FISH CULTURE ON PADDY FIELDS IN INDONESIA

by

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INTRODUCTION

Evidence derived from libraries, official reports and oral information received from elderly farmers points to the fact that fish culture in rice fields started in the middle of the 19th century. So to date we look back about a hundred years. Moreover, it can be stated that this technique began in West Java *(Preanger Regencies)* on rice fields situated in the neighbourhood of centres of pond culture mainly found in the vicinity of well known religious schools such as the ones near Tjiandjur and Singaparna. After finishing their course many students brought this practice to their places of origin and thus many religious foremen became pioneers of fish culture in paddy fields. Other circumstances of importance for the spreading were:

1. the establishment by Government of the rights of the people on their lands and products which caused new paddy fields to be created.
2. the spreading of information, propaganda, guidance and technical advice by Government Agencies, initially the Civil Administration, later on the Agricultural Extension Service and finally the Inland Fisheries Extension Service, and
3. the good prospects in various regions.

In Central Java this form of fish culture was established by the proper authorities towards the end of the 19th century *(Purwokerto and Muntilan)* and in East Java in the year 1924.

Conditions outside Java are as follows:

Sumatra : Around Bukittinggi this culture started in 1894. The people of Padangsidempuan began to be interested in 1930, as a result of propaganda by the Agricultural Extension Service.

In Lebong and Muaraman the Sundanese from West Java, formerly working the gold mines near Redjang, started fish culture in paddy fields.

Celebes : A start was made in North Celebes towards the beginning of the 20th century, as a result of propaganda by the Civil Administration of Tomohon.

Menado-area began in 1897 and Southern Celebes in 1936 as a result of the work of the Inland Fisheries Department.

Bali and Lombok : Propaganda by the Inland Fisheries Department began about 1953.

Subsequent spreading is shown in the following table (data for the whole of Indonesia, acreage in ha, yield in tons of consumption fish).

Year	Acreage	Yield
1951	24,000	2,444
1952	24,146	2,967
1953	48,748	5,259
1954	65,167	9,088
1955	90,492	9,160

It might be mentioned here that the increase in yield in 1955 is not in accordance with the increase in acreage as a result of untoward climatic conditions.

Next to the yield of culture operations in paddy fields the yield of capture operations on about 4 million ha. paddy fields may be estimated at about 6,000 tons of fish annually.

Proc. Indo—Pacific Fish. Coun., 7 (II—III): 119—154, 1957.

METHODS OF FISH CULTURE ON PADDY FIELDS

Formerly, fish used to be grown in paddy fields in West Java after the harvest of the rice. One or two months after the single crop of rice grown during the wet season, had been harvested the fields were prepared and stocked with fingerlings measuring 5—8 cm. in length and cultivated for 3 months. So the original method was to grow fish once in a season. In Bukittinggi this method is followed till the present time. The consumption fish cropped was used by the farmer himself. However the increased circulation of money in the villages made fish an object of trade.

Later on, two periods of 2 months each were used on well irrigated and easily surveyed paddy fields. Not later than one month after the paddy was harvested, the fields were prepared.

When fish was grown only once a year in fields where rice was grown once a year too, the practice became known as "palawidja", the same as the present "second crop" method, whether this period was the dry season or the wet season. In Tjurup and Kepajang this period coincided with the wet season.

As a result of the extension of fish culture in paddy fields as second crop and the increased demand for fry, centres were established where fry about 15 days old were nursed until 5—8 or 8—11 cm. long.

After World War I the farmers were induced for various reasons to plant rice more than once a year in regions where the water supply was adequate. However, as fish was cultured in these fields as second crop the time available for such culture became short. The more rice was grown, the more fish culture was hampered. The period of 6 months was decreased in this way to 1—3 months and became more and more a mere "interval" between 2 crops of rice.

Accordingly, this method became known as the "interval method". Originally the aim was consumption fish as was the case in the previous method, but a gradual shift towards the production of fry became apparent. In this period the urge to grow fish become stronger and so was the demand for fry. Therefore the possibility of raising fry to larger size was considered. Afterwards fish were grown in the paddy fields along with rice until the first weeding, in fields not far removed from centres of fish culture and villages.

The above picture is mainly true of West Java. A different development took place in other regions on Java and elsewhere, in connection with the irrigation and the way of planting of the rice, for example in East Java.

In Bali and Lombok, the Inland Fisheries Department fostered the growing of consumption fish along with rice as the first stage.

Although West Java can be considered to be the cradle for fish culture, the cultivation of consumption fish along with rice started earlier in East Java. Data on production cost and income, collected in 1950 are given in the Appendices.

Second Crop Method

Usually an entire region grows fish by this method at the same time, and thus the demand for fry rises as does the price. For this reason the farmer will try to obtain sufficient fry slightly before his rice is harvested, by ordering some from a trader or fry grower. Sometimes he buys the fry himself in small numbers at a time and stores it in a small pond on his compound or in specially prepared paddy fields where the rice was harvested beforehand. Such fields are often planted with a special variety of rice and must be within easy reach for supervision.

One or two weeks after the rice has been harvested the field is prepared for fish culture. In the first place the irrigation canals are cleaned and overhauled, sometimes by communal labour. Afterwards the dykes are repaired.

In the plains, at places far from the village, a couple of fields are often combined and new dykes constructed. Sometimes new dykes are made on the inner side of the old ones sealed when the danger of holes dug by *Monopterus* and is *Paratelphusa* apparent. This practise can be observed in high plains, as in Bandung. Paddy fields in the plains situated near villages or irrigation canals are usually prepared individually. Fields on sloping areas are prepared in

the same way. No new dykes are constructed here.

The acreage of a combined field depends on the distance from the main irrigation canal. The further removed, the larger the field and the higher the dykes, with the result that the water will be deeper. Thus three groups of ponds can be distinguished in a large complex with a mutual source of water.

a) ponds consisting of a single paddy fields.

b) ponds consisting of a 2 or 3 paddy fields.

c) ponds consisting of more than 3 paddy fields.

Exploitation of each group differs from the other.

In group a) the dykes measure 50 cm. in height from the moat to the top. The dykes are made from earth piled up during the digging of the moat. Recently constructed dykes will lose 20 cm. in height as a result of sinking of the soil. At the base the dykes are at least 50 cm. wide.

The dykes of groups b) and c) measure 80—100 cm. in height and the base is 80—100 cm. wide, depending on the size of the pond.

A piece of bamboo put through the dykes acts as inlet and outlet. The height of the outlet depends on the desired height of the water on the field, 20 cm. above the base of the dyke in type a), 50 cm. in type b) and 80 cm. in type c).

The outlet slants slightly towards the outside, the inlet towards the inside. Its mouth is 10 cm. under the surface. The inlet is screened with bamboo strips, in order to bar undesired fish and rubbish.

The paddy straw is sometimes left on the field and only cut under the surface when the the young paddy is fairly high, or the straw is knocked down with a piece of bamboo. Sometimes the dry straw is cut at the base and piled up in heaps. The space between two heaps measures 5 cm.

The circular moat created when the dyke is strengthened is overhauled in the next stage and its width is enlarged to 50—150 cm. depending on the size of the field. The depth is 20—30 cm. in the centre. In large fields, where the straw has been piled up cross moats are constructed as well.

When all preparations are finished, the fields are filled in 2 or 3 days with water to a maximum capacity in order to test the strength of the dykes. Before the field is stocked the water polluted by the straw is replaced by clear water.

Management of the fields involves inspection of dykes, the inlet and outlet twice a day. During heavy rains the inlet is closed. About 2 weeks after stocking of fry, the paddy shoots and other aquatic vegetation are cut under the surface or pulled out, which operation is repeated a few days before the fish is cropped, in order to facilitate cropping.

In the case of second crop cultivation, divided into 3 periods, cleaning takes place every month. During the day time birds are scared away, notably towards the end of May, which is the end of the dry period, by men sitting in small bamboo huts on long stilts. In order to capture *Monopterus* small dykes are placed on the heaps of paddy straw, baited with snails. Cropping takes place in the morning or the evening. During cropping noxious fishes and other pests are removed. Edible aquatic animals are captured by the labourers during cropping and kept as part of their pay.

After cropping the heaps of decomposing straw are worked under dykes, and moats overhauled and weeds pulled out. When the paddy straw is not cut but knocked down at the beginning of the period, it will be cut after the harvest and laid out in long rows, one or two days before the second stocking.

Common carp is the main fish grown, other species of fish are of minor importance. The aim of this form of culture is two fold:

a) to raise fry 3—5 or 5—8 cm. long,

b) to grow consumption fish.

In order to obtain fry 3—5 cm. in length, the field is stocked with fry 1 cm. long, 15 days old, at a rate of 60,000—100,000 fry (6—18 bowls). The growing period lasts 3 weeks, and the loss amounts to 50—60%. The crop is counted by bowls of 500 fry each.

To raise fry, 5—8 cm. long, the field is stocked with fry, 2—3 cm. long, at a rate of 2 bowls of 700 fry each, grown for 3—4 weeks; the yield is 800 fry. Loss: 40%.

Fry 8—11 cm. long is grown from fry 5—8 cm. long, stocked at a rate of 2,000—3,000 for 20 days. Loss: 45%.

With the main stock an additional stock of bigger fish is used. To fry 15 days old are added about 500 fry (5—8 cm. long)/ha. A stock of fry 5—8 cm. long is supplemented with not more than 10% fish measuring 8—12 cm., while a stock of fish 8—11 cm. in length is supplemented with not more than 10% fish weighing 100 gram each.

A summary of the number of growing periods and ways of exploitation in various regions is given below.

1) Tjiandjur Area

During half of the year 5 periods of 3 weeks each.

a) First stock: Fry 15 days old. Result: Fry 3—5 cm. long. Rate: see above.

b) Second stock: Same as first, or Fry 3—5 cm. long. Rate: see above.

c) Third stock: Fry 3—8 cm. long. Rate: see above.

d) Fourth stock (after the fields have been tilled, ploughed and harrowed): Fry 15 days old. Rate: 15% higher than first time.

e) Fifth stock: Fry 3—5 cm. long. Rate: 20 bowls of 500 fry each.

2) South of Bandung

a) Three times stocking with fry 15 days old, then once more in order to obtain consumption fish. Stocking rate: first and second time-40,000-60,000/ha. Result: Fry 5—8 cm. long; third period 20,000 fry (2—3 cm. long)/ha. Fourth period stocked with the bigger fish from the previous periods, in order to obtain consumption fish. Rate: 6,000/ha. Loss: 50% first and second time, 30—40% third time and 20—30% fourth time. From first to fourth period: 40 days.

b) Three periods of 40 days. First period: Stocking material: Fry 5—8 cm. long. Rate: 6,000—8000/ha. Loss: 20—30%. Second period: Rate and percentage of loss similar to first. Third period: Rate=2,000 fish (10—14 cm. long) per hectare, quick growers of previous periods. Loss: 10—20%. On fields downstream in the vicinity of city: Length of period 40 days. In areas further removed: 2 periods only, 50 days each. Stocking rate: 3,000—4,000/ha. In some regions still further from the city, one period only is practised. Rate: 2,000 fish 8—11 cm. long or 3,000 fry 5—8 cm. long per hectare. Length of period: 3 months.

3) East of Bandung (Rantjaekek, Tjiparaj, Madjalaja, Sumedang)

Usually 2 periods of 50 days. Stocking rate, depending on fertility of the fields. 1,000—2,000 fry 5—8 cm. long per hectare. Loss: 20—30%.

4) Other regions in West Java

In other regions, such as S. Bogor, W. Banten etc., fry stocking rates fluctuate between 1,000 and 2,000 fry 5—8 cm. long to 2,000—4,000 fry 3—5 cm. long. per hectare. Loss: 20—30% and 30—40% respectively.

Duration of period about 3 months, a single crop each season. Rate depends on fertility, estimated according to the yield of rice in quintals.

i. 40 qu./ha. dry—Needed 60 fry 8—11 cm. long or 90 fry 5—8 cm. long per qu.

ii. 30 qu./ha. dry—Needed 50 fry 8—11 cm. long or 75 fry 5—8 cm. long per qu.

iii. 30 qu./ha. dry—Needed 40 fry 8—11 cm. long or 60 fry 5—8 cm. long per qu.

5) Bukittinggi

A single period per season of 4—6 months. Stocking takes place after the field has been ploughed and sometimes harrowed. Rate: 20,000—50,000/ha., fry 3—5 cm. long or 60,000—100,000/ha., fry 1—2 cm. long. Cropping takes place gradually. The bigger fish (50 g.) are captured first and sold as consumption fish. Loss: 40—60%.

6) Muaraaman and Lebong (Bengkabulu)

Fish grown as second crop from September-February. Some fields are combined and made into a pond, with 50 cm. of water. One period per season. Well-to-do owners crop once only, others twice. The surface of the water is cleaned in exceptional cases only. 6—8 thousand carp fry measuring 5—8 cm. or 10,000 fry measuring 3—5 cm. are stocked. Loss: 70%. The aim is consumption fish weighing 0.75 kg. each.

7) Minahasa

Fish is grown as second crop for 4—6 months. Rate 1,000/ha. of 8—11 cm. A single period of growth. Aim: consumption fish of 250 gram. Loss 10%. Other way: 2,000/ha. of 5—8 cm. in 2 periods. Aim: consumption fish of 100 gram. Loss 20% per period.

Recently the second way is the more frequent one. In places where fish is grown in 2 periods the yields differ greatly, although all circumstances are equal. If the straw decomposing under water is of a quickly mineralising variety the higher yield is obtained in the first period, if the straw decomposes slowly the higher yields are the ones of the second period. The third period always yields less than the previous ones.

The number of additionally stocked fish usually amounts to 10% of the primary stock.

An experiment carried out at Buahbatu (South Bandung) in 1936 the fields were stocked at a rate of 3,000/ha. with carp fry weighing 5 gram. Carp fry weighing 50 gram were added in various numbers. The period of growth was 50 days. The soil was Bandung clay. Results are given in Table I.

Table I. Effect of mixed stocking of small and large carp fry on the yield.

Percentage big carp	Total yield (Kg.)	Increase in grams per fish	
		Fry	Big carp
5	96.90	79.9	231.8
10	97.94	78.7	236.7
15	105.0	65.6	201.6
20	107.8	77.6	183.5

According to the individual increase in weight of the big carp, their stocking at 10% gives the best results. Calculation of the rentability also gives similar results. The experience of the farmers is in accordance with this finding as they mainly use an additional stocking of 5—10%.

Another experiment at Buahbatu compared green with red coloured fry. According to the farmers the loss of red carp is higher in clear water than that of green carp. Length of period: 50 days. Rate: 3,000/ha. of fry weighing 5 gram, and 10% of fry weighing 100 g.

Table II. Mortality of green and red carp fry during culture.

Fry	Percentage of loss	
	Green	Red
Small	23	45
Big	3	12

Another experiment investigated the result of a mixed stocking of carp with *Trichogaster pectoralis* (Regan).

Stocking rate of carp: 3,000/ha. of measuring 6—10 cm. plus 10% of fry measuring 12—15 cm.

Stocking rate of *Trichogaster:* 300/ha. of fry measuring 10—12 cm.

The result was disappointing. After 50 days the *Trichogaster* showed only 2% of the increase of the common carp. Individual increase of *Trichogaster* amounted to 15 gram, that of the carp to 50 gram.

Cultivation of Fish in between Two Rice Crops

Preparation operations consists of overhauling of dykes, ploughing and harrowing. In case the fields will not be used for the cultivation of consumption fish, the dykes are constructed in accordance with the needs of the cultivation of the paddy. Moats dug in order to facilitate cropping are constructed at the time of cropping. For the cultivation of consumption fish, hoe-ing and ploughing are considered necessary but harrowing is not. The bamboo inlet and outlet pipes are fitted in such a way that the depth of the water is 10 cm. for fry and 20 cm. for consumption fish. The duration of this method is from 1 to 3 months, depending on the frequency of the rice culture, each period lasting one month.

Originally the aim of this method was the procurement of consumption fish for the labourers on the fields. But as the area used for fish culture increased, the fields were more and more used to produce fry.

Stocking rates and sizes of the fry do not differ much from that used in the "second crop", in similar soil and of same duration. They are slightly different in East Garut (Wanarakja). Here fry 15 days old, are stocked at a rate of 20—30 thousand /ha., in order to raise 10,000 fry measuring 3—5 cm. Part of this crop is not sold but restocked at a rate of 4—5 thousand/ha. and grown up to a size of 8—12 cm. (2—3 thousand fish/ha.) in 1 month. This product is usually stocked in fields with growing paddy.

When the total duration of the growing period is 3 months, fry are either produced twice, or fry are grown for 1 month and consumption fish, for 2 months. The size of the fry to be grown to consumption size depends on the distance of the field from the house of the operator. When short distances are involved, fry, 5—8 cm. long, are used, otherwise fry 8—12 cm., long at rates of 2,000/ha. in the first, and 1,000—1,500/ha. in the second case. Loss: 30% and 20% respectively.

Formerly, fish measuring 10—12 cm. and weighing 20 gm. were considered to be consumption fish in Sukabumi and Tjiandjur and sold at a high price. Compared with the period before the Japanese occupation this means a distinct shift, as during that period fish weighing 30 gm. was considered as consumption fish.

From a biological point of view the latter process must be the more economic one as less maintenance food for the fish is involved. But this is not proportional to the volume and weight of the fish.

A slightly different form of this method is found in East of Tjiandjur. Here fish are grown after the harvest of soyabeans (*Glycine soja* L.) grown as dry second crop. The fish are stocked after the soil is ploughed and all remaining vegetation is worked under. Culture fish measuring 8—12 cm. are stocked at a rate of 1,500/ha. The period is 1 month and the percentage of loss 10—20%. Cropping: see second crop method. The product is exceptionally tasty.

Fish Culture along with Rice

Preparation consists of raising the dykes, because higher ones must be constructed for the fish than those needed for paddy only. Inlet and outlet pipes are fitted as in the case of the second crop method.

If the dykes of fields used for cultivation of consumption fish are not yet finished when the soil is tilled, they are finished gradually during the first and second weeding.

At the first weeding the rice plants close to the dykes are pulled out and replanted in the centre. In the open area along the dykes the circular moat is dug, and the earth is used to enlarge and/or to raise the dyke. This work is continued during the second weeding. On sloping grounds, only the dykes weakened by the construction of the moats are strengthened. Cross-moats are constructed during the tillage

of the soil, or during weeding. These moats measure twice the distance between two rice plants in width and are 30—40 cm. deep.

When consumption fish are to be cultivated the moats and dykes are prepared after the second weeding. Sometimes a small pond (1 × 1 m.) is dug at the intersection of the moats in the centre in order to provide the fish with shelter when the temperature of the watet is too high or when they are chased by predators. In some cases similar "ponds" are dug out in circular moats.

The following table gives different methods and rates of stocking.

Table III. Stocking rates for fish culture along with growing paddy.

No.	Stocking time	Aim	Duration of Period	Remarks
I.	Five days after planting until first weeding	Fry 2—3 or 3—5 cm. long.	3—4 weeks	Fry 2 weeks old.
II.	Two days after first weeding	Fry 2—3 or 3—5 cm. long.	3—4 weeks	Field previously drained for 2 days. Fry of 10—50 days.
III.	Some days after planting until second weeding	Consumption fish	6 weeks	Stocked with fry 2—3 cm. long
IV.	After second weeding	Consumption fish	8 weeks	Stocked with fish 5—8 or 8—11 cm.
On extremely fertile paddy fields with good irrigation cultivation may take the following course:				
V.	Some days after planting until flowering	Consumption fish	12 weeks	Stocked with fry 2—3 cm. long.
VI.	5 days after planting until second weeding	Consumption fish	6 weeks	Stocked with fry 2—3 cm. long.

The depth of the water is 2 cm. at the time of planting and is gradually increased once a week until it measures 5 cm. after 2 weeks. For consumption fish the depth is increased to 20 cm. after the second weeding.

After 3 weeks the fry is cropped. If weeding is carried out mechanically and not by hand, it starts 2 weeks after planting. Not all the water is run off, but only so much that about 1 cm. remains. In order not to harm the fish parts of the field are weeded alternately.

In the case of fry cultivation as indicated in No. III of the preceding table, the water in the circular moat is constantly changed. After weeding the same water level is restored.

When fry is being produced as indicated in Nos. I and II of the table, cropping takes

place during the second weeding. The rice will then be 4-5 weeks old calculated from the time of planting.

On the 3rd day after the second weeding the depth of the water is about 5 cm. It is raised once a week until a height of 15-20 cm. is reached 3 weeks after stocking. Afterwards, this level is maintained. About 3 weeks after stocking the moats are checked for depth. In case of an attack by mice the water level is increased until three internodia of the stalks are under the water, so as to inundate mice holes.

Raising of 15 days-old fry up to a size of 3—5 cm. takes place during a single period of 3—4weeks. But in regions where 30—40 days after planting weeding is carried out only once, the growth period is prolonged. This is done in East Garut (Wanaradja and Sadang).

Because management of a paddy field up to the time of the second weeding is fairly easy, fish culture along with rice is practised at distances of 1 km. from the villages. But after the second weeding, when the rice plants are high and it is not easy to observe the fish nor to walk on the dykes, this form of fish culture is restricted to areas nearer than 1 km. from the village or the road.

Experience has further shown that rentability is poor on complexes less than 5 ha., because of pests and diseases.

For cropping, the water is drained off more slowly than in the case of the other methods, to enable the fish to follow the stream and not to remain in the central part. For this reason draining usually begins during the night preceding cropping.

Generally, those fields are used where the ground is slightly sloping and fertile, the water contains organic substances and the living quarters of the owner are not too far away. It is important that men live among the fields used for this form of culture. Large uninhabited stretches should not be used.

In 1954 a new form of fish culture along with rice started in Surabaja and Lamongan, in paddy fields bordering brackish water ponds. These fields are situated on marly soils. At the beginning of the rainy season the fields are surrounded by heavy dykes with a base of 1 metre. Along the inside wide moats are dug, measuring 1.5—3 m., and 50—70 cm. deep. About a week after planting of the rice, when the central part of the fields is covered by 20 cm. of water, small fry of the milkfish *(Chanos)* and *Puntius* about 2 weeks old are introduced, at a rate of 2,500—3,500 for both fish. The depth of the water is gradually increased. The period of growth begins in December and lasts 6—8 months. The fish is cropped 2 weeks after the paddy is harvested. So, when the paddy is being harvested the field is still covered with water. The yield—200—300 kg. ha—is satisfactory. At the moment this method covers about 300 ha. only.

Instead of propagation of this mixed culture in marginal brackish water ponds with a salinity less than 8.00 % and extending towards the inland, extension work now proceeds from the inland regions towards the coast. The new method is readily accepted by the farmers. From older times this method was practised outside Java (near Lake Ranau, S. Sumatra). Some days after rice planting *Osteochilus* is introduced, but no moats are dug. Cropping takes place at arbitrary times beginning about 3 months after stocking. Even when the rice is completely harvested all fields still contain fish. The farmer does not capture these fish straight away. He holds on to them, taking them out gradually until the end of the dry season, when the ponds are emptied. So the total growing period takes 8—9 months. Exact data on production and stocking rate are lacking, but it can be stated here that this is the only example of the cultivation of *Osteochilus* in paddy fields, that the total acreage involved measures 200 ha. situated at an altitude of 800 m., that the water is clear, the soil sandy and that a heavy growth of *Ceratophyllum*, covered with epiphyton is found in the ponds in the dry season. The dykes are 1 metre wide and strong.

Spawning of common carp takes place at Muntilan (Central Java.) In fields suitable for this purpose owing to the quality of the land and the water, holes of 1.0—1.5 m. diameter are dug near the inlet, the dykes are strengthened, and the water in the central part measures 20 cm. Two or three female and one male spawner are released in the holes. These are now covered with aquatic plants such as *Eichornia*. Where the fields had not been ploughed and harrowed

beforehand, such plants are not necessary and the remaining paddy straw is deemed to be sufficient. If the spawning succeeds the fry is cropped when 2 months old and 3—5 cm. long, large enough to be sold. If the spawners do not produce eggs after two or three days they are removed and the process is repeated after some days, when the field has been drained once again

Spawning of common carp in order to obtain fry takes place in regions north of Jogjakarta (Ngajlik). It is intended to use the fry for culture along with rice.

The spawning pond measures $5m^2$ with a depth of 1 metre and is situated near the paddy field to be cultivated. Before use, the pond is drained in 5—7 days and *Eichornia* plants without roots are inserted as a material to which the eggs will adhere. About one week afterwards the plants are removed and the fry is used to stock paddy fields, measuring about 10 ha. Stocking takes place 3 days after the planting of the rice. Afterwards, cultivation in between two rice crops takes place after the field has been harrowed. The growing period takes 4 weeks and the yield consists of fry 3—5 cm. long.

When the farmer considers the density of fish to be too high, he often lets some of the water together with fish flow into an adjacent field. In doing so he will be guided by his personal feelings.

In Tasikmalaja and Singaparna, *Helostoma* is spawned in paddy fields in between two rice crops. A fertile field (rice yield 26 qu. ha.) with a good supply of fresh water and situated near the farmer's house is selected. After the paddy has been harvested and the soil has been dried out, dykes (base 80 cm., height 50 cm.) are constructed. Inlet and outlet are constructed in such a way that the height of water is 30 cm. in the central part. Both pipes are plugged with palm fibre. In a 1 ha. paddy field 3 pairs of spawners weighing 200 gm. each are used. The field is manured with 40—80 kg. horse manure. The straw in the central part is cut when the fry is one week old. The period of growth lasts for 40—50 days. One female spawner yields 4,000 fry measuring 2 cm.

When the fry is 20 days old, 3-month old fry of *Osphronemus*, 2—3 cm, long, are added at a rate of 70—100 ha.

In Purwokerto only *Osphronemus* is spawned as second crop. The dykes are raised making the depth of the water in the centre 30—50 cm. The stocking rate is 150—200 fry measuring 2—3 cm. in length. The fry is fed with fine bran and white ants every day. The growing period lasts 2. months. The end product is fry measuring 5—8 cm.

Sometimes a nest is used instead of fry of *Osphronemus*. Two or three fields are needed for a single nest. Cultivation of fry of *Osteochilus* in Java in between two rice crops has been carried out for a long time in fields near centres of pond culture, such as Rantijapaku in the eastern part of West Java. After the fields have been prepared (dyked, ploughed, harrowed) they are manured with quickly decomposing plants, at a rate of 5 tons ha. Stocking takes takes place at place a rate of 200,000 fry measuring 1 cm. (5 days old) and 3,000 carp fry measuring 5—8 cm Every day the fish are fed with as much fine bran as is needed to cover the entire surface. The period of growth lasts for 40 days.

Raising fry of *Puntius* in between two crops along with rice, takes place iu Singaparna. Recently also in Purwokerto, as a result of propaganda by the Inland Fisheries Department and the wish of the farmers to grow this fish among their rice. The inlet and outlet must be securely screened with palm fibre. In the centre a moat 20 cm. deep and 30 cm. wide, is dug from inlet to outlet, in order to facilitate cropping.

In the centre the water is 10 cm. deep. Between 1 and 3 p.m., when the temperature is high, the water along the dykes is moved by the farmer with his feet or the water supply is increased for a couple of hours.

The fry is fed daily with fine bran. Two to three bowls are given in 1 ha., stocked with 150,000 fry along with rice or 200,000 fry when cultivated between two crops. Length of period: 25 days, Loss: 40% Yield: fry 2—3 cm. long.

Tilapia is grown between two rice crops and along with rice near Singaparna. Paddy fields with a layer of mud not less than 10 cm. in

thickness are used. Production is satisfactory. The method has spread rapidly. Begun at the end of the Japanese occupation it now occupies an area of 400 ha. In order to facilitate cropping, a small pond (1 m. square) is dug at the upper end of the central moat which is about 30 cm. deep, until a hard layer is reached.

When the fish is cropped they swim against the stream and gather in the small pond.

SPECIES OF FISH USED FOR IN PADDY FIELDS CULTURE

Official reports of the second half of the 19th century as well as other scientific publications show that the farmers regard the common carp as the fish most suitable for fish culture on paddy fields.

Government Agencies assumed responsibility for the spreading of this form of fish culture in order to ensure suitable local production of protein food for the population.

As the older reports mention "goldfish" only, *Cyprinus carpio* L. as well as *Carassius auratus* might have been included in that terminology. It is supposed that the name "gold-fish" relates to colour only and not the habitus of the fish. It is not impossible that *Carassius* was grown in paddy fields in earlier times and was as important as *Cyprinus* now, as is the case in Japan to day. It is not clear why *Carassius* is not used any more at present as this fish does not lag behind in rate of growth compared with the common carp.

It might be supposed that the brightly coloured *Carassius* is too conspicuous in clear water and will be preyed upon by birds to a large extent, thus causing heavy losses, and was therefore replaced by green varieties of *Cyprinus*.

In the second place the population in certain regions objects to orange-yellow carp on the grounds that consumption of this fish deteriorates the morals of the females. (reported by the Sub-station at Punteg, Java). When this Sub-station started the extension of yellow carp culture in 1924, the population was not willing to accept the fry for the above reason, and requested fry of a green colour, Therefore the selection of the Punten carp was initiated.

At the moment, the colour of the carp does not bother the population any longer, and carp of various colours are being grown in paddy fields. The length of the fry to be stocked depends on the ultimate purpose of the culture.

In various regions large carp are stocked in combination with fry, when carp is grown as a second crop between two rice crops.

When tiny fry measuring about 1 cm. in length are used, 5—10% by weight of fingerlings measuring 5—8 cm. are added.

When fry 5—8 or 9—12 cm. in length fry are stocked, measuring 10—20 or 30—50 cm. are added in quantities of about 5—10% by weight. Why the farmers originally started to stock their paddy fields with fish is unknown. It is yet unsettled whether careful observation, advice from abroad or just pure chance were the cause. It is likewise unknown whether or not the farmers were acquainted with the natural environment of the common carp, (shallow water, soil without gravel or stones, fairly high temperature, slowly running water) and were able to presume that paddy fields might prove to be a suitable environment.

Moreover, the carp is a quick grower and an easy and prolific spawner, most adaptable to different temperatures, different sources of food and fluctuating concentrations of oxygen. For these reasons this fish must have drawn the attention of prospective farmers long ago.

Untoward features of the common carp are that it is an easy prey for carnivorous fishes, and is rather susceptible to high temperatures. For this latter reason the yield from paddy fields in the plains at low altitudes is unsatisfactory.

This might be the reason why in the beginning of the 20th century, farmers living in the vicinity of Djakarta began to grow *Puntius javanicus* (Blkr.) as second crop during periods of at least 3 months. However the main cause may be the procurement of fry in this case. Propaganda by the Public Health Authorities to the effect that *Puntius* might clean the water surface in the fields and thus lower the incidence of malaria, might also be one of the reasons.

In these regions the culture of this fish did not spread and was restricted to marshy paddy fields with suitable water. Ultimately the farmers became more inclined to the use of the common carp. In other regions (Singarparna in the eastern part of West Java) the culture of *Puntius* meets the need for fry of this fish to be used in ponds in paddy fields. Here the ponds have received a mixed stocking since 1916. In paddy fields fry measuring 2-3 cm. only are raised these being subsequently transported to ponds in remote areas. Such nursing takes place only in paddy fields situated not too far from fish ponds.

In Purwokerto (Central Java) *Puntius* is being raised up to consumption stage. Procurement of fry is rather difficult as the water contains too much silt for the spawning of the common carp. Culture of *Puntius* up to consumption stage takes place in growing paddy fields in about 2 months' time and starts after the second weeding.

For the past two years *Puntius* together with *Osteocheilus* has been grown in the paddy fields near Lake Ranau in Sumatra as a 50-50 mixture. These paddy fields depend entirely on rain. Stocking takes place in December, a few days after the rice is planted. At the end of the dry period consumption fish is cropped. So in this case fish culture is continued until the end of August, long after the rice has been harvested.

In the vicinity of Jogjakarta a start was made with the cultivation of *Cyprinus* and *Puntius* up to consumption stage, along with rice during the period between weeding and ripening. An equal mixture of fry measuring 5-8 cm. in length is used.

It was found that the rate of growth of the common carp is about 150% of that of *Puntius*.

In Redjang Kapahiang (Regency Bangkahulu, W. Sumatra) an additional stocking of *Puntius* (33.3% by weight) is added to a stocking of common carp.

Culture of *Osteochilus hasselti* (C.V.) fry alone is practised only in paddy fields in the neighbourhood of Lake Ranau (S. Sumatra). Fry, a few weeks old, are raised up to consumption stage. The fry are stocked some days after the rice is planted and are cropped 10 months later, at the end of the dry period when the field to be tilled and prepared for the next planting of rice. These paddy fields are situated at an altitude of over 900 m., the soil is sandy, they are never totally drained, the water is very clear and a dense vegetation of *Hydrilla* and *Ceratophyllum* develops after rice is harvested. Such an environment is most suitable for *Osteochilus*, feeding as it does on the periphyton of the leaves and stalks of aquatic vegetation.

In W. Java *Osteochilus* is grown only in between two rice growing periods in fields near fish culture centres. Culture takes one month (Singapore). Fry, 5 days old, are stocked in paddy fields previously manured with easily decomposing green manure. The initial stocking rate amounts to 100,000 *Osteochilus* ha., together with 5-8 cm. long carp fry (5% of the *Osteochilus* by weight). The soil where this type of culture is practised is sandy.

The demand for fry of *Helostoma*, to be grown in ponds mixed with other species had been increasing since 1910, and fry producers were no longer able to grow sufficient quantities. For this reason farmers near Tasikmalaja (eastern part of West Java) began to grow this fry in their paddy fields between two periods of one month. The fields are always manured in this case. The procedure is as follows:

In a field measuring 2 ha., 2 female sprawners weighing 250 gm. each are released, together with 3 males weighing 150 gm. each. The fry so produced, are fed daily with fine bran in quantities of half a handful to two handsful. Part of the bran is consumed directly and another (yet unknown) part will act as manure. When the fry are 10 days old, either young *Osteochilus* or common carp are added.

The number or *Helostoma* fry need for 2 ha. is usually 10,000 together with 10,000 *Osteochilus* 5 days old or 1,000—2,000 Common carp 10 days old. When the *Helostoma* is 20 days old, usually fry of *Osphronemus goramy* Lac., 2-3 cm. long (3 months) are added at a rate of 150-200 fry in two ha.

The following combination is often used in the eastern part of West Java.

Helostoma	35 %	or	*Tilapia*	50 %
Osteochilus	15 %		*Helostoma*	20 %
Cyprinus	15 %		*Osteochilus*	15 %
Puntius	35 %		*Puntius*	15 %
			Cyprinus	10 %

Since 1943 a marked change occurred in the usual stocking of ponds, owing to the introduction of *Tilapia mossambica* Peters. The demand for *Tilapia* fry increased still and so did the price. The change in stocking composition including *Tilapia* was accelerated by the decrease in the yield of the other species cultured so far. This decrease took place from the beginning of the Japanese occupation until the first years of Revolution. Owing to the increased demand and the ease of spawning in shallow, muddy water, farmers near Singaparna began in 1954, to spawn *Tilapia* in paddy fields with a mud layer of 20 cm. both along with rice until the second weeding and also between two periods of rice growing.

Eggs or fry of *Osphronemus goramy* are placed in paddy fields as a second crop., in Purworkerto (Central Java) only. Eggs are hatched into fry 3-5 cm., long and fry into fingerlings 8-11 cm. long. They are sold to other regions of Central Java end grown until until consumption stage in small farmyard ponds. The "second crop" method takes about 5 months, the stocking rate is 4-5 thousand fish measuring 4-5 cm. Eggs are stocked at a rate of 5-10 nests/ha.

An attempt to use *Trichogaster pectoralis* (Regan) as additional stocking material in the culture of common carp as a second crop, for 50 days, was not successful. The stocking rate was 10% of the weight of the carp. The average addition in weight of the *Trichogaster* amounted to only 15% of the stocking weight, that of the Common carp to 400.

BIOTA FROM PADDY FIELDS AND THEIR INFLUENCE

Little information on the biota of paddy fields has been published so far *West*, 1902; *Fritsch*, 1907; *Bernhard*, 1908-1909; *Woloszynska* 1912; *Van Oye*, 1921. Based on the data of *Bernhard*, ecological investigations concerning the most important groups were carried out.

As a result of the changing ecological conditions, Myxophyceae are abundant during the first state, later on Desmidiacae, followed by a mixture of both groups and in the final stage Myxophyceae once more dominate the plankton.

Blue-green algae appear before the rice plants and other aquatic vegetation shade the water. Later on, when the rice has been harvested and the sun rays can reach the surface, these algae reappear.

Chlorophyceae are also often encountered, mainly on more or less obligosaprobic fields (*Buschkiel, 1938*), particularly, those that have been under irrigation for a long time, and where blue-green algae have begun to rot. In these Diatomeae also are often found. Under such circumstances both groups of algae are important oxygenators and they will furnish the water with oxygen from top to bottom.

It should be understood that not only the algal flora but also the micro-fauna should be taken into account. The totality of this biological evidence is to be correlated with characteristics of the crop, the soil, the water and the climate, the tillage of the soil and other technical features of the industry. Only in this way biological evidence can be applied with maximal efficiency, and the study of micro-organisms of paddy fields may not only be of importance for fish culture but also for the rice culture, and fruitful co-operation between agronomy and limnology might develop. Limnology might add materially to the solution of problems concerning metabolic changes in paddy fields.

The above bio-ecologic aspect, as seen from the point of view of fisheries and agriculture may be summarized as follows:

"Measures should be taken for the establishment of algal successions ensuring maximal oxygenation of the biotope, efficient and unhampered conversion of food and optimal yields. Which algal succession will ultimately fulfill these requirements must be elucidated by long-term research" (*Buschkiel* 1938).

In 93% of all juvenile waters, including paddy fields, blue-green algae are found. The optimal temperature for blue-green algae is above 20°, which is about the usual temperature for paddy fields.

The occurrence of blue-green algae in large numbers and of many species in paddy fields is an indication of fertility. But better insight into specific differences between the numerous species is needed. Still it should not be forgotten that great caution is needed before various algae can be singled out as indicators in piscicultural practice.

The paddy field-fish ponds of South Bandung (Bodjong Lao), for example are extremely fertile. The soil is fertile and the water even more so, as it contains much calcium and organic substances drained from neighbouring villages and from parts of the city of Bandung. This inflowing water is rich in Chironomidae, Oligochaetae and blue-green algae. The surface of the water is entirely or partly covered by *Euglena sanguinea* Ehrb, sometimes occurring in such dense layers that the fish breeders dare not stock their pond with fry, for fear of substantial losses. Thus, although, *Euglena sanguinea* Ehrb. might seem to be an indicator for water fertility, it can actually interfere drastically with fish culture, making the water thus less productive.

The water of ponds further down stream from Bandung is coloured green by a water bloom of Chlorococcales, indicators of an eutrophic environment, and has a high content of phosphorus and lime. These ponds are also rich in Rotatoria, Infusoria, Crustaceae, diatoms and blue-green algae, which serve as food for the carp fry. This is one of the reasons why paddy fields situated near villages are stocked with carp fry. If a pond or paddy field is rich in the organisms mentioned above, it will likewise contain Chironomidae and Oligochaetae, subsisting on such algae as *Aphanizomenon* and similar blue-greens, either living or in various stages of decay. These animals serve as food for the common carp is not limited to certain specific kinds of food, but takes those types of natural food most plentifully available. Hence the gut contents of carp sampled at the end of the rainy season (April) differ from those sampled in July (dry period).

M. Sachlan and I. Zahir (1942), investigated the biota of two paddy fields behind the Laboratory of Inland Fisheries at Bogor, Indonesia, during several months. They arrived at the following conclusions:

1. One day after the fields had been irrigated snails, aquatic insects *(Micronecta quadristrigata)* and skaters (Gerridae) can be found.

2. Four days leter 75% of the soil was covered by a thin layer of greenish-brown diatoms *(Navicula, Suriella)* As soon as the sun rose this layer showed the greyish colour of the numerous oxygen bubbles, produced by photosynthesis which supersaturated the water. This layer, mainly consisting of *Navicula*, later covered the entire bottom. Chemical data of the water were: O_2—25—30 mgl.; CO_2—4-7 mgl.; pH—7 2-3.0; and temperature 39° C.

3. The water did not contain as many organisms as the soil, where plenty of *phora*, *Vaucheria* and *Kirchneriella* were found. In the water were seen: Oscillatoria, Protococcales, *Spirogyra Euglena* and Desmidiaceae. Animals were crabs *(Paratelphusa)* and frogs.

The difference between the algal succesion is probably caused by topographical differences.

Among the submerged Phanerogams which might be used as an indicator of the fertility of the soil and the water is, *Hydrilla verticillata* Presl. Its occurrence as well as its growth indicate the trophic state of its habitat. In oligotrophic water the habitus is poor and spare, the leaves are few and lean, but in eutrophic waters the shoots and the leaves are numerous. In eutrophic paddy fields where sunlight cannot penetrate far and also where the water is flowing rapidly, the poor growth, known in taxonomy as "*fluitans*" is often encountered.

Another plant indicating the fertility of the water is *Cerotophyllum demersum* L., to be distinguished from the less important *C. submersum* L. by the spines on the fruits. When one or more important factors governing plant growth are deficient, the leaves of this plant are scarce and the habitus poor. In calcium-deficient paddy fields (those on old lateritic soil) *Ceratophyllum* is rather soft to the touch.

Both plants often occur together in large quantities in eutrophic waters and form the substrate for periphytic diatoms and other algae. With these algae many animals such as Protozoa, Rotatoria, worms, Chironomides and other insect larvae are found, together with non-planktonic Crustaceans and bacteria.

Such waters are most suitable for the cultivation of periphyton-feeding species of fish, for instance *Osteochilus hasselti* (C.V.) as is the case in the vicinity of Lake Ranau (South Sumatra).

Both these submerged plants can be used as indicators, and they are also most important in the total nutrient cycle in fish ponds and paddy fields.

No conclusive experiments concerning the relationships between the yield of fish and the occurrence of various aquatic plants have been carried out. Individual differences between various species of plants might be investigated using different species of fish at different periods of their growth. The same fish species might be hampered in its growth as very small fry by too luxurious growth of plants. This might be true of a fish which is herbivorous in the fingerling stage and carnivorous later on.

On paddy fields with a thin layer of mud, situated at altitudes over 900 m., *Blyxa* is often found. On those under 700 m., in regions where the dry period is not very severe *Ottelia* is often found. Presence of these two totally submerged plants and of *Najas* indicate less fertile fields.

On the surface of paddy fields of at least mesotrophic fertility are found:

Salvinia natans All., *Spirodela polyrrhiza* Sch., *Lemna paucicostata* Heg., *Azolla pinnata* R. Br., *Pistia stratiotes* L.

Pistia and *Salvinia* often cover the entire surface, mainly when paddy fields are being stocked with fry during the second or third period (beginning of the dry period, May or June). In such cases they must be removed as they might interfere with the growth of the fish. Another harmful plant is the aquatic fern, *Marsilia crenata* Presl., (up to an altitude of 900 m.) mainly during March-November, in the case of stocking with fry. Although *Azolla*, *Lemna* and *Spirodela* usually cover the entire surface as well, they are not considered as harmful. They are even often used as fodder in ponds stocked with *Osphronemus* and *Helostoma*.

Among the emergent plants growing in the middle of the paddy fields, *Monochoria vaginalis* Presl., and *Limnocharis flava* Buch., as well as *Jussieua repens* L. growing along the dykes are considered to indicate fields suitable for fish culture. In the central part of the field, *Monochoria* usually appears first, followed by *Limnocharis*, a plant capable of rapid growth and apt to cover entire fields. Often they have to be cut in order to clear the surface. As they decompose easily they make suitable green manure.

On the other hand such plants as *Cyperus odoratus* L., *C. eragrostis* Vahl., *C. elatus* L., and *Fimbristylis miliaceae* Vahl., indicate unsuitable conditions for fish culture.

Investigations concerning the bacterial flora are almost entirely lacking. According to Buschkiel (1938) anaerobic bacteria are most important in the mud. But, on the other hand, this author concludes that aerobic bacteria must also find suitable conditions in the mud, because the water often shows a high concentration of oxygen, and conditions for photosynthesis by diatoms and desmids are favourable.

Decomposition of vegetable remains and paddy straw in previously drained paddy fields is caused by the extremely rapid development of bacteria and leads to an increased production of fish. Action by the bacteria also makes the highly polluted water entering the paddy fields of South Bandung (Tegallega) suitable for fish culture. Decomposition of organic substances is most rapid in this water. The oxygen necessary for this process is generated by the photosynthesis of Cyanophyceae, Diatomae and in a stage of advanced purification, Desmidiaceae. The farmer, knowing by experience that these organisms need sunlight for photosynthesis, removes all floating vegetation from the surface of his pond. When in 1934 these measures were not taken, many fish died; H_2S was formed, which harmed both animals and aerobic bacteria.

Among the animals living in the mud on organic substances and forming an important source of food for fish, limnicole Oligochaetes (Tubificidae) are important (A. Vaas van-Oven,

1953). Also, when paddy fields are drained many Pulmonata are found, mainly on those fields where the layer of mud is thick, e.g.: *Melania testudinaria* Lam., *Ampullaria ampullacea* Lam., *Planorbis (Helisoma)* spp., and *Paludina (Vivipara) javanica* Montf. These snails probably harm the fish in a direct or indirect way as Schuster (1949) holds in the case of those of the genus *Cerithidea* for the cultivation of the milkfish *(Chanos chanos)*.

No investigations concerning this harmful action have been carried out so far. It might be held that the snails, finding suitable conditions and growing prolifically, will have a noxious influence in an indirect way, as they are vegetable feeders and also ingest decomposing organic substances. These snails are used as human food and are gathered when the pond is cropped. For this reason they usually do not develop into a serious pest.

The following insects are to be considered as pests in fry ponds: *Belostoma indicum; Encharis; Corixa, Dysticus; Libellia; Laccotrephes.*

Other insects often encountered on the surface are: *Hydrometra, Gerris* and *Hydorus piscicornis* (Family Gyrinidae). Fishes are often harmed by the leech *Hirudo medicinalis*, and crabs *(Paratelphusa)* and *Monopterus albus* Zuiew, dig holes in the dykes. In fry ponds frogs can be harmful, as they are apt to swallow the tiny fish; so the farmer's practice of catching them in the evening and selling them must be considered to be most useful.

Otters (*Lutra* sp. and *Ablamyx cineria* Ill.) are serious pests. They live along the banks of the rivers and roam about in search of prey during the early hours of the night. They are eradicated by smoking them out of their holes with sulphur by means of a pair of bellows. Sometimes such holes have many exits, in which case all but one must be stopped beforehand. This method is more efficient than the use of traps. Other pests are various snakes, such as *Homalopsis buccata* (L), *Chersydrus granulatus* (Schneider) *Python reticulatus* Schn.

Herons, Kingfishers and Cormorants prey on the fish in both ponds and paddy fields. Predacious fish and other fish acting as food competitors with the cultivated species, are plentiful in paddy fields. For example:

Ophiocephalus striatus Bl., *Monopterus albus* Zuiew, *Ophiocephalus gachua* H.B., *Trichogaster trichopterus* (Pall), *Clarias batrachus* L., *Anabas testudinius* (Bl), *Lebistes reticulatus* Peters., *Aplocheilus javanicus* Blkr., *Puntius* sp. *Panchax panchax* (HB.), *Rasbora* sp.

In formed years, *Panchax* was often released in paddy fields to combat malaria.

MANURING AND INFLUENCE OF THE RICE ON THE FISH

Manuring of paddy fields for the sole purpose of fish culture is practised only in the case of spawning of *Helostoma* and in fry production of *Osteochilus*. The manuring of fields where *Helostoma* are to be spawned takes place as follows:

When the fry are one week old, easily decomposable plants are scattered on the surface of the water. Sometimes a mixture of plants and farmyard manure is used.

Plants often used for this purpose are the following:

Erythrina indica L., *Dysoxylum canlostachyum* Miq., *Erythrina crassifolia* Krds., *Dysoxylum ameoroides* Miq., *Leucaena glauca* Linn., *Hibiscus tiliaceus* Linn., *Crotalaria retusa* L., *Areca catechu* Linn., *Stachytarpheta indica* Dahl., *Ficus toxicaria* Linn., *Crewia paniculata* Roxb., *Tithonia diversifolia* Gray.

Experience has shown that fry raised on fields manured exclusively with farmyard manure cannot be transported over large distances. Mortality of fry raised on green manured fields is lower. A mixture of equal parts of both kinds of manure gives optimal results.

Depending on the fertility of the field the quantity of manure needed for 1 ha. is 40 - 80 kg. green manure or 20—40 kg. green manure and 10—20 kg. farmyard manure. Half of the total quantity of green manure is applied when the fry is 7 days old and the remainder is added in small amounts every third or fourth day. Farmyard manure is applied daily when the fry is 7 days old.

It is supposed that enough manure has been given when the water shows a blue-green colour, smells slightly of decomposition and the

fry do not swim along the dykes. If the water is black, a large number of common carp fry die, and the *Helostoma* fry do not dash towards the surface in order to gulp air with vertical movements but rise sluggishly with a slanting movement, the amount of manure applied must have been too large. In that case the pond must be flushed with clean water. The effect of manuring is most conspicuous. Fields used for production of fry without manure often show disappointing results and sometimes complete failures.

When fry of *Osteochilus* is raised on paddy fields green plants are usually the only kind of manure used. Five tons are needed for 1 ha. during a period of 40 days. The manure is applied before the field is filled with water. The use of manure is obligatory in this case, as the soil in the paddy fields used for this type of culture is sandy and the water clear and oligotrophic.

Manuring of fields used for fish culture between two rice crops takes place in Tjisaat (near Sukabumi). Farmyard manure is applied about 5 days after stocking with fry. About 7.5—10 tons are given for 1 ha. Manuring accelerates the growth of part of the fry (growing period of 30 days). Without manure 75% of the fry grow to a length of 2—3 cm., and 25% to a length of 3—5 cm. With manure, 40% of fry grows to a length of 2—3 cm., 40% to 3—5 cm. and 20% to 5—8 cm.

When fields used for fish culture between two rice crops are to be manured the cost of manuring should be calculated, except when manure can be obtained without any expense. But, because the next crop of paddy may also benefit by the previous application of manure the entire enterprise should be taken into account and not only the culture of fish.

When *Tilapia* is grown between two rice crops or along with rice, horse manure is given when easily available. In the first case, manure is applied on alternate days, and in the latter, every fourth day, in quantities of 1 ton/ha. Experience showed that manuring increased the production of fry.

Coarse rice bran is often applied on fields situated in the vicinity of places where rice is pounded and where harrowing is practised. It has not be on proved as yet that the fish grown in between two rice crops, benefit from this kind of manure but when the fish are grown along with rice, the effect is evident; the fish grow quicker and more evenly.

In the method of fish cultivation as second crop, manure is never applied as such, but plants cut off and thrown in to decompose will increase the yield. The same applies to the paddy straw, either piled up or not. Some varieties of rice decompose quickly, others do not. In the case of easily decomposed straw the effect of manuring will be evident in the first growing period. The experiments at Buahbatu near Bandung in 1933, were later corroborated by the experience of the farmers. When the straw does not decompose quickly the effect will be felt during the second growing period. The variety known as Djalan Srimahi decomposes slowly, Paddy Tjina and Back quickly.

Another form of manuring paddy fields where fish is grown as second crop is applied in fields near the road or in the villages, when public conveniences are constructed on the dykes. No well planned manuring of fields where fish is grown along with rice has been carried out to date. Goor (1952) states that the influence of double super-phosphate on fish and rice is not reliable. Probably this statement is meant to apply to the rice only, and it is doubtful whether it applies to the fish.

In recent years, the farmers have realised the disadvantages of those varieties of rice where vegetative formation of shoots is heavy, such as Paddy Tjina. When this variety is planted closely the leaves touch, the sunlight is heavily screened, the fish are hampered in their movement, and the yield is low. For this reason the interspaces must be 40 cm. or larger on a fertile field stocked with fish. It is yet unsettled whether the method, advocated by the Agricultural Extension Service, to plant the rice in regular rows in order to facilitate mechanical weeding has any influence on the fish.

YIELD AND RENTABILITY OF THE VARIOUS METHODS

'Yield' means the total quantity of fish cropped and not the increase in weight during a certain period.

A. Yield of "second crop" method per ha. *(Cyprinus carpio)*

1. Consumption fish

a. Fields and water most fertile (South of Bandung); 3 periods of 40 days; yields of 200, 220 and 180 kg.

b. Fields and water moderately fertile; 2 periods of 50 days; yields of 130 and 160 kg.

c. Fields and water unfertile; a single periods of 90—120 days; yield of 100—120 kg.

d. Paddy fields in Radjang Lebong, Kapahiang, Bengkulu, South Sumatra. A single period of 6 months, or 2 of 3 months; Yield of 200—400 kg. of *Cyprinus* plus 100—150 kg. *Puntius*.

In a paddy field receiving heavily polluted water and constantly used as fishpond (Bodjong Loa, Bandung) the yield amounted to 3—4 quintals 30 days.

2. Production of fry

a. Field and water most fertile; stocked with fry of 14 days; 4 periods of 30 days; field 30,000; 40,000 and 20,000 fry 4—6 cm. long. In the case of the third and fourth period the yield of additionally stocked large carp (30—50 kg.) should be added.

b. Field and water fertile; 3 periods of 3—4 weeks; yield per period 25—40 thousand fry 2—3 cm. long.

B. Fish culture in between two rice crops.

1. Consumption fish

A single period of about 50 days, yield 40—60 kg.

2. Production of fry

a. Fry of *Cyprinus*, 14 days old. 1 or 2 periods totalling about 4 weeks.

Stock: fry 2—3 cm. long.

Yield per ha.:

a(i) One period: 20—30 thousand fry 3—5 cm. long.

a(ii) Two periods: 10—15 thousand fry 5—8 cm. long, weighing 3 g.

Yield of the additionally stocked large fish:

a(i): 30 kg. a(ii): 20 kg.

b. Fry of *Puntius*, 10 days old. A single period of 30 days.

Stock: fry 2—3 cm. (Purwokerto) long.

Yield: 80—100 thousand fry 2—3 cm. (Singaparna) long, and 20 thousand fry 3—5 cm. long.

c. Fry of *Osteochilus*, 5 days old. A single period of 40 days.

Stock: fry 5 days old.

Yield: 75—90 thousand fry 2—3 cm. long (eastern part of West Java).

d. Spawning of *Helostoma*. A single period of 40—50 days.

Yield: one million fry 1—2 cm. long, 30 days old.

e. Spawning of *Tilapia* (See Appendix I)

C. Fish culture along with rice

1. Production of fry, 14 days old

a. Fry of *Cyprinus*:

First period: 3—4 weeks (till first weeding).

Yield: 20—30 thousand fry 3—5 cm. long.

Second period: (in between both weedings).

Yield: 15—25 thousand fry 3—5 cm. long.

In other cases (Garut): a single period of 30—40 days.

Yield: 10 thousand fry 5—8 cm. long.

b. Fry of *Puntius*: A single period of 30 days. Fry 10 days old.

Yield: 60 thousand fry 2—3 cm. long (Singaparna).

In other cases (Purwokerto): stocked with 2—3 cm. long.

Yield: 20—30 thousand fry, 3—5 cm. long.

c. Spawning or raising of fry of *Tilapia*. (See Appendix II).

2. Consumption fish

a. *Cyprinus*. A single period of 60 days.
Yield: 50—70 kg./ha.

b. *Puntius*. A single period.
Yield: 40—60 kg./ha.

c. Mixture of *Cyprinus* and *Puntius* (equal numbers). Total yield: 60—110 kg./ha.

According to the Statistics Department of the Inland Fisheries Service, the total production of consumption fish in 1955 amounted to 9,160,000 kg. valued at Rp. 76,000,000 (@ Rp. 8.3/kg.). The highest prices were noted in West Java (Rp. 11/kg.) and W. Sumatra (Rps. 12.5/kg.), the lowest one in Jogjakarta (Rps. 4/kg.) and East Java (Rps. 5.5 kg.). West Java produced 7,000,000 kg., more than 3/4 of the total production in Indonesia. The total production of fry amounted to 3,256 million fry in 1955, mainly produced in West Java (Singaparna and Sukabumi) along with rice and between two rice crops. A large proportion of this fry was raised up to consumption state in paddy fields, the remainder in ponds.

The following examples are given of the cultivation of fry, advanced fry and consumption fish.

When 14-day old fry is to be raised up to the stage of consumption fish (about 15 cm. and 50—70 gm.), the following stages must be passed:

1. 900,000 fry 1 cm. long, 14 days old, grown in 1 ha. (about 100 bowls of 9,000 fry each) will need 14 ha. of paddy field. Stocking rates: 7 bowls per ha. paddy field. About 50% will be lost. The yield 14 ha. will be about 460,000 fry 3—5 cm. long.

2. Stocking rate of paddy fields used for advanced fry is 16,000/ha. of 3—5 cm. long fry. The yield will be 5—8 cm. long fry. When all the fry produced in stage 1 is to be stocked, 28 ha. of paddy fields will be needed. Percentage of loss will be 40%. The yield will amount to 269,000 of 5—8 cm. long fry.

3. In order to use the entire crop of stage 2, 134 ha. paddy fields are needed, stocked at a rate of 2,000 fish/ha. Loss, 30%. The yield would be 180,000 consumption fish, (12—15 cm., 30 gram) representing a total weight of 5,400 kg.

It follows that the yield for 1 ha. of spawning pond is sufficient to stock about 14 ha. paddy field for nursing fry, about 28 ha. paddy field for advanced fry, and about 134 ha. paddy field for consumption fish.

A calculation of the profit derived from fish culture on paddy fields is given in the following summary. This profit depends on the ratio between the selling price of the product and the expenses of the procurement of the fry to be stocked. If this ratio is 3:1, the profit is 3 times.

The detailed data are given in Appendix III.

It has been shown that overall expenses of labour are maximal when fish is grown as second crop. In both other methods the farmer's relations take the bigger share of the labour.

Culture of Cyprinus

1. Second Crop

a) Very small fry

Paddy straw is cut of, scattered on the water or piled up. Circular or cross-moats are constructed.

Stocking Rate : 60—100 thousand fry 2 weeks old.

Period of growth: 3—4 weeks.

Yield : 31—50% of stock (fry 3—5 cm. long).

Profit : 3—4 times.

A maximum of 3—4 growing periods per season can be attained; at each successive period the stocking rate is reduced by 10%. The largest carp, which grew rapidly during the period up to a size of 5—8 cm., are used as additional stock in the next following period.

The final (4th) period consists of the left over stock of all previous periods only.

b. Moderate sized fry

The paddy straw is not cut but knocked down only. Moats are constructed. The stocking rate: 12—16 thousand fry measuring 3—5 cm. (3 g.).

Period : 40 days.
Yield : 60% of stock (fry measuring 8—11 cm., 10 g.).
Profit : 3 times.

The young rice plants are removed. In this method the fry is stocked once in the beginning of the season.

c) Consumption fish

i) First period:

The rice straw is sometimes cut, sometimes knocked down only.

Stocking rate: 1—2 thousand fish/ha. (8—11 cm. = 10 g.).

Period : 50 days.
Yield : 75—80% of stock (fry measuring 15—20 cm. 8 g.).
Profit : 2—4 times.

Alternatively:

Stocking rate: 2,000/ha. of fry measuring 5—8 cm. 4 g.).

Period : 50 days.
Yield : 70—80% of stock (fish measuring 14—18 cm., 70 g.).
Profit : —

ii) Second period:

Both stocking rate and yield are usually 10% higher than in the first period. In this case an additional stocking of larger fish, at a rate of 5% of the primary stock, is made.

d) Cultivation of consumption fish on paddy fields in Redjang Lebong.

Dykes are enlarged. No harrowing. Stocking in August. Cropping in February. Well-to-do farmers grow fish only once, the small farmers twice.

Depth of the water : 50—100
Stocking rate : 3,000 carp fry (5—8 cm., 4 g.).
1,000 *Puntius* fry (3—5 cm., 1 g.).
Period : one of 6 months or 2 of 3 months.
Yield in 6 months : *Cyprinus* 30—40% of stock (25—30 cm., 200 g.).
Puntius 40—50% of stock (20—25 cm., 150 g.).
Profit : —

In the district Lebon 600 ha. is used in this way, in all other Districts a total of another 600 ha.

2. Fish Grown in between Two Rice Crops

a) Production of fry

Before stocking the field is ploughed and harrowed.

Stocking rate : 60—90 thousand/ha. of 1 cm. long, 10—15 day old fry, counted in bowls of 10,000.
Period : 1 month (In Tjisaat sometimes fine bran is given).
Yield : about 50% of the total stock (2—5 cm., 1—2 g.).
Profit : 3—5 times.
Additional stock : 2—3 thousand fry (5—8 cm.).
Yield of additional stock : 70% of stock (9—12 cm., 20 g.).

b) Fry measuring 3—5 cm. (2 g.)

The field is ploughed once. No harrowing.

Stocking rate : 16,000/ha.
Period : 1 month.
Yield : about 60% of stock (5—8 cm., 4 g.).
Additional stock : 1,000 fish (8—11 cm., 7 g.).
Yield of additional stock : 70% of stock (11—14 cm., 20—30 g.).
Profit : 3—5 times.

c) Consumption fish

Field not tilled. Paddy straw cut only. Very small fry are raised on fields far removed from the spawning ponds (about 2 hours walking).

Stocking rate : 500—2,000/ha. of fry (9—12 cm., 20 g.).
Period : 40—50 days.
Yield : 70% of stock (14—18 cm., 60 g.).
Sometimes additional stock : about 100 fish weighing 60 g. each.
Yield of additional stock : about 80% of stock (18—23 cm., 100 g.).
Profit : 2—4 times.

3 Along with Rice

a.i) Fry measuring 1 cm.

Stocked 5—7 days after planting of the rice.

Stocking rate : 50—90 thousand/ha.
Period : about 25 days till first weeding.
Yield : 40—50% of stock (2—4 cm., 1—2 g.).
Profit : 3—4 times.

a.ii) Second time small fry

Stocked after first weeding.

Stocking rate : 40—60 thousand/ha. fry (1 cm.).
Period : —
Yield : 40% of stock (2—5 cm., 1—2 g.).
Profit : 3 times.

b) **Fry measuring 2-5 cm.**

Stocked one week after planting, until second weeding.

Stocking rate : 6,000-8,000/ha. of fry (3-5 cm., 2 g.).
Period : 50 days.
Yield : 40-60% of stock (8-11 cm., 15 g.).
Profit : twice.

c) **Consumption fish**

Usually after second weeding until flowering.

Stocking rate : 1,000-2,000/ha. of fry (5-8 cm., 4 g.).
Period : 80 days, if field is weeded once.
— or —
Stocking rate : fish measuring 8-11 cm., (10 g.).
Period : 60 days, if field is weeded twice.
Yield : 50-80% of stock (13-20 cm., 70-100 g.), for the period of 80 days. 80% of stock (15-20 cm., 80-100 g.) for the period of 60 days.
Profit : 4 times.

Culture of Puntius

1. Raising of Fry about 10 days old (1 cm.) at Singaparna

Field ploughed once, harrowed once.

Stocking rate : 160-200 thousand/ha. of 1 cm. long fry; measured in bowls of 4-6 thousand.
Period : 30 days, fed twice a day with fine bran in the morning and evening.
Yield : —
Profit : at least 3 times.

In Purwokerto, where this method was introduced only recently, the following stocking rate is practised.

Stocking rate : 40-80 thousand/ha. of 1 cm. long fry.
Period : 1-1.5 month.
Yield : 40-50% of stock (2-3 cm., 1 g.); measured in bowls of 2,000 — 2,500 fish., additional food occasionally given.
Profit : twice.

2. Along with Rice

a) Fry production (Singaparna)

Stocking 5 days after planting.
Stocking rate : 120-150 thousand/ha.
Period : about 4 weeks, until first weeding.

Yield : 40-60% of stock (2-3 cm., 1 g.).
Profit : almost 5 times.

b) **Larger Fry (Purwokerto)**

i) Stocking rate : 20-30 thousand fry (2-3 cm., 1 g.).
Period : 30 days.
Yield : 40-60 3-5 cm. (1½ g.)
Profit : twice.

ii) Between first and second weeding.
Stocking rate : 10-15,000/ha. of 3-5 cm. (1½ g.).
Period : 3 weeks.
Yield : about 60% of 5-8 cm., (2 g.).
Profit : twice.

c) **Consumption fish**

i) Stocking after first weeding at Purwokerto; during the second weeding the fish stay in the moat.
Stocking rate : 2-3,500/ha. of 3-5 cm. (1½ g.).
Period : about 80 days till flowering.
Yield : 50-60% of 13-18 cm. (40 g.).
Profit : twice

ii) Stocking after weeding; recently started in Jogjakarta.
Stocking rate : 2-3 thousand/ha. fry (5-8 cm., 3 g.).
Period : 60 days until flowering.
Yield : 50% of stock (11-12 cm.. 40-60 g.).
Profit : 3 times.

Mixed stocking of *Puntius* and common carp along with rice at Jogjakarta; stocked 5 days after planting.

Stocking rate, Carp : 1,000/ha. fry (5-8 cm., 4 g.).
Puntius : 1000/ha. fry (5-8 cm., 3 g.).
Period : 60 days.
Yield Carp : 50% of stock (14-22 cm., 70-100 g.).
Puntius : 70% of stock (11-20 cm., 40-60 g.).
Profit : 4 to 8 times.

The growth of *Puntius* is usually slower than that of common carp, but its spawning may succeed in regions where common carp cannot be spawned. One of the bottle-necks of the extension of fish culture on paddy fields in Indonesia will be the procurement of fry. Only fry of *Puntius* larger than 3 cm. can be transported successfully.

Culture of Osteochilus.

1. Second Crop (production of fry)

So far this culture has been restricted to places near centres of pond culture, where manure is readily available. The soil must be sandy and the water supply plentiful. The average depth of water in the fields is about 30 cm. Quantities of manure needed: 6-8 tons green manure/ha. or 3-4 tons farmyard manure, to be given one week after stocking with fish.

Stocking rate : 150-20 thousand/ha. of 7 days old fry.
Period : about 30 days.
Yield : —
Profit : 4 times.

2. Along with Rice (continued as second crop)

Practised in Balik Bukit (South Sumatra) at an altitude of 900 m., on about 200 ha. The soil is sandy, the water clear, the paddy field cannot be totally drained, the depth of the water in the centre is 25 cm. Fry is stocked when the rice is 1 month of age. Cropping takes place at the end of the dry period, when the field must be tilled for the next planting period. The duration of the period of growth for the fish amounts to 6-7 months along with rice plus 3-4 months as second crop.

Stocking rate : about 25,000/ha. of 3-5 cm. long fry.
Period : 9-11 month.
Yield : 30% of stock (12-15 cm., 40 g.).
Profit : —

Culture of Tilapia mossambica Peters.

1. *In between two crops and along with rice.*

Stocking rate : 2,000/ha. of 4-7 cm. (3 g.) long fry.
Period : 35 days plus 15 days plus 15 days.

Yield, 1st Weeding : about 650 fish (10-12 cm.) = 18 kg. 27,000 fry (3-7 cm.) = 65 kg.
2nd Weeding : about 750 fish (10-12 cm.,) = 21 kg. 44,000 fry of (3-7 cm.) = 110 kg.
final : 30,000 fry (3-7 cm.) = 75 kg.
Profit : 40 times.

b) Stocking rate : 2,000/ha. of 8-12 cm. (20 g.)
Period : 20 days plus 20 days. (first weeding).
Yield, 1st Weeding : 762 fish of 12-14 cm. = 36 kg.
2nd Weeding : 21,000 fish of 3-7 cm. = 53 kg.
Profit : 4 times.

2. *Mixed stocking of common carp and Tilapia*

Stocking rate : 1,200 *Tilapia* (8-12 cm.) = 8 kg.
450 carp (8-12 cm.) = 6 kg.
Period : —
Yield : *Tilapia*–1,100 (12-14 cm.) = 39 kg. 14,000 (2-4 cm.) = 14 kg. Carp–300 of (13-16 cm.) = 20 kg.
Profit : 8 times.
Manuring : 1a.– 7 public conveniences.
1b. – farmyard manure on alternate days.
2. – horse manure every third day.

Culture of Helostoma.

A fertile paddy field with sufficient water supply, situated near the village and where the finished product can easily be sold might be used for the spawning of *Helostoma* in between two rice crops as is done near Tasikmalaja.

Surface : 10 ha.
Manure : 4-8 hundred kg. green manure and 2-4 hundred kg. farmyard manure.
Period : 40-50 days.
Spawners : 30 pairs, each fish about 200 g.
Yield : about 100,000 fry measuring 1-2 cm. and 30 days.

When the *Helostoma* fry are 20 days old, 70-100 Goramy, 2-3 cm. in length, are added, and fed with fine bran.

Culture of Goramy

Production of fry on paddy fields near the village.

Depth of the waters : 40-50 cm.
Surface : 10 ha.
Stocking rate : 2,000 fry measuring 2-3 cm. (2 g.) or: 1,000 fry measuring 5-8 cm. (8 g.).
Period : 2 months; fed with pupae of white ants and red ants.
Yield : fry measuring 5-8 cm. or: 8-11 cm.

Practical experience has shown that the profit may be stated as follows. During a growing period of 30 days the profit amounts to 3-4 times the costs of the fry stocked. During a period of 50 days to 2-3 times. Nearly all labour is carried out by relations of the operator.

In the case of paddy fields situated near a town, where hired labour must carry out all work the cost of labour amounts to the entire gross profit of the first growing period. A net profit can only be attained during subsequent periods.

Expenses involved in fish culture in between two rice crops are considered to belong to the costs of next rice crop.

When the income is calculated as a percentage of all expenses the following figures are founded:

Cost of fry	:	30-50%
Expenses	:	5-30%
Profit	:	65-20%

The customary rent for a paddy field amounts to 33.3% of the expected yield. For instance in Singaparna the rent for a paddy field to be used for fish culture in between two rice crops is Rp. 75-150.—depending on the distance from the road or the village. Near Bandung about Rp. 400 are paid for 1 ha. of paddy field to be used for fish culture as second crop during 40 days.

In region where the population is sufficiently "fish-minded" the way fry is procured and the product sold is as follows. A large percentage of the fish growers do not sell their product on the market as they do not possess the necessary equipment and are not acquainted with the customs of marketing. For this reason they sell their fish to middlemen from place to place. Many middlemen selling fry make an appointment with the farmer to buy the product afterwards. Different ways of buying and selling are encountered. Often the price is esta-

blished by weight (consumption fish), or by number, measured in bowls (fry) after the fish have been cropped. In some regions religion forbids the selling of something that cannot be properly valued beforehand and the fish are sold in bowls or saucers, coconuts or sieves.

But often the price is established before the pond has been cropped. It is obvious that the buyers must be experienced persons in this case. They consider the stocking rate, the water, soil, and the habitus of those fish easily observed in the field. When they do not furnish the stock themselves they have to rely on information of the farmer concerning the numbers involved. They walk around on the dykes scrutinising the water and soil and often churn up the mud in the neighbourhood of the inlet, mainly in the case of consumption fish. When a field is heavily stocked the water is turbid and the dykes are pitted, a result of the active feeding of the fish. The buyer knows that between 9 and 10 in the morning the fish are feeding most actively. Fry of equal length are considered superior to fry of fluctuating length.

When the crop is sold as a whole the buyer often must crop the fish himself, otherwise buyer and seller co-operate. The farmer sometimes pays for the fry at the time of stocking but often not until after the fish has been harvested. Often the buyer will sell once more to other middlemen who go to the market. At the market they meet other traders, who also do not often pay straight away, but afterwards. Some persons make a living by contacting buyers and sellers. The trader who buys fry on the market sells it to farmers in other regions and often hires a special person to carry the fish. These carriers are often prospective traders sometimes empowered to trade themselves. In this way the fry sold to the farmer has passed 2 or 3 middlemen and increased in price from 200 to 300%. Consumption fish is bought for the purpose of salting or other forms of preservation. Usually the traders work together in groups of 4 or 5 under one head, who is responsible for all financial transactions.

THE INFLUENCE OF LAND TENURE SYSTEM ON FISH CULTURE IN PADDY FIELDS

The desire to own land acts as a stimulus to grow fish on paddy fields. However on Java the increase in available land suitable for fish culture lags behind the demand. Moreover, the area owned by a small group of capitalists increases rapidly owing to the rent system, and as a result, a large group of farmers will rent land from owners possessing excess land.

The present unsatisfactory situation found in West Java was explained by Vroon (1935) as follows. Eighty four per cent (84%) of all inhabitants make a living from agriculture, of which 14% have other sources of income and 70% depend entirely on agriculture. Only 42% of the farmers own the land themselves, and 5.79% of all land owners possess 31.76% of the total acreage suitable for agriculture.

Of the farms, 42% are smaller than 0.5 ha., 46% in between 0.5 and 2.67 ha., 10.4% in between 2.67 and 13.33 ha., and only 1.6% more than 13.33 ha. Hence about 50% of the farmers have such small holdings that there is not sufficient work on their land to occupy them the whole year round. Often the rent combined with the expenses for planting etc., exceeds the value of the crop, the more so when the fields are situated far from the farmers residence. Some data on rents customary in Tjiandjur are given below.

Classification of field	Yield of rice in quintals	Annual rent in quintals of rice
I	35—40	25—30
II	30	20
III	20	16
IV	18	14

The way the land is to be operated is not specified in the rent contract provided the rent is paid at harvesting time during the wet season.

In the Tjisaat (Sukabumi) Sub-district the lease-holder receives 20% of the yield of rice and is entitled to grow fish as second crop for 3 months and along with rice for 1 or 2 periods.

In Tjiparaj, where a few persons own most of the fields, these are managed by special overseers, who may lease out the fields on a share basis or on pre-arranged conditions, e.g. rent of 1 ha. will be about 11 qu. from yield of about 20 qu./ha. Taxes, seed and gratifications are paid by the farmer. The overseer receives 10% of the owner's share. Moreover the

leaseholder is bound to assist in the tillage of the overseer's paddy fields to an acreage of 20% of what he has rented.

Hiring land on a share basis is quite common. In some regions the leaseholder receives half or one third of the rice only, in other regions the second crops must be shared as well. Concerning seed, fry and taxes the contracts differ, sometimes the leaseholder pays for seed and fry and the owner pays the taxes, sometimes the leaseholder pays all.

Usually the leaseholder—mainly a man of weak economic position—is satisfied when his share of the rice crops covers his expenses. They try to reduce expenses as much as possible and, if possible, work their fields themselves with the aid of their families. They curb the expenses for procurement of fry and try to obtain a marketable crop quickly, and arrange that the crop is marketable in bulk in case of emergency. Fish culture fulfils these needs. For this reason fish culture spreads rapidly in regions near centres of pond culture where rents are high. Which of the three types is practised depends on the frequency of the rice cultivation. In case the farmer is unable to buy the necessary fry, the owner or the overseer may do so and the final crop will be shared by both parties. In such cases the owner will receive one third.

Experienced fish growers dare to cede their entire crop of rice to the landowner, provided they will be able to grow fish as second crop, in between two rice crops and along with paddy, for two periods. In regions such as the Bandung area, where fish culture on paddy fields is well established, rents are paid in cash, calculated per period. Near Bandung the rent of 1 ha. paddy field to be used for fish culture as second crop during 5 months in 3 periods of 40 days, amounts to Rp. 250—300 per period. If the owner constructs the dykes, the rent will be Rp. 400—500. In the vicinity of Rantjaekek, for 2 periods of 50 days, second crop method, the rent is Rs. 150, when the owner constructs the dykes. On less fertile paddy fields, where fish is grown for a single period of 3 months, the rent will be Rp. 100/ha. In Singaparna, the rent for 1 ha., where fish is grown along with rice or between two crops, amounts to Rp. 75—150. In the Wanaradja area, the rent for the entire growing period in between two crops of rice, 1 period of 20 days and 1 of 60 days, amounts to Rp. 300—600/ha.

When fish is grown between two rice crops, sometimes the leaseholder stocks and later crops the field which is given back to the owner at the time of replanting with rice.

Quite often conditions of lease are most severe for the farmers. Why do they still submit to them? Here psychological factors, concerning the farmer's social standing in his village, come into play and he also feels more independent. This desire for independence is encountered outside Indonesia as well. It is the reason why the farmer prefers to work in his own environment with his own family and relations in his own way and to make a small profit. Moreover, the owner wants the rice, even if the profit is going to be small.

An experiment carried out in Sabandar (Tjiandjur area) in 1948 showed that the culture of fish as a second crop after the harvest of the rice gives the highest profit. The influence of a previous crop was investigated, as well as the hours of labour and the expenses involved. The relative advantages of the following combinations were examined: rice and rice (3 crops in 2 years); rice and fish; rice and sweet potato.

In connection with hygienic measures taken in the Tjiandjur area, three different cases of rice and fish culture were compared. Yield of a paddy field stocked with fish and treated according to the customary way of the farmers (Case B) was compared with the yield obtained when the technique advocated by the Public Health Department was employed (Cases C and D). Plot in Case B irrigated in an arbitrary way; the depth of the water was 10—15 cm. After the rice was harvested the straw was immediately cut and piled up. Dense aquatic vegetation was cut as well.

In Plots belonging to case C, the water was 20 cm. deep, the straw was cut as was done in the B-Plots, the vegetation was cut and the surface of the water was kept clean. The D-Plots were treated in the same way as the others but the depth of the water was 30 cm.

Straw and vegetation were cut and discarded. The growing periods were as follows:

7 January to 23 June : fish.
30 December to 8 May: sweet potato.
5 March to 20 June : East monsoon paddy.

The results are given in the following table:

Effects of various crop combinations on the yield of rice.

Product		Labour by relations in man-hours	Other forms of labour in man-hours	Hired labour in man-hours	Hired labour man-hours	Total in man-hours	Yield in quintals per ha.
Sweet potato	(A)	455	70	303	—	828	50.9
Fish	(B)	267	90	—	—	357	2.1
Fish	(C)	370	103	—	—	473	3.2
Fish	(D)	451	97	—	—	548	2.3
Rice	(E)	575	316	390	30	1,281 (plus 30 man-hours for animals engaged)	10.3

It follows that cultivation of fish does not increase the expenses, particularly when it is realized that only half of the paddy field is under exploitation. The period of exploitation of the paddy field for fish culture does not coincide with the period when the soil is to be tilled for the planting of paddy during the rainy season.

A calculation of the expenses and profit, taking into account the respective prices of rice, sweet potato and fish, showed that the combination of rice and fish with sufficient water supply (B and C) yields the highest profit. So it will be evident that the combination of rice and fish will be the most suitable one in regions where the water supply is adequate the whole year round.

THE DEMANDS OF FISH AND RICE ON WATER SUPPLY

No exact data are available on the quantities of water needed for the growth of fish in paddy fields. Investigations are lacking and the data given here are derived from local experience. A large percentage of the paddy fields used for fish culture are situated in regions outside the area irrigated by the Irrigation Department. Here irrigation is arranged locally, by mutual consent of all interested parties and in accordance with local customs.

Usually the quantity of water needed for fish culture is considered to be equal to the amount needed for the rice (tillage of the soil and irrigation of the crop). Data on the needs of the rice fluctuate heavily. A paddy field in the lowlands stocked with fish will need 1—2 litre/sec./ha. However, the amount actually running through the fields is lower than the amount to be drawn from the main irrigation canal, as some water will be lost through leaking dykes. In Modjokerto (Reg. Surabaja) this amounts to 19% and at Tegal (Reg. Pekalongan) even to 50%. Probably these figures are true only for rice alone, as the same amount is usually stated for ordinary paddy fields. Practical experience goes to show that 2 litre/sec./ha., and even 1—1.5 litre/sec./ha. is sufficient for fish culture on a paddy field where the soil is not exceptionally loose, the dykes are firm and the field is properly guarded. The question is to maintain a sufficient height of the water layer on the fields.

The question now arises how much water is needed to fill the fields up to a height suitable for fish culture. At a rate of 2 litre/sec., from 5 to 6 days are needed to fill one ha. with a layer of 30 cm. in the centre.

Therefore large areas are not filled at once, but the individual fields are filled one after another according to their respective distances from the main irrigation canal. This way of filling is practised in the case of all three forms of fish culture. However cropping takes place in reversed order, the fields downstream first and those upstream afterwards. In this way the fields downstream can be filled with the water flowing out of those upstream, This practice also saves time for the filling of adjacent fields.

As experience has shown that the growth of the fish is hampered by fluctuations in the water level, the farmer tries to prevent such fluctuations as much as possible during the period of growth of fish in his fields. When the East Monsoon is exceptionally dry and the supply of irrigation water is almost exhausted, the farmer has to take care of his field even during the night. Extremely dirty water must be passed through a sedimentation tank if it is to be used for fry.

When, during the middle of the dry period, the water in the most is insufficient the management is as follows: during the day the fields with small fry receive as much water as possible and towards the night they are almost filled to maximum capacity. During this period the outflow is reduced. During the night all water is used to fill the other fields and in the morning the outlet is once more reduced.

It has been shown that tilling the soil of an irrigated paddy fields and the preparation for the next planting of rice are easier and less expensive than in the case of a dry field (fish as second crop allowing wet fallowing, versus dry second crop and dry fallowing). For this reason cropping operations are usually carried out at the same time as the tillage of the soil and water management is planned accordingly.

The irrigation water flowing constantly over the soil will influence its fertility. When fish has been grown as second crop on a certain field for many years in succession and the water contains a high concentration of organic substances, the rice may show decreased seed formation and the yield may decrease. Accordingly, after 4 years of fish as second crop often a dry second crop is grown or the field lies fallow for one season. In some cases an annually rotating quarter of the area is intentionally not stocked with fish for fish reason.

Fertile water not only influences the fish and the rice but the soil as well. The mud becomes softer and the expenses for weeding decrease,

In the case where the fish is regarded as "catch-crop" the management of the water is in accordance with the irrigation of rice, as indicated by local customs. Accordingly, fish culture along with rice is practised in the vicinity of Tjiandjur only until the second weeding i.e. 2 months after the planting of the rice After the second weeding the paddy fields here are totally drained until a rosette of adventitious roots has been formed at the base of the shoots. After drainage as much water as possible is drawn out of the irrigation canals into the field. Then intermediate irrigation is applied in order to keep the soil in wet condition, until the rice is flowering on the 90th day. During the next 10—15 days as much water as possible is supplied, and complete drainage follows immediately afterwards, as long as the flower does not yet protrude. When it does so, water is again supplied until the fruit is set, but still shows a green colour, about 29 days before it is harvested. Final drainage follows at this stage.

It follows that fish can only be grown until the second weeding on such fields. The same applies for fish culture along with rice on paddy fields manured heavily and previously used for fish culture as second crop. The yield of fish grown along with rice for 60 days at the second time of weeding is quite sufficient (100—150 kg./ha.) but the rice does not bear enough seed. At Buahbatu, near Bandung, the yield of the paddy dropped to 20% of that of previous crops.

Now the question arises: does fish culture have any right to part of the water? Official regulations concerning the water situation

state that fish ponds are among the objects in need of a constant supply of water and entitled to a share in the irrigation water. The usual regulations for crops needing water are valid for paddy fields stocked with fish.

It is further stated that:

a) Minimal and optimal quantities of water needed by different crops are established by the Head of the Civil Administration in accordance with data furnished by the Ministry of Agriculture.

b) When the above mentioned data are lacking the ratio between the quantities of water available for second crops, sugar cane grown by the population, sugar cane grown by the factories and paddy fields stocked with fish, is 1:1.5:3:4. The regulations thus evaluate fish culture in paddy fields as second crop as high as rice cultivation. For both the other forms of fish culture the same rights are valid as for rice cultivation.

However, these regulations only concern irrigation by the official Irrigation Department. In the case of irrigation governed by the local village administration, all questions are discussed by the village council. This arrangement ensures quick decisions on matters of irrigation, canals and allotment of water.

EFFECTS OF THE FISH ON THE RICE

In this respect the activity of the farmer is to be considered as a unit. Cultivation of rice is the main activity and that of fish should be seen as an additional enterprise.

1. Fish as Second Crop

a) Effects on the Expenses of Rice Cultivation

The time of cropping of fish immediately precedes the time of tillage of the soil for the next crop of paddy. If not, the soil hardens and harrowing becomes more difficult. In this way 50% of the expenses involved in harrowing can be saved.

The average number of hours necessary to harrow a paddy field where no fish has been grown before, is as follow:

Manpower 570 hr. Animals 182 hr.
For a field where fish has been grown:

Manpower 460 hr. Animals 50 hr.

These were the results of an experiment carried out by the Agricultural Extension Service in 1932, in collaboration with the Inland Fisheries Department.

b) *Effects on the Cost of Weeding*

Here a reduction can be noticed as well. According to the above publication the labour involved for the weeding of 1 ha. amounted to:
Without previous fish : Cultivation—400 hr.
With previous fish : Cultivation—270 hr.

c) *Effects on the yield of rice.* (see also Appendices IVa & b)

The result of the above mentioned experiment at Subandar gave the following figures: (Variety of rice: Back, planted in distances of 25 × 25 cm. between the plants).
Field used for rice and dry second crop : Yield–36.69 q./ha.
Field used for rice and fish : Yield–46.90 q./ha.

2. Fish in between Two Crops

As long as the cultivation of fish lasts the water in the fields is checked, and no parts become dry. The soil becomes soft and is easily converted to collodial form. The water also brings in some manure. The profit derived from the fish, attained without much capital, can be used to cover some of the expenses of rice cultivation. The mud layer will be thick, and consequently the cost of labour for planting and weeding will be low. Comparative data are still lacking, but although the influence can not yet be expressed in figures in a direct way, the farmers are well aware of it.

If a field is leased out for this method of fish culture, the owner stipulates in the contract that the field must be returned in a condition ready to be planted, and thus evades the expenses of harrowing.

3. Along with Rice

Hardly anything can be said on the direct effects of fry grown, either in the period until the first weeding or in the two periods until the second weeding. An indirect influence has

been shown, as the water supply is better checked by the farmer the mud will always be in good condition, and the soil will never be too hard. For this reason weeding will be easier and more thorough. According to information received a saving of 10-20% can be attained this way.

Another advantage of the constant supervision of the water supply, early in the morning and at night-fall, is that diseases and pests of the rice will be noted and control measures applied quickly. No fish is grown along with rice for the first 60 days in regions where the water is heavily polluted with organic substances (Bodjong Lao, near Bandung) because the rice will grow too much leaf, the ears will partly be empty and the ripening unequal. But in the period before the first weeding (4 weeks) no such effect is noticed.

Deterioration of the yield in rice caused by cultivation of consumption fish after the second weeding (60 days) was noticed in an experiment carried out at Buahbatu, near Bandung in 1935, and amounted to 15% (Variety of rice: Srimahi, distance 25 × 25 cm. soil: Bandung clay).

These fields were constantly used to raise fish as second crop before rice was grown (6 months, April–September) and during the period, beginning a few days after planting until the first weeding, fry was grown. A second experiment was carried out on the same plot to investigate further the influence of fish culture. Results are shown in Appendix IV (a).

In various regions of West Java the reactions of the rice to the fish were studied and the results were published by Hofstede and Ardiwinata (1950). The following table gives some data.

Effects of paddy-cum-fish-culture on the yield of rice. Yield in kg./sq.m. of wet rice.

Observation	Paddy	Paddy+fish	Increase
I	55	57	7.5
II	54	58	7.4
III	54	56	3.7
IV	35	37.2	6.3
V	62	65	4.8
VI	41	44	7.3
VII	42	45	7.1

As these figures indicated that a combination of fish and rice increased the yield of the rice, further research was initiated at various places on Java and Sumatra (Lampong, S. Sumatra). Experiences at Jogjakarta, Blitar II and Malang did not show any obvious influence, those at Blitar I and S. Sumatra indicated a decrease. (Appendix IV (b). However, no conclusive data have been gathered to date and research will be continued in various regions, other factors than fish must be taken into account. The habit of the common carp of churning up the mud in search of food must be considered to be a sort of tillage of the soil. The absence of vegetation on fields used to grow fry a few days after planting might be explained this way. Moreover the faeces of the carp might be considered as a sort of manure, but probably the quantity is negligible. The dropping will be easily mineralised, except for the chitinous remains of digested animals.

The desire of the farmers to combine rice culture and fish culture must be considered of primary importance. In this case the farmer takes better care of his fields, and endeavours to obtain maximal yields.

Experience gathered by the Agricultural Extension Service shows that the increased attention paid by the farmer when new methods of rice cultivation are introduced, usually gives better results than is probably due to the method itself. The same can be said for paddy-cum-fish culture.

Observations in the field indicate that mice are a less serious pest on paddy fields where fish is grown among the rice.

It is possible that the higher water level, maintained during the period between the second weeding and the time the rice flowers, which is also the period when the mice reproduce most rapidly, floods the mice holes in the dykes, inhibits breeding of the mice and thus serves as an indirect control of the pest.

RELATIONSHIP BETWEEN FISH CULTURE IN PADDY FIELDS AND MALARIA

In a region where specific regulations are created for combating malaria, these rules have to be observed in fish culture in as much as they govern the irrigation canals and the surface

of the water in the fields with the object of killing the larvae of the malarial mosquitoes.

In the Regency of Tjiadjur the following regulations apply to the "second crop" method:

a. Inlets and outlets must be thoroughly clean, no vegetation is allowed in them and shore vegetation must be cut short.

b. When fish is grown as a second crop all paddy straw must be cut, piled up and burnt after the rice has been harvested and before the field is flooded, either by irrigation water or by rain or well water.

c. The central part of the paddy field should be covered with at least 25 cm. of water and the moats with at least 30 cm. The height of the dykes should be chosen accordingly.

d. The dykes should reach 40 cm. over the surface of the water and be devoid of any vegetation. On the slope, the vegetation should be kept short.

e. The walls of the irrigation canals should be constructed and maintained in such a way that the water does not overflow, and if leaks do occur the outflowing water should be directed in such a manner that no holes and pits are formed.

Other regulations are applicable to fish culture in between two rice crops and require that the tillage of the field for the next cultivation of rice must fulfil certain specified conditions.

Experience has shown that these regulations, when strictly adhered to, will have good results in non-technically irrigated areas. A large fraction of these fields lie fallow for some months after the harvest of the paddy. However, paddy fields lying fallow are usually not covered by the regulations, as there is no possibility of the deposition of mosquito-eggs on dry fields. Nevertheless fields lying fallow usually show a wet soil, due to rain or leakage, even in technically irrigated fields or if no water is added for tillage or the soil for the next planting period. On non-technically irrigated fields or on those without technical irrigation, this danger is even more apparent. Quite often paddy fields resemble marshes and the possibilities of deposition of mosquito-eggs are many.

Between the extremes of a totally clean surface, completely devoid of any vegetation and a surface entirely covered by vegetation and resembling a meadow, the majority of the fields can be placed. If a field, observed from the margin, shows mainly water with occasional groups of plants there is little chance of *Anopheles aconitus* being found. But when mainly plants and hardly any water are seen the danger of malaria is apparent. Unfortunately, the regulations are far from lucid in this respect and incorrect interpretations of the term "unclean surface" are many. Low-grade fields workers entrusted with the supervision of paddy fields for malaria purposes are apt to interpret the regulations in a strict way and have often created difficulties. The provision that, "no vegetation should occur on the surface", created the impression that a few grasses on a paddy field endanger the health of the population. Such field workers should be instructed beforehand by fishery personnel.

Until recently these fields workers directed their activities to fish culture as second crop and fishculture in between two rice crops only. However, fish culture along with rice raised the question whether the circular moats or cross-moats enlarged the danger of malaria as in these moats vegetation might grow more luxuriantly.

Hoeks (1935) investigated this question in the plains of Tjiandjur and his results have been published by Hofstede (1951). The data show that during a period of 90 days after the planting of the rice the following *Anopheles* species were found: *subpictus*, *vagus*, *barbirostrus*, *annularis* and *hyrcanus*. After 90 days, when the leaves are broader and a dense vegetation is found along the inside of the dykes, the dangerous *A. aconitus* is found in large numbers. Although these results must be corroborated by further research they are in accordance with the experience of fishery personnel that malaria-danger is negligible before the leaves of the rice close and reduce the penetration of sun-light. Fish culture along with rice will not increase malaria-danger during the first 90 days after planting.

Not only fish ponds but every open water should be checked for its danger in this respect. Incidence of malaria is about 40% *i.e.* 30 million Indonesians contract malaria each year. Mortality is estimated at 6-7% of the total mortality of the country (20/1,000 inhabitants). Thus 120,000 Indonesians die from malaria each

year. This figure is a minimum. These facts depict the economic loss involved. According to a statement by F.A.O. "The economic loss to the country through morbidity caused by malaria is conservatively estimated to be over 1.5 million rupiah annually". Furthermore, these facts illustrate the importance of the fight against malaria from the point of view public health as well as from that of national economy, and also their importance for fish culture in paddy fields.

OTHER ASPECTS

To increase fish production the area of paddy fields used for fish culture must also be increased. As was stated before, the total acreage of paddy fields used for fish culture in Indonesia amounted to 65,167 ha. in 1955 of which 52,210 ha. were in Java and Madura. The total area of paddy fields in Indonesia in 1955 was 3,430,290 ha. and 1,559,093 ha. in Java and Madura. So the paddy fields used for fish culture in Java and Madura amounted to a mere 2% of the entire acreage, or 5% of all irrigated fields (2 million ha.). Additional culture in irrigated field could be planned. In view of the success of the culture of *Chanos* and *Puntius* in the Surabaja and Lamongan area, the paddy fields near the coast might be included in the programme. Outside Java, the regions of West, North and South Sumatra, Celebes, Bali, Lombok and Sumbawa merit every attention.

The spreading of this form of fish culture means amelioration of the daily menu and of income (Saanin, 1955), increase of paddy production at a rate of 3.7—7.5% (Hofstede and Ardiniwinata, 1950) and an increase in income.

The history of this culture, mainly in West Java, has shown that the following factors are of primary importance: water, labour, economic situation, subsistence fisheries in open water, transport of fish to the relevant region and last not the least, the fishmindedness of the population. Not only technical problems but the wish of the farmer as well come into play. A case in point is the attitude of the farmers of Jogjakarta towards *Tilapia*. After only two years of intensive propaganda this species became popular. Moreover, fishery measures should always be combined with measures to increase the yield of the rice, as rice remains the principal crop. In view of the fact it is desired in various circles to increase the frequency of rice cultivation in all areas with sufficient water, the growing of fish between two rice crops and along with rice stand the best chances. The second crop method might become exceptional in the future. Growing fish well along with rice may be the only method in plains where mechanical cultivation of rice is practised. Perhaps, 2-3 crops of rice with be grown alternately with a single crop of fish as is done in Arkansas.

Other factors influencing the rentability, apart from satisfying the needs of the operator, are:

a. altitude and slope of the area,

b. suitability of soil and water,

c. competition with preserved fish products and fish caught in inland waters and in the sea,

d. possibilities of marketing,

e. difference between the yield of fish and dry second crops,

f. effects on quantity and quality of the rice, vegetative growth, number of seeds in the ear, weight of the seeds, percentage of breakage and difficulty of husking (Saanin, 1956).

The following data, gathered in various regions on the effects of fish culture in rice cultivation are of interest:

1. Ripening takes place 1-2 weeks earlier.

2. If the water is too fertile near villages, fish is only grown along with rice until the second weeding. If cultivation is continued beyond this stage, the rice will grow too many leaves and bear too few seeds.

3. Usually fish grown along with rice do not influence the plants, provided the variety of paddy is suitable for the type of soil (unawned varieties e.g. Tjina, are unsuitable for fertile soil, as they are apt to collapse, unless planted at distances of 50 cm.).

4. On marshy paddy fields the yield of the rice is usually decreased by the fish.
5. No increase of breakage of the seeds during husking is noticed.
6. Possibility of growing fry of various ages and lengths is increased.

In regions where the culture was recently introduced difficulties in the procurement of fry are often encountered. In order to satisfy the requirement for fish fry in such regions Spawning Stations should be created working according to well defined plans. The site of such an institute should be chosen so as to ensure efficient transport of fry. The farmers should be encouraged to establish spawning centres and the Inland Fisheries Department should provide these centres with selected spawners. In order to select the right species of fish to grow in paddy fields the amount of fry obtainable from one pair of spawners should be taken into account. Although common carp is usually preferred *Puntius* might be more suitable in places where spawning of carp is inhibited by local conditions. Fry of carp might be used as additional stocking material in such cases. The economic and social structure of the area must also be considered. If many villages are scattered in a certain region special measures of guarding the field need not be taken.

Problems of fish culture in paddy fields are closely connected with problems of rice production, as the latter is the main enterprise. Special varieties of rice should be chosen for combination with fish according to the quality of soil and water. Nothing is known in this respect; even the relationship between the soil and rice as the only crop are unknown. Experience has shown that a suitable variety of paddy will quickly lose its good qualities and needs to be replaced after four years. Some varieties are suitable for the dry seasons only and must be replaced by others during the wet season.

In regions with fishminded populations the following problems await solution:

1. Optimal stocking rate within a certain period under certain conditions.
2. Ratio between *Puntius* and common carp in various regions where such a combination is practised.
3. Effects of manuring: whether green manure or farmyard manure should be applied after the field has been ploughed and hoed; what is the effect when fish is grown in between two rice crops; whether fertilisers should be applied after the field has been planted with rice.
4. Effects of artificial feeding on the growth of the fry of *Helostoma*, Goramy and *Puntius*.
5. Water requirements for fish culture in paddy fields on various types of soil. However, Goor (1952) holds that the problems of water does not arise in the case of culture of fish along with rice.

In large, sparsely populated, well irrigated plains, *Tilapia* might be grown as the only species. The soil should be well tilled, in order to create a layer of mud not less than 20 cm. thick. The size of the end product is unimportant as small fish are acceptable as consumption fish. At the moment the population is easily satisfied with small fish, probably in future bigger fish will be required. To date a tendency to consume fish even smaller than before is evident, the minimum size having dropped from 30 to 15 cm.

Experience has shown that fish grown along with rice in fields near the villages never decrease the yield of rice. This only happens on marshy fields. In paddy fields near villages the yield of the rice even shows a slight increase, perhaps mainly due to the attention paid by the farmer to the water supply, better control of weed, aeration of the mud owing to the movement of the fish, mineralisation of organic substances and the control of diseases and pests. Paddy fields situated far from the village will perhaps not show these advantages, as control will be less rigid and weeds will not be so easily noted. In order to obtain a complete picture of the importance of paddy fields as a source of protein food for the population, data on production of fish and other edible aquatic resources in such fields should be gathered regularly.

SUMMARY AND CONCLUSIONS

1. According to available information fish culture in paddy fields originated in the eastern part of West Java. The first written information appeared in 1860. The spread of this practice was caused by the feeling of safety created by suitable agrarian law, freedom of activity and, to a large extent, by the fishmindedness of the people and the geographical situation of the area far removed from centres of sea fisheries. The activities of civil servants, the Agricultural Extension Service and, since 1934, the Inland Fisheries Extension Service may be credited with the spread of the practice outside Java.

2. Of the total acreage of paddy fields in Indonesia, 35 million ha. in Java and 1.5 million ha. outside Java, about 10 to 25% of the irrigated paddy fields are suitable for fish culture.

3. According to the Central Office of Inland Fisheries about 52,000 ha. in Java and Madura, together with 13,000 ha. outside Java were used for fish culture in 1955, producing about 9 million kg. of consumption fish.

4. Fish culture in paddy fields may be divided into fish culture as second crop ('palawidja'), fish culture in between two rice crops ('panjelang') and paddy-cum-fish culture. The first form of fish culture is practised in paddy fields where rice is grown once a year, the second form in those where more crops annually are grown.

   Depending on the fertility of the soil and the water, the distance of the pond from a major irrigation canal, and on the socio-economic condition of the farmers, culture of fish as second crop is subdivided into 3 periods of 40 days, 2 periods of 50 days or a single period of about 3 months. In between two rice crops fish is grown for 1 or 2 months of 1 or 2 periods. This method dates back to the years immediately after World War I, When there was a substantial increase in rice cultivation. In the eastern parts of West Java, the paddy-cum-fish culture method is much older than the "panjelang" method, but was originally practised for raising fry only, during the period between the planting of the rice until the first weeding. Subsequently, fry were grown in the period between the first and the second weeding of the rice and consumption fish were grown in the final period between the second weeding and the ripening of the rice. However in Central and East Java only consumption fish have been grown simultaneously with the rice since about 1930, owing to the paucity of water and the needs for water in the sugar cane fields. In the culture of fish as a second crop as well as between two rice crops, part of the field is used to raise fingerlings.

5. The principal species used are the common carp *(Cyprius carpio* L.*)* in all varieties available, together with *Puntius javanicus* (Blkr.) 'tawes', and *Tilapia mossambica* Peters, 'mudjair'. All three are being grown to fingerling stage as well as to consumption stage. *Tilapia* was introduced after the Japanese occupation. Culture of 'tawes' started near Purwokerto only a few years ago, owing to a shortage of fry of the common carp. Mixed culture of common carp and 'tawes' along with rice started only recently. However, culture of fry of 'tawes' between two rice crops or along with rice until the time of the first weeding, was practised in the vicinity of Singaparna (eastern part of West Java) as early as 1920.

   Culture of *Osteochilus hasselti* (C.V.) 'nilem', to consumption stage takes place in the neighbourhood of Lake Ranau in South Sumatra, formerly along with rice only, later on also as a second crop. On Japanese paddy fields situated in the vicinity of 'nilem' ponds, 5-day old fry of the 'nilem' are sometimes grown between two rice crops. *Helostoma temmincki* C.V., kissing goramy, 'tambakan'

are spawned in paddy fields near Tasikmalaja in the eastern part of West Java, in the period between two rice crops, in order to obtain fry.

Trichogaster pectoralis (Regan) is unimportant as a second crop in Java. *Osphronemus goramy* Lac., goramy, is grown as a second crop near Purwokerto, mainly, fry 2-3 or 5-8 cm. in length are used. Sometimes goramy nests with eggs are placed in the paddy fields to hatch. At Tasikmalaja goramy is used only in combinaton with 'nilem' fry.

6. No elaborate investigations concerning the biota of Indonesian paddy fields ingested by fish have been carried out to date, neither have paddy fields been studied as ecological biotopes. Some incidental observations have been recorded by Bernhard, Oye, Woloszynska, Buschkiel, Vaas, Sachlan and Oven, *loc. cit.* Numbers of aquatic biota are apt to fluctuate heavily. It is evident that the growth of the fish is influenced by the aquatic vegetation of emergent and submerged plants, and also by the availability of Chironomides and Oligochaetes. Our knowledge concerning the mutual influence of various groups of aquatic animals and their importance for the growth of the fish leaves much to be desired. Diseases and pests of the fish are fairly well known.

7. Addition of stable manure, green manure or a combination of both manures for the sole purpose of fish culture in paddy fields is practised only in the case of the culture of *Helostoma temmincki* and fry of *Osteochilus hasselti*. In between two rice crops, stable manure, rice bran or both are mainly used for the benefit of the next crop of rice. The field in which fish are grown as a second crop is not intentionally fertilised, but up-rooted aquatic vegetation and paddy straw act as fertiliser.

8. Yield and rentability of each of the three methods is as follows:

a) Yield of second crop method, per season;

Consumption fish:

i) Fertile water (3 periods) about 600 kg./ha.

ii) Moderate water (2 periods) 300 kg./ha.

iii) Unfertile water (1 period) 100-200 kg./ha.

Fry: (4 periods) about 100-200 thousand fry measuring 4-6 cm., together with 50-100 kg. of large consumption fish, always stocked along with the fry.

b) Yield of fish culture in between two rice crops:

Consumption fish: (1 period) 40—60 kg./ha.

Carp fry: (1 or 2 periods) 40—60 thousand fry (3-5 cm. long), or 20—30 thousand fry (5—8 cm. long), together with 20—30 kg. of large consumption carp.

Puntius fry: (1 period) 80—100 thousand fry (2—3 cm. long) (Singaparna) or: about 20,000 fry (3—5 cm. long) (Purwokerto).

Osteochilus fry: (1 period) 75—90 thousand fry (2—3 cm. long).

Spawn of *Helostoma:* (1 period) 1 million fry (1—2 cm. long).

c) Paddy-cum-fish method:

Consumption fish: (1 period of 60 days)

Cyprinus	50—70 kg./ha.
Puntius	40—60 kg./ha.
Equal numbers of both	60—100 kg./ha.

9. Value of consumption fish: 9.16 million kg. = Rp. 76 million. The total number of fry raised on paddy fields in 1955 amounted to 3,200 million. The value of this fry cannot be easily worked out as price for fry varies, in time and space within wide limits. The relative efficiency of each method is illustrated by a comparison between the price of the stocking material and that of the end product.

Consumption fish: Value of end product = 2–4 times that of fry

Fingerlings fish: Value of end product = 3–5 times that of fry

The economics of the operations may be expressed as follows:

Price of fry : 30–50%
Expenses : 5—30%
Profit : 65—20%

10. In the important centres of fish culture in West Java rents for paddy fields are usually moderate for the smallholder; a relatively high rent stimulates the farmer to embark upon fish culture in one of its various forms.

11. Exact data on the quantity of water needed exclusively for fish culture on paddy fields are lacking. Irrigation authorities usually allot equal quantities to rice and fish. Further investigations on this subject are urgently needed.

12. The effect of fish culture on the rice is to be divided into the following items.

a) Fish as second crop:

i) The cost of preparing of the field for cultivation of rice decreases by about 30% of the amount needed to prepare the field when rice had been grown in the previous period.

ii) The costs of weeding are lower.

iii) The yield of rice increases.

b) Fish between two rice crops:

i) The fields benefit from longer fertilising action of the water.

ii) The income derived from the fish helps to meet the expenses necessary for the work on the paddy field.

iii) As a result of the constant irrigation the soil is softer and yields better to the plough.

c) Paddy-cum-fish culture:

i) Irrigation is better controlled.

ii) Aquatic weeds are better controlled.

iii) The movements of the fish aerate the soil.

iv) Possibly organic substances are better mineralised.

v) Diseases and pests of the rice are more efficiently dealt with.

vi) Probably the yield of the rice increases. Investigation concerning this question are still in progress and do not yet yield clear-cut results.

13. Where regulations concerning the cleaning of the surface of the paddy fields in order to decrease the hazards of malaria have been set up, these regulations should be strictly enforced.

14. About 10% of the total area of paddy fields, or 25% of the irrigated area (about 5 million ha.), could be added to the area used for fish culture at present, mainly by the extension of the methods of fish culture between two rice crops and paddy-cum-fish culture. Mechanical tillage of the soil might become important in this respect.

15. Procurement of fry will be among the most important problems encountered in extension. For this reason *Puntius* and *Tilapia* might come to the fore in the near future.

16. Systematic investigations will be needed as the size of the industry increases.

17. In order to obtain a comprehensive insight into the importance of paddy fields as sources of animal protein, comprehensive statistical information should be collected.

REFERENCES

ANONYMOUS, (1943). Agriculture and pisciculture as correlative industries. *Dept. Agric. Bengal Leaflet* No. 5.

ARDIWINATA, R.O. (1952). Pemeliharaan Tambakan. *Pemeliharaan Ikan*, Seri I.

— (1952). Pemeliharaan Tawes. *Pemeliharaan Ikan*, Seri II.

— (1953). Pemeliharaan Gurame. *Pemeliharaan, Ikan*, Seri III.

— (1953). Pemeliharaan Ikan Mas. *Pemeliharaan Ikan*, Seri IV.

— (1954). Pemeliharaan Ikan Mas disawah. *Pemeliharaan Ikan*, Seri V.

BERNARD, C.H. (1908-1909). *Protococcacees et Desmisdiees.*

BIE, H. de (1909). *De teelt van Zoetwatervis in de Preanger—Regentschappen.*

BUDIRACHMATO, R. Udi (1955). Pemeliharaan Mudjair disawah.

BUSCHKIEL, A.L. (1938). Stoffwechsel im tropischen Teich, Fischereibiologisch betrachtet. *Archiv fur Hydrobiologie*, **16.**

CHACKO, P.I. and S.V. Ganapati (1952). Fish culture in paddy fields. *Ind. Com.*

CHEN, Thung-Pai (1953). The culture of *Tilapia* in rice paddies in Taiwan. *Chinese American Joint. Comm. on Rural Recons. Fish. Series.* No. 2.

DJAMHUR, R, (1954). *Pemeliharaan Ikan disawah di sekitar Tjiandjur dan Sukabumi.*

FRITSCH, F.E. (1907). Fresh-water algal flora of Ceylon. *Proc. Linn. Soc. London*, Series B, Vol. 44.

GOOR, G.A.W. van de (1952). Rice Cultivation in Indonesia. *F.A.O. Inland Fisheries Training Centre Bogor, Indonesia.*

HICKLING, C.F. (1951). Fish raising in paddi fields. *Corona* 2.

HIYAMA, (1951). Rice Paddy carp culture in Japan. *Prec. U.N. Sci. Corp. Conser.* **7**: 124-126.

HOFSTEDE, A.E. (1951). The development of *Anopheles* larvae on rice fields during a combined cultivation of rice and fish. *Landbouw*, **23.**

— and R.O. Ardiwinata (1950). Compiling statistical data on fish culture in irrigated rice fields in West Java. *Landbouw*, **22.**

HOEKS, (1955). *De rentabiliteit van "ikan mas" of andere karpersoorten op sawahs in de Preanger als mede vergelikingen tussen de rentabiliteit der vrucht wisselingen, paddi—vis. padi—palawidja—padi.*

HORA, S.L. (1943). Paddy cultivation cum fish culture. *Curr. Sci.* (Bangalore), **12** 169-172.

— (1943). Paddy cultivation and fish culture. *Indian Farming*, (Delhi), **4**: 232-233.

— (1944). Paddy cultivation cum fish culture, Calcutta.

— (1951). Fish culture in rice fields. *Curr. Sci. (Bangalore)*, **20** (7): 171-173.

IYENGAR, H.D.R. (1953). Paddy-cum fish culture. *Ind. J. Vet. Sci. Anim. Husb.* **23** (4): 289-297.

JANSEN, A. (1953). Angket Pemeliharaan ikan. *Pemberitahuan kilat Balai Penjelidikan Perikanaan Darat*, No. **II.**

MARTONO, (1952). *Ikan mas di Tjiandjur* (Laporan perdjalanan).

— (1952). Sekitar soal² pemeliharaan ikan di Bodjongloa (Bandung). (Laporan perdjalanan).

OVEN, A. Vaas van (1951). Zoetwater wormen. *Penggemar Alam Th.*, **34** (1-2).

— (1951). *Limnologie.*

SAANIN, H. (1955). Pemeliharaan ikan mas (karper) disawah di Djepang. *Berita Perikanan* Th. **7** (2).

— (1954). *Kuntji untuk determinasi ikan. Djilid I, II.*

SACHLAN, M. and Zahir (1942). *Pemeriksaan Fauna & Flora di sawah.*

SCHELTEMA, A.M.P.A. (1923). De ontleding van het inlandsch landbouwbedrijf. Mededeelinger van de Afd. *Landbouw*, **6.**

— (1923). Deelbouw in Nederlandsch Indie. Mededeeling van de Afd. *Landbouw*, **18.**

SMALT, T.H. (1939). *Periodieke drooglegging van sawahs ter bestrijding van Malaria.*

SOEHARDI, (1952). *Sekitar soal pemeliharaan ikan di Tjisaat (Sukabumi). (Laporan perdjalanan).*

— and Martono (1952). *Sekitar pemeliharaan ikan mas didistrik Garut. (Laporan perdjalanan).*

— (1952). *Sekitar pemeliharaan ikan di Tasikmalaja.* (Laporan perdjalanan).

SOETIJO, (1939). *Tournee verslag Tjiandjur.*

SOONG MIN KONG, (1954). Fish culture in paddy fiields in the federation of Malaya. *FAO Int. Rice Comm. 4th Session, Tokyo.*

SOEWADI, R. (1955). *Pemeliharaan Nilem di daerah Ranau.*

VAAS, K.F. (1951). Selaput Merah dan hidjau pada permukaan air kolam. *Berita Perikanan,* **12.**

— (1947). *Biologist inventarisatie van de Binnenvisserij in Indonesie.*

VROON, L.J. (1934/1935). Het dessalandbouwonderwijs in Priangan. *Landbouw,* **5.**

WILDE, A. (1911). *Neytzell de. De visserij & visteelt. Een en ander onder de Welvaarts toestand der Bevolking.*

WOLOSZYNSKA, (1912). Das Phytoplankton einiger javanischer Seen mit Bericksichtigung des Sawa-Plankton. *Bull. Intern. de l'Academie des Sciences de Gracevie,* Serie B.

WUNDER, W. (1949). *Fortschrittliche Karpfenteschwirtschaft,* Stuttgart.

— (1943). Rice fields to be used for fish cultivation in Bulgaria. *Rice J.* **46** (11).

APPENDIX I Data on fish culture along with rice.

Form of culture	Stock				Period (day)	Yield					Expenses		Income (Rp.)	Further information
	Number	Length (cm.)	Total weight (kg.)	Price (Rps.)		Number	Length (cm.)	Total weight (kg.)	% Loss	Value (Rps.)	Labour and Material (Rps.)	Rent of Field (Rp.)		
Common carp Raising of fry														Sukabumi. One family operates about ½ ha. Growing lasts until 1st weeding.
1st period (Sometimes)	60,000	1-2	6	200	21	80,000	3-5	60	50	600	20	—	380	
2nd period	10,000	3-5	20	200	25	5,000	8-11	50	50	400	20	—	180	
2nd period	40,000	1-2	4	120	21	20,000	3-5	50	50	400	20	—	260	Tjiandjur
2nd period	80,000	1-2	8	100	21	25,000	3-5	50	60	400	20	100	182	Singaparna
Raising of fry														Wanaradja. (East part of West Java). Paddy weeded only once, 30 days after planting.
1st period	15,000	2-3	8	75	25	10,000	5-8	50	30	400	20	—	305	
2nd period	2,000	5-8	10	80	60	1,500	12-15	70 ca.	20	420	40	—	300	
	or					2,000								
	1,500	8-11	15	120	60	1,200	14-17	70 ca.	15	420	40	—	260	
Consumption fish	1,500	5-8	7	75	60	860	13-20	70	40	420	20	—	325	Jogjakarta. Stocking after final weeding.
	2,000	5-8	8	100	60	1,400	14-20	85	30	510	20	—	390	
	2,500	5-8	10	125	60	1,450	12-22	90	40	540	20	—	395	
	3,000	5-8	12	150	60	1,600	14-20	84	45	566	20	—	396	
TAWES Raising of fry	100,000	½-1	6	200	25	60,000	2-3	45	40	600	20	100	280	Singaparna (Tasikmalaja), until 1st weeding only. Purwokorto, (mixed culture) until 1st weeding only.
Consumption fish (Carp and Tawes)	2,000	2-3	2	20	30	1,000	10-13	25	50	100	20	—	70	
	1,000	1-2	½	10	30	504	8-11	5	49	200	20	—	70	
Consumption fish	1,500	5-8	4	45	60	930	12-20	48	40	240	20	—	175	Jogjakarta. Stocked until final weeding.
	2,000	5-8	6	60	60	1,100	12-20	65	45	325	20	—	245	
	2,500	5-8	7	75	60	2,000	12-20	60	25	300	20	—	205	
	3,000	5-8	11	90	60	1,200	11-22	52	60	260	20	—	150	
Consumption fish [Carp (c) and Tawes (T)]	(C) 500	5-8	2	20	60	450	19-23	48	10	258	20	—	353	
	(T) 500	5-8	1	15	60	480	12-20	30	4	150				
	(C) 750	5-8	3	30	60	450	16-26	70	40	350	20	—	422	
	(T) 750	5-8	2	22	60	600	12-19	36	20	144				
	(C) 1,000	5-8	4	40	60	750	14-12	35	25	275	20	—	329	
	(T) 1,000	5-8	3	30	60	800	12-12	36	20	144				
	(C) 1,500	5-8	6	60	60	900	13-20	53	40	275	20	—	280	
	(T) 1,500	5-8	6	45	45	750	11-18	26	50	130				

APPENDIX I. Continued

TILAPIA 1st crop	2,000	4-7	6	86	35	27,000 fry 648 ad.	8-7 10-12	60 18	—	195 (39 ad.	20	—		Circular moat 35×20 cm., farm yard, manure on alternate days. Fields near villages 5 periods of fish culture after planting of rice. Height of Water 3 cm. Mechanical weeding after 25 days, stocking of fish follows. At 2nd weeding (40 days) part of the crop is gathered. Then field drained for 2 days.
2nd crop					50 (15 after 1st period	14,000 fry 756 ad.	8-7 10-12	88 21		1,256 thou- sand fry	20	—	1,355	
3rd crop					20 (20 after 2nd period	31,000	8-7	32			20			
1st crop	2,000	8-12	40	200	21	1,524	12-24	72	20	360	20	—	140	25 days after planting fields weeded for 1st time, fish remain in moat, field then flooded to 7 cm. Variety of rice: Tjina. Field manured 3 days with horse manure once a day. Stocking as above. Depth of water in central part, 3cm. at first. Later increased to 5-7 cm. 4 conveniences constructed, and horse manure on alternate days. Irrigation water passes village. Circularmoat 35 cm. wide 20 cm. deep.
At 2nd cropping					20	42;000	8-7	84	—	504	20	—	484 624	

APPENDIX II Data on Fish culture by Penjelang, Second Crop Method.

Form of culture	Stock				Period (days)	Yield					Expenses: Labour and material (Rp.)	Income (Rp.)	Further information
	Number	Length (cm.)	Total weight (kg.)	Price (Rp.)		Number	Lenght (cm.)	Total weight (kg.)	Loss (%)	Value (Rp.)			
COMMON CARP													Sukabumi: Labour costs include work on field. Field once hoed or ploughed and once harrowed. Depth of water 5-10 cm.
Raising of Fry													
1st period	80,000	1-2	8	150	21-28	25,000	3-5	Ca70	Ca. 70	600	50	400	
2nd period	60,000	1-2	6	100	21-28	20,000	3-5	60	70	500	20	380	Field weeded again after 2nd period.
Raising of fry 1st period	40,000	2-3	20	200	21-28	16,000	3-8	70	60	600	20	380	Tjiamojur area: Depth of water 20 cm. Soil not tilled, straw knocked down, moat dug and dykes strengthened.
2nd period	3,000	5-8	10	120	30	2,200	10-14	60	25	420	20	280	Field hoed before stocking.
Other ways: Raising of fry													Field hoed twice and harrowed, vegetation worked under. Depth of water 20 cm.
1st period	5,000	3-5	10	100	40	3,500	8-12	60	30	420	20	280	
	3,000	4-8	12	120	40	2,400	12-14	60	20	420	20	280	Field hoed once before stocking.
2nd period	45,000-60,000	1-2	5	100	30	18,000-24,000	3-5	50-60	60	500	20	380	
Raising of fry 1st period	30,000	1-2	6	100	30	15,000	5-8	54	50	450	20	330	East of Garut: Fields ploughed or hoed once and harrowed. Depth of water 5 cm.
2nd period	2,000	5-8	8	80	40	15,000	12-14	60 Ca.	30	360	20	260	Depth of water 10 cm. Fry from 1st period.
or	1,500	8-11	15	100	40	1,200	14-16	60 Ca.	20	360	20	240	

APPENDIX II (continued)

Raising of fry	80,000 plus 400	1-2 5-8	8 1	100 12	28 28	24,000 320	3-5 8-12	60 4	70 20	360 40	20 (Rent 100)	140 40	Singaparna:
TAWES Raising of fry	120,000- 150,000	1	10	200- 250	25	80,000- 100,000	2-3	40	40	600- 750	20 (Rent 100)	280- 380	Singaparna: Fry of 1 cm. counted in saucers of 8,000 fry. Fry of 2-3 cm. counted in bowls of 2,000 fry.
Raising of fry	20,000	2-3	20	150	30	15,000	3-5	45	25	375	15	210	Purwokerto: Field once hoed and harrowed.
TILAPIA Raising of fry	15,000	3-3 3-3	30	180	30	24,000 900	3-9 10-12	— 24	— —	308 125	20	233	Singaparna: Field ploughed and harrowed. Fry. 50-60 days. Crop fish of 8 cm. Fry excluded. Depth of water 10 cm.
NILEM	300,000 plus 3,000 Carp	Ca. 5-8	5 14	200 60	40 —	90,000 2,000	2-3 10-14	90 40	70 30	750 200	320 —	230 200	Expenses of cropping Rps. 20. Fodder-bran added daily, repair of dykes, 10 ponds Rps. 100. Manured with vegetation 5,000 kg.= Rp. 200.

APPENDIX III. Second Crop Method

Form of Culture	Stock				Period (days)	Yield					Expenses		Income of operator (Rp.)
	Number	Length (cm.)	Weight (kg.)	Price (Rp.)		Number	Length (cm.)	Weight (kg.)	Loss %	Value of Crop	Labour and Material	Rent (Rp.)	
A. Fry Raising I	4,000	8-11	40	400	40	3,200	15-18	200	20	1,400	430	250	320
Fry Raising II	4,500	5-8	35	350	40	2,900	12-16	220	25-30	1,500	70	250	870
Fry Raising III	3,500	8-11	35	280	40	2,900	15-18	180	25	1,080	125	250	435
B. Fry Raising I	2,000	8-11	20	200	50	1,600	14-16	130	20	840	310	150	250
Fry Raisin II	2,500	8-11	25	250	50	2,000	14-16	160	20	1,050	70	150	650
	100		10	70									
	90		2.7	169									
C. Fry Raising I	1,500	12-15	30	300	90	1,300	20-25	200	15	1,300	325	100	775
or	1,500	12-15	30	200	120	1,200	25-30	240	20	1,680	325	100	1,055
al													

Details of Expenses	First Period			Second period		Third Period
	A	B	C	A	B	A
Construction & Repair of Dykes (Rp. 15 p.c., p.d.)	300	180	225			
Cutting of straw (Rp. 10 p.c., p.d.)	80	30	50	50	50	75
Cropping (Rp. 10 pc., p.d.)	20	20	20	20	20	30
Material	30	30	30			20
Total	430	310	325	70	70	125

Notes: (a) Field Area A. ca 0.5 ha. B. 1 ha. C. 2 ha.
Water depth 30 cm. 30-50 cm. 30-80 cm.
(b) During the third period, the price of fry drops to Rp, 6 per kg.

APPENDIX III Contd. Data on fish culture by Second Crop Method (Alternative Systems)

Form of Culture	Stock				Period (days)	Yield					Expenses		Income of operator (Rp.)
	Number	Length (cm.)	Weight (kg.)	Price (Rp.)		Number	Length (cm.)	Weight (kg.)	Loss (%)	Value of Crop	Labour and Material	Rent (Rp.)	
D. Fry Raising	60,000	1-2	9	210	20-30	30,000	4-6	120	50	750	485	—	215
Fry Raising (A) I	80,000	1-2	12	280	20-30	40,000	4-6	160	50	1,000	—	—	465
Fry Raising II	80,000	1-2	12	280	20-30	40,000	4-6	160	50	750/1,000	10	—	530/710
Fry Raising III	40,000	1-2	6	140		20,000	4-5	80	50	500	85		275
	50,000	1-2	7.5	175	30	25,000	4-6	120	50	625			185
plus consumption fish	300	12-14	90	63		240	16-20	86	20	252			189
Fry Raising IV	40,000	1-2	6	140	30	20,000	3-5	70	50	400	—	—	260
plus consumption fish	400	12-14	12	84	30	320	16-20	40	20	280	—	—	196
or/Fry Raising III (a)	4-5,000	5-8	24-30	240-250	40	2,800	12-14	100/125	30	875	95		270/525
or/Fry Raising IV (a)	4-5,000	5-8	24-30	240-250	40	2,400-3,000	12-14	84 105	40	588 735	20		328 415
E. Fry Raising I plus consumption fish	20,000 100	3-5 16-20	40 10	600 70	40	14,000 98	10-14 20-24	210 25	ca 30 ca 2	1,750 175	450	300	525
Fry Raising II	20,000	3-5	40	600	40	15,000	9-12	220	ca 25	1,800	70	300	1,040
	100	16-20	10	70		98	20-24	40	ca 2	280			
Fry Raising III	15,000	3-5	20-30	375	40	9,000	8-11	70	ca 35	1,125	310	150	290

* Stock of 15-21 days

Note: One farmer operates 2 ponds of 0.5 ha. each, depth of water 15-20 cm. The owner operates the ponds himself and the expenses of cropping are paid by the buyer.

Fry raising continues into Third Period, if high prices are expected; if not, consumption fish are grown during third and fourth periods.

APPENDIX IV (a) Effects of fish culture along with rice on the yield of rice.

Locality: Buahbatu, Bandung. Soil: Bandung Clay. Variety of Rice: Back Planting distance: 25×25 cm.

No. of Field	Yield (a) (kg.)	wet weight (kg.)	dry weight (kg.)	Rice (kg.)	Bran (kg.)	Stalks (kg.)	No. of Field	Yield (a) (kg.)	wet weight (kg.)	dry weight (kg.)	Rice (kg.)	Bran (kg.)	Stalks (kg.)
3	149.0	35.0	25.8	15.9	8.5	1.4	4	149.0	36.0	25.0	15.2	8.3	1.5
5	133.9	34.4	20.4	11.2	7.9	1.3	6	124.9	31.2	23.8	13.5	8.5	1.8
8	145.4	36.3	23.6	14.0	8.1	1.5	7 (c)	152.9	38.2	26.5	14.6	10.3	1.6
9	127.9	31.9	22.9	13.5	8.0	1.4	10	152.4	38.1	26.1	16.2	8.2	1.7
11	138.6	33.9	23.6	13.6	8.5	1.5	12	155.4	38.8	25.7	14.5	9.4	1.8
14	153.4	38.3	26.0	16.4	8.0	1.6	13	136.9	34.2	25.9	14.9	9.5	1.5
15	133.4	33.3	23.3	14.3	7.1	1.6	16	164.4	41.1	27.8	17.8	8.2	1.8
17	100.9	25.2	19.0	11.1	6.8	1.1	18 (b)	130.9	32.7	26.5	16.1	8.8	1.6
20 (b)	136.9	34.2	22.5	12.3	8.5	1.7	19	141.4	35.3	23.3	13.5	8.3	1.4
25	144.5	35.0	26.4	16.0	8.9	1.5	24	148.0	32.0	25.0	16.5	6.9	1.6
27	160.6	41.0	29.0	17.6	9.9	1.5	26	170.0	42.0	31.5	19.9	9.9	1.7
29 (c)	151.9	37.9	24.5	12.6	10.2	1.7	28	144.6	36.1	26.0	15.0	9.0	2.0
31	151.6	37.9	28.5	17.6	9.3	1.6	30	138.6	34.6	26.5	16.4	8.6	1.5
32	129.6	32.4	25.0	14.0	9.5	1.5	33	136.6	34.1	24.5	15.5	7.7	1.3
34 (c)	172.9	43.2	34.5	18.5	13.4	2.6	35 (c)	132.5	33.2	23.4	11.5	10.0	1.8
36	158.6	39.6	29.8	18.8	9.2	1.8	37	154.4	38.6	26.8	16.8	8.4	1.6
38	146.4	36.6	28.1	17.9	8.7	1.5	39	118.9	29.7	23.7	15.0	7.3	1.4
40	168.9	42.2	29.1	17.2	9.9	2.0	41 (c)	168.4	42.1	26.7	12.8	11.9	2.0
		648.3	461.7	272.5	160.4	28.8			658.0	464.6	275.7	159.3	29.6

(a) Calculated, per 200 sq. m. stalked paddy

(b) Damaged by mice

(c) Yield reduced due to lodging

APPENDIX IV (b). Effects of culture of Common carp along with rice on the yield of rice (1955).

Location	Jogjakarta		Blitar I (Djiwut)		Blitar II (Pagergunung)		Malang (Bululawang)		Lampung I		Lampung II	
Soil	Alkaline volcanic lixiviate		Brown lixiviate		Brown lixiviate		Volcanic lixviate		Red lixiviate		Red lixiviate	
Variety of rice	Sigadis		Bongawan		Bongawan		Gadjah rawe		Sidjéro		Tjere?	
Planting distance (cm.)	30 × 20		24 × 24		23 × 23		20 × 20		?		?	
Number of seedlings	3		2		4		2		?		?	
Manuring (after planting)	—		—		—		—		1 q./ha. double super-phosphate		1 q./ha. double super-phospate	
Age of rice (Days)												
1st weeding	26		26		26		40		37		30	
2nd weeding	58		—		—		—		80		60	
Age of rice when fish stocked	A —	B 30	A —	B 38	A —	B 50	A —	B 42	A —	B 10	A —	B 15
Average number shoots after tillering	14	13	2	2	1.3	1.2	2	2	21	21	21	20
Yield of rice*												
wet weight (kg.)	120.50	119.50	166.20	143.20	99.50	103.20	163.5	160.0	248.2	186.1	239.2	209.4
dry weight (kg.)	105.00	104.40	141.60	122.00	85.00	87.90	124.1	121.8	189.4	134.6	200.1	197.9
rice (kg.)	3.20	3.15	3.76	3.78	4.13	4.19	2.9	3.0	3.8	3.6	2.6	2.7
bran & stalks (kg.)	2.80	2.85	2.34	2.22	1.87	3.81	3.1	3.0	2.2	2.4	3.4	3.3
Breakage (%)	77.00	74.50	30.00	27.00	59.00	57.00	84.0	83.0	73.0	77.0	68.0	73.5

*Per 300 sq.m. A. Without fish B. With fish