the day and night. Results of this study indicate that milkfish feed during the night on various types of zooplankton, Oscillatoria and diatoms. The next period of feeding is between 7 and 8 a.m., at which time the fish feed principally on benthic algae. These algae are completely digested by noon. The earliest period of feeding was at 3 a.m. These two projects, in addition to a study on the control of chironomids and the taxonomy and ecology of algae, are supported through a grant from the Rockefeller Foundation.

Coral Lake and Coral Lake Fisheries Station

On October 15 we visited Coral Lake and the small research station located nearby. Coral Lake is an irrigation reservoir of 1,200 hectares and is similar in construction and general appearance to Lake Martin in Alabama. The impoundment is characterized by extreme drawdown during dry summer months. When we were there, the water level was down approximately 30 to 40 feet. There is no public fishing in this reservoir. The irrigation reservoir is operated by a private company and they sell fishing rights to individuals who trap Tilapia and seine for other species at the low water level. Both the grass carp and silver carp have been found to spawn in the upper end of the reservoir where the river enters. The eggs float downstream and hatch in the reservoir. This fact will have to be considered in stocking the grass carp into Alabama ponds. We had previously considered that this fish could not spawn in such areas.

The fisheries research station at Coral Lake is supplied with water from the irrigation reservoir. There are 15 rearing ponds with 2.4 hectares of water. Major emphasis at the station is on induced spawning of the Chinese carps. Annual production is approximately 12 million fingerlings. Several long concrete tanks have been constructed with water flowing in at intervals along the sides. In late spring, sexually mature grass carp, silver carp, bighead carp, black carp and mud carp are removed from holding ponds and held for a few days. They are then given pituitary injections, and the eggs are stripped and fertilized. The fertilized eggs are then placed in a conical net with water entering through the bottom, and which is suspended in the concrete tank so that the top of the net is at least six inches above

the water. The mesh of the net is approximately 30 per inch. The young carp are held in this net until they are able to swim horizontally. They are then transferred to a nylon trough in another concrete tank with running water and fed boiled eggs, crumbled and strained. Also, they are fed soybean meal and flour. Feeding continues for approximately 4 days. The young carp are then transferred to ponds containing a good growth of zooplankton. Despite this care, it is reported that the survival of grass carp from the eggs to fingerlings is only approximately 12 to 17 percent. Many private individuals have gone in the business of producing fingerlings of the Chinese carps by pituitary injections of the adults and raising the fry in small ponds. Hatcheries are usually much simpler than this one of the Fisheries Division; however, the principle is the same. In one farm visited, water was pumped into a concrete tank from an adjoining pond. It then flowed by gravity into concrete ponds similar to those at the Coral Lake hatchery. The private fingerling producers have been so effective in the production of Chinese carps that these species are no longer imported from Hong Kong, and several millions were available for sale throughout Southeast Asia. In fact, Taiwan has about taken over the business that used to go to Red China by way of Hong Kong. We have taken pictures illustrating the various types of stations and their equipment where fry are produced.

Lukang Fisheries Research Station

This station,operated by the Fisheries Division,is located along the coast near the reclaimed intertidal land areas. There is a good laboratory, approximately 20

concrete ponds, and approximately 20 additional earthen ponds with 7 hectares of water. The work at this station consists of eel culture, oyster culture, the hybridization of fish, research on mullet, and other marine animals. A large part of the effort goes into experiments on eel culture.

Eel Culture

Eels have long been cultured in Japan and elsewhere, feeding them trash fish. The conversions were of the order of 12 pounds trash fish to produce 1 pound eel. This is a considerable waste in the pond. This and the scarcity of trash fish has led to the development of mixed feeds for production of eel. Mixed feeds usually contain over 60 percent fish meal, various seed meals, yeast, and a binder. Binding material was CMC, chemically known as carboxymethyl cellulose, which was mixed with the feed at the rate of 0.2 percent. When mixed with water, this makes the feed into a tough, rubbery mass. It might be worth trying in formulating feeds for channel catfish. The chemist suggested that flaxseed cake might be used as a binder, as this also makes a rubbery mass when mixed with water. However, flaxseed is poisonous to some fish and is a laxative to many others. To make the binder effective, the meals must be ground very finely, and the CMC intimately mixed with it. With the dry feed, conversions of 2.4 to 1 were obtained. Feed usually contains 30 percent or more protein, 7 percent fat, 6 percent carbohydrates. Malt is also added to the feed, and often fish solubles are added for vitamins.

Eel larvae are collected at the river mouths during November and December. At this time, the larvae weigh approximately 1 kg per 7,000 larvae. By February,

the size of the young eels taken in the estuaries is 2,000 per kg and by June, 200 per kg. Trawling is continued throughout the period as long as eels can be caught. Trawling is most effective at night. Many are also caught with the small push-nets operated by individuals, similar to the equipment used to collect milkfish fry. A favorite place to collect eels is below the falls or the first dam on a river. The species cultured is Anguilla japonica. The young eels are placed in ponds with concrete sides and a T-type top extending 3 to 4 inches vertically with the sides. This lip is to prevent the eels from climbing out. Since eels are bought by weight, the stocking rates are given in weights. The stocking rate was given at 200 grams of young eels per square meter of pond. This does not seem the best method of stocking a pond as the size of eels collected vary from 7,000 per kg to 200 per kg. The final size of the fish would depend on the number, not the weight stocked. With the larval form, the number is 1,400 per square meter. These are fed on ground oysters or crab meat for approximately 2 weeks. They then change color and darken like the adult. They grow to 20 grams by August. In commercial ponds, the feed is then changed to trash fish, or trash fish and meals. In 6 months the small eels reach the size of approximately 30 grams. At sizes from 5 to 30 grams they are ready to stock into the rearing ponds. The stocking rate given is 300 grams per square meter. In these rearing ponds the eels are fed daily at 10 percent of their weight with trash fish. This is gradually changed to artificial feed at the experimental station. However, many private growers raise the eels entirely on trash fish or mixtures of trash fish and meals. Where ponds are stocked with large fingerlings in

June, or from March to June, harvest can be begun in September and continued until the ponds are drained in November. The fish are harvested at the point of feeding by the use of a dip net. The feed is placed in wire baskets in some cases, and in others, in a long trough with a side opening. The latter appears most desirable. We have pictures of both types. The eels rapidly learn to come to the feed, and come in tremendous numbers. They are also very suspicious. In one pond where they had been accustomed to being fed in wire baskets, the trough-type feeder was placed in the water to show how it worked; however, most of the eels left the area when they saw this new device, and only came back to feed after it had been removed. They also become suspicious and stay away from the feed if very many are removed by a dip net. Research workers at the station said that growers got up to 10,000 kg per hectare by the end of the year. All eel culture is in freshwater as eels do not grow well in brackishwater.

Private Eel Farms

Quite a number of individuals have gone into the commercial culture of eel, as this sells at a higher price than other types of fish. This is because the Chinese consider the eel a good fish and also to have certain medicinal properties if eaten. One private eel farm visited had five hectares in water. All ponds had concrete sides and concrete raceways. The farm uses well water. The ponds have a depth of 1.2 meters and dirt bottoms. Pictures were taken of the entire operation. The total cost of construction was 4 million N.T. dollars. The profit was estimated by the research workers at approximately 3 million N.T. dollars per year. The eels were stocked as previously described. In this farm each day, 2,400 kg of trash fish

were fed, and the grower expected to get 240 kg increase in eel flesh daily. This is a 10 to 1 conversion. He uses half trash fish and half dry feed, or was reported to do so. However, we watched the feed being mixed and it was at least 80 percent trash fish and not over 20 percent dry feed. Dry feed is fish meal, rice flour, soybean meal and salt. Exact composition was not given. The trash fish were frozen. The two were mixed on the concrete floor and ground in an electric grinder. A boxlike structure was constructed above the water level in one area of the pond from which to do the feeding. This protected the feeding eels from bird enemies and also made the feeding area somewhat darker, which they apparently like. The feed was placed out in trough-like feeders. Because of the 10 to 1 conversion, approximately 90 percent of the fish feed was waste. Consequently, the grower has added the bighead carp, the common carp, and the silver carp to each pond to clean up any waste from the food. Sale of these carps is reported to pay for the entire cost of the operation, leaving the eels as a profit. Most of the eels were sold locally at from 90 to 95 N.T. dollars per kg or about U.S. $0.90 per pound.

Fish Breeding Experiments

At this station, experiments were being conducted on the production of hybrids between the various Chinese carps. One of the best hybrids was a cross between the silver carp and the bighead carp. The production per hectare of the hybrids on natural feeds was being tested in a series of pens made in large ponds by fences of either nylon netting or steel wire. One setup was testing the hybrids on the latin square arrangement in a large pond. However, the winds blow from only one direction

across this pond and make conditions at opposite ends and in the middle quite dissimilar. These winds were often so strong that it was hard to stand against them. Breeding was also being conducted with Tilapia zillii, Tilapia mossambica, and Tilapia nilotica obtained from Japan. Mr. Lin through this was the same as T. aurea, which we have; however, it appeared to us to be a different species, and probably is T. nilotica. A fish breeder showed us a method of distinguishing between Tilapia zillii and T. mossambica. In T. zillii, the lateral line ends two scales from the caudal end of the dorsal fin. In T. mossambica, it ends five to six scales from the caudal end of the dorsal fin.

Commercial Oyster Culture

Oysters were cultured in the area by placing out bamboo stakes or wooden stakes approximately 2 to 3 feet long at about the time the spat set. However, generally, shells were used for the purpose of collecting spat. The hanging wire method of culturing oysters is widely used in Taiwan.

Chu Pei Fish Cultural Station

This station, also operated by the Fisheries Division, was visited October 17 as we traveled back to Taipei. The station has a total area of 2.6 hectares, of which 2 hectares is water. There are 15 earthen ponds and a newly constructed laboratory building. Part of the research here is supported by a Rockefeller grant. Research is on the chemistry of pond fertilization and also on the culture of pure strains of algae. However, since the work was just starting, there was little to report.

Toayuan Fish Propagation Farm

This facility was established by the Taiwan government with assistance from USAID as a means of supporting veterans. As these veterans approached retirement age, there was very little for them to do and very little money for pensions. This group, consisting of 600 retired veterans, operates approximately 120 ponds and irrigation reservoirs consisting of 840 hectares of water. In addition, they have an area on the coast in a reclaimed intertidal area. However, here the wind blows so hard that it is a relatively poor area to operate. At the main freshwater station, ponds are used to raise eel and soft-shell turtles. The buildings and ponds were constructed with a capital investment of 11 million N.T. dollars. At the present time, the property is worth 55 million N.T. dollars. It has been able to increase the monthly earnings of the veterans from 250 N.T. dollars up to almost 1,000 N.T. dollars. The reservoir ponds are fertilized only with superphosphate and are stocked with mullet and the various Chinese carps. Before using phosphate, the ponds were not yielding much profit. However, the use of phosphate has made it a profitable operation. The soft-shell turtle, Amyda sinensis, is cultured in ponds, but only about 300 kg per year are produced. We did not see this culture. The yearly production from all the irrigation ponds of fresh water were as follows: (production figures in kg) mullet - 40,000; mud carp - 25,000; snakehead - 200; Japanese eel - 35,000; sea perch - 10,000; common carp - 25,000; goldfish - 10,000; grass carp - 20,000; black carp - 2,000; silver carp - 190,000; and bighead - 50,000. For 120 ponds, the profit was in excess of 1,700,000 N.T. dollars in 1965. In 1966, the profit was 2,134,000 N.T. dollars. One irrigation pond visited was in

the process of being drained. During the entire time, a strong wind blew and heavy rain fell because of a typhoon nearby. Consequently, the pictures may not be too good. However, we did get pictures of each of the Chinese carps. All the fish taken from this pond were very large; from 2 to probably 8 kg, which indicated that the lake had been understocked originally. However, this was the first year of its operation with fertilization and they hope to adjust their stocking rate for next year. Unfortunately, it was impossible to completely drain the lake which had been built for irrigation, and the fish were being removed by seining.

Taiwan Chlorella Factory

On October 17, we also visited a facility that was set up to produce the algae, Chlorella, in commercial amounts. Production is 1,000 kg per month and it looked like a rather expensive proposition. Pure cultures were first started in small glass jars, later transferred to larger jars, and then to small ponds and finally into large circular ponds with constant mixing. The algae, recovered by centrifuge and dried, sells for 600 N.T. dollars per kg. It is mainly used to provide a growth factor for mixing with other foods. A large amount of it is exported to Japan. The factory also produces soybean milk enriched with Chlorella for distribution to school children.

Mushroom Culture

We also had opportunity to observe mushroom culture. This is also a new business in Taiwan, but many people have recently gone into the business and it is

expanding very rapidly. Mushrooms are consumed locally and also shipped to Japan and elsewhere. The mushrooms are grown upon decaying straw, either rice straw or the straw from the citronella plant. This plant is grown to be pressed for citronella oil, which has been widely used in the past to repel mosquitoes. The straw is placed in piles approximately 2 meters wide and 10 meters long. For every 3 square meters was added 0.5 kg urea, 3 kg of lime ($CaCo_3$), and a small amount of superphosphate. These materials were added to induce more rapid decay of the straw. The straw is watered and turned weekly until ready to be placed in the shed. These sheds are constructed of bamboo with straw top and sides to keep it dry and warm. There were seven tiers of benches with approximately 20 inches between each bench. The floor of each bench was composed of bamboo poles placed several inches apart. Decaying compost is piled six inches deep on these shelves. This is prepared the last of October or early in November. The mushroom spores are then planted on the wet straw. After two days, the straw is covered with 1 inch of soil. Two weeks later, the soil is watered and the mushrooms come up within the next 24 to 72 hours. After the first crop is ready, they are harvested at two-week intervals. The houses must be kept between 16 and 24^{o} C, as temperature below 10^{o} C kills the mushrooms. If the spores are planted about October 18, the first crop should be about November 1, and the last harvest would be in March. Production is about 6 kg of mushrooms per square meter of bed.

JCRR and Taiwan National University

October 18 was the last day of our visit to Taiwan. We reported to Mr. Chen and talked over various fisheries problems. The Commission arranges for the training of various people from other countries, sending them to local laboratories allowing them to see various culture methods and research in progress. One point discussed was the low rates of pay available to research workers in fisheries in Taiwan. Even heads of stations received no more than $50.00 per month. As a result, most of their best trained people move to other countries to work as soon as they can find positions. They are unable to educate their children on the salary received. Many of the fisheries stations were staffed with people who did not have any college training. Most of these men, however, had developed into relatively good research workers by their own efforts. It was reported that most young Chinese with a B.S. degree try to arrange for training abroad and then do not return to Taiwan.

We then visited the Taiwan National University in Taipei and found conditions somewhat similar. The University receives little money and the staff very poor salaries. The Institute for Fisheries Biology of the University, as a result, was practically inactive. The three staff members of the Institute teach a few fisheres courses: fisheries biology, including something on statistics and population dynamics, and some limnology. Also, short courses in fish diseases, fish parasites and plankton were available. The B.S. degree is given in Fishery Biology. There were 10 students working on degree programs.

APPENDIX

Prices of Commercial Fish Paid to Farmers

	N.T. dollars/kg
Eel	90 - 100
Soft-shell turtle	200
Sea bass	40
Grass carp	25
Mullet	25
Bighead carp	20
Silver carp	15
Milkfish	15 - 20
Goldfish	20 - 24
Tilapia	12 - 14

Cost of Feed

Peanut cake	6
Rice bran	3
Soybean cake	3
Dried sweet potatoes	2

Salinity Tolerance o/oo

Grass carp	7
Silver carp	5
Bighead carp	5
Mudcarp	0.1 - 0.5