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CHINESE SYSTEMS OF POND STOCKING

by

S. Y. Lin[1]

The basic principle of the Chinese system of stocking ponds for fish culture is to accomplish the full utilization of the space and food available in the pond. On the basis of this principle the system has evolved of stocking various species of carps which live on different types of food and dwell in different layers of water in the same pond. The practice of introducing more than two species of fishes in a pond for cultivation is common in many countries but the idea of associating numerous species in definite proportions seems to be a unique feature of Chinese pond culture. The fishes used are:

1. The grass carp, *Ctenopharyngodon idellus* (Cuv. & Val.), an upper layer dweller and chiefly herbivorous in feeding habit.
2. The black carp, *Mylopharyngodon piceus* (Richardson), a snail and shell-fish feeder.
3. The big head, *Aristichthys nobilis* (Richardson), a macroplankton feeder.
4. The silver carp, *Hypophthalmichthys molitrix* (Cuv. & Val.), an omni-plankton feeder.
5. The mud carp, *Cirrhina molitorella* (Cuv. & Val.), a bottom feeder on worms and small particles of organic origin.
6. The common carp, *Cyprinus carpio* Linnaeus, an omnivorous feeder and bottom scavenger.
7. The bream, *Parabramis pekinensis* (Basilewsky), an omnivorous feeder.
8. The grey mullet, *Mugil cephalus* (Linnaeus), feeding on small particles of cereal and organic matter.
9. The milk-fish, *Chanos chanos* (Forskal), an algae and soft-vegetable feeder.

By means of various systems of stocking, a high production is achieved. But in this connection the fact that all the Chinese ponds are heavily fertilized with manure and the fish are regularly fed with organic matter of both animal and vegetable origin cannot be overlooked. In the silk-producing areas the fish are fed with oil cakes, silk-worm waste, grass, kitchen waste, cereals, etc., at least twice a day, although many canals and field ponds in the low-lying lands are not provided with regular artificial feeding.

Stock spacing.—The conception that 5.6 cubic metres or 4.5 square metres in surface area of water should be given to a carp to raise it to marketable size does not hold true in the Chinese practices. As is indicated in the following tables, when carps are raised for market, the fish farmers usually stock their ponds with 5,250 to 12,200 fingerlings of various sizes per hectare, so that the space allowed per fish is very small, being 1.3 to 3.3 cubic metres or 0.94 to 2.0 square metres. An extreme condition of intensive stocking is shown in the brackish-water ponds of Hong Kong (Table 11). Because of the cheap and abundant supply of grey mullet fry, the brackish-water pond in Hong Kong is stocked with exceedingly great numbers, so that this pond contains as many as 30,700 fish per hectare. In the case of total survival, therefore, there would be only 0.32 square metres of water area available per fish. To relieve the fish from a condition of overcrowding (and to provide them with more space and favourable conditions for growth) after 3 or 4 months part of the stock is fished out once every day or twice a week for market; the larger mullet over 150 grammes in weight are selected for sale, while the smaller ones are returned to the pond for further rearing.

The fish farmer in Malaya practises an entirely different system of stocking; he first rears the young fry about 40 mm long for a few months until they grow to 350–500 grammes in weight and then introduces these fish into the stocking pond at the rate of only 645 to 1,120 fish per hectare, i.e., one fish occupying 9 to 15.5 square metres of area of water, about 130 cm deep, which is a great contrast to the 0.94 to 2.0 square metres per fish in the ponds of South China.

KIANGSU AND CHEKIANG AREA

The characteristic feature of the ponds in the low-lying lands of Kiangsu and Chekiang is their depth, ranging from 2 to 7 metres. As is shown in the following tables, the black carp is more important than the grass carp in pond culture in this area on account of its high market value, and the mud carp is not available because of the cold climate.

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[1] Fish Culturist, F.A.O. Expanded Technical Assistance Programme.

Pond snails as food for the black carp are easily obtained from neighbouring canals and rivers. The general belief in this district that grass carp and black carp cannot be grown together on account of their similar feeding habits and roaming nature is more imagination than truth because the black carp feeds chiefly on shellfish, especially the pond snails, while the grass carp is mainly a vegetarian, although it will, when hungry, devour food of both animal and vegetable origin.

It is, however, to some extent true that both the grass carp and the black carp are active fish, roaming everywhere in the pond, and they will interfere with each other in movement when a large number of them are present in the same pond. Both the black carp and the grass carp succumb easily to bacterial diseases such as intestinal inflamation, dysentery, gill rot, etc., and cannot tolerate foul water so well as do other species. The mortality rate of these two species in congested ponds is always high; the fish farmer, learning through experience, is prepared to recognize the almost inevitable result that 50% of his 2,000 or more original stock of black carp or grass carp per hectare will have disappeared at the time of harvest, and it is

Table 1

Typical stocking systems in the Kiangsu and Chekiang low-lying areas (Hung 1946 and She 1946).

Species	Length of fish-fry in mm	Number of fish per hectare of pond with average depth of water 2½ metres		
Systems		A	B	C
Black carp ..	250-350	1,000	2,000	2,400
Grass carp ..	200-300		2,000	
Silver carp ..	150-200	3,000	3,000	2,400
Big-head ..	150-200	600	1,600	
Common carp ..	150-200	200	200	1,200
Bream ..	120-150	500	500	
Black carp ..	150-180	2,000	200	
		7,300	9,500	6,000
Approximate m^3 of water for a fish:		3.4	2.6	4.1
Approximate m^2 of water for a fish:		1.3	1.0	1.6

According to Chn, Chang, and Tsui (1934) the stocking systems generally used in Ling Hu, Chekiang for ponds 3 to 7 metres in depth are as follows:

Table 2

Other stocking systems in Chekiang.

Species	Wt. of an individual fish yearling (gms)	Number of fish per hectare		
Systems		D	E	F
Big-head and Silver carp ..	500	4,500	4,500	9,000
Grass carp ..	500	600		3,000[1]
Black carp ..	500		450	
Common carp ..	200	200	200	200
Total ..		5,300	5,150	12,200

[1] In many cases 3,000 black carp are used instead of the grass carp.

probable that this fact accounts for the practice of not stocking large numbers of the two species together in one pond.

The fish farmer here believes that the presence of the common carp is necessary in every pond as it acts as a scavenger due to its omnivorous feeding habits and serves as a " protector " of the pond, but that it is not advisable to stock too many in a pond lest it hamper the growth of other species. In other localities, where common grass is available in sufficient quantity, the grass carp is used as a principal species.

Table 3 compiled from data given by C. S. Chen (1935), Liu (1935) and Hung (1946) shows the growth rate of the various carps in the ponds of the Yangtze delta area. First year fish are actually two years old as the fingerlings available for stocking—measuring over 150 mm long and weighing over 200 grammes—originate from the river fry of the previous year. The relationship between the number of fish introduced into the pond, the productivity and mortality, can be calculated according to the general stocking formula, taking into account that the artificial food supplied to the fish has been incorporated into the natural productivity. This productivity may vary from 2,000 to 5,000 kgs per hectare per annum or an average of 3,500 kgs, the total initial weight of the fish being 200 kgs and the average increase per fish 500 gms.

If n = the number of fish to be stocked,
p = average eventual weight increase per fish,
p_1 = initial weight of fish introduced,
p_2 = gross productivity weight, and
V = mortality,

Then
$$n = \frac{p_2 - p_1 + V}{p}$$
$$= \frac{3500 - 200 + V}{0.5}$$
$$= 6600 + V$$

Thus, if 7,300 fish yearlings were introduced into the pond, the mortality in this case would be $7,300 - 6,600 = 700$ or 10.6%

In such a case it is the general practice to stock around 7,000 fish per hectare in order to produce fish of the desired marketable size. The smaller the number of fish put in the pond, the bigger they will grow during the season.

Based on the data of Tables 1 and 3 the possible production can be calculated as shown in Table 4. (Mortality is not included in this calculation).

If all the conditions under which a pond is managed are ideal it is possible to have 3,863 kg and 4,815 kg/ha/annum for ponds A and B, respectively, in the lower Yangtze area, although in practice production varies according to individual management and the actual condition of the pond.

Black carp stocking.—The black carp is highly esteemed as a food fish in the lower Yangtze regions and its cultivation is extensive. There are many ponds that are mainly devoted to black carp cultivation. As this carp is very sensitive to heat and will suffer heavy mortality in congested and foul waters, it is not raised in association with a large number of other species. Actually, many fish farmers prefer to stock their pond with black carp alone, although they are not so productive in comparison with those stocked with a combination of species. Nevertheless, the chance of serious loss is comparatively slight if the black carp is raised alone. Tables 5, 6 and 7 represent some common practices employed in Tinghai, Shaoshing, and Chekiang. Liu (1935) also mentions similar stocking in his " Practical Fish Culture ".

The mortality in the first year varies from 10 to 20%, so that the gross production figure is roughly 3,000 kgs per year ; the actual net increase in total weight should of course be 3,000 less 254 kgs (the

Table 3

Growth rate of carps in Yangtze River Region in grammes.

Species	First year		Second Year		Third Year	
	Total wt. per fish	Net increase per fish	Total wt. per fish	Net increase per fish	Total wt. per fish	Net increase per fish
Black carp ..	600	550	2,750	2,250	5,000	2,750
Grass carp ..	600	560	2,000	1,400	4,000	2,000
Silver carp ..	750	700	1,500	750	3,000	1,500
Big-head ..	750	700	1,500	750	3,000	1,500
Bream ..	375	340	750	385	..	..
Common carp ..	400	350	750	350	1,500	1,150

Table 4

Calculated production of Kiangsu and Chekiang ponds.

Species	No. of fish	Increase in wt. in first yr. (gms)	Calculated production (kgs)
Pond A			
Black carp ..	1,000	550	550
Silver carp ..	3,000	700	2,100
Big-head ..	600	700	420
Common carp ..	200	340	68
Bream ..	500	250	125
Black carp ..	2,000	300	600
Total ..	7,300		3,863
Pond B			
Grass carp ..	2,000	550	1,100
Silver carp ..	3,000	700	2,100
Big-head ..	1,600	700	1,120
Common carp ..	200	340	68
Bream ..	500	250	125
Black carp ..	200	300	60
Total ..	7,500		4,573

Table 5

Stocking system for first year rearing in ponds 130-150 cm deep.

Species	Initial wt. per fish in gms	Age	No. of fingerlings per hectare	Wt. per fish in gms after 1 yr. rearing	Total wt. of fishes calculated in kgs
Black carp ..	35	3 to 9 months	6,000	500	3,000
Silver carp ..	40		400	600	240
Big-head ..	40		400	600	240
Common carp ..	30		400	350	140
Total ..			7,200		3,620

Table 6

Stocking system for second year rearing, depth of pond 2 metres.

Species	Initial wt. per fish (yearlings) in gms	age	No. of yearlings per hectare	Wt. per fish in gms after 1 yr. rearing	Calculated total wt. of fish in kgs
Black carp ..	500	15 to 21 months	1,300	2,750	3,575.0
Silver carp ..	600		100	1,500	150.0
Big-head ..	600		80	2,000	160.0
Common carp ..	350		50	750	37.5
Total ..			1,530		3,922.5

Table 7

Stocking system for third year rearing, depth of pond 2½ to 3m.

Species	Initial wt. per fish (yearlings) in gms	age	No. of yearlings per hectare	Wt. per fish in grams after 1 yr. rearing	Calculated total wt. of fishes in kg
Black carp ..	2,750	27	240	5,000	1,200
Silver carp ..	600	to	400	1,500	600
Big-head ..	600	33	300	2,000	600
Common carp ..	350	months	200	750	150
Total ..			1,140		2,550

total initial weight of the fish), or 2,746 kgs. The fish at this stage are usually kept as yearlings for the second year rearing in deeper ponds, and the system of stocking shown in Table 6 is used.

If the mortality in the second year is 10%, the total calculated yield is 3,530[1] kgs and there is usually no mortality in the third year. As the initial total weight of fish in the second and third year ponds are 775.5 kgs and 1,150 kgs, respectively, we have then: 3,530-775.5 equals 2,754.5 kgs being production in the second year, and 2,550-1,150 equals 1,400 kgs production in the third year.

The second year, in which yearlings of 350 to 500 grams are used as stock, is the most profitable, as its theoretical yield comes to 3,922.5 kgs/ha/annum against 3,620 kgs of the first year and only 2,550 kgs of the third year. The same holds true in the actual increase of weight, for we have 2,754 kgs in the second and 1,400 kgs in the third year. No attempt is made to rear black carp for the fourth year.

WEST RIVER REGION

This area includes most provinces of South China and Tonkin. Examples taken for discussion here are based mainly on actual pond management in Kwangyung and Kwangsi, especially the Delta Region. The most prominent feature of pond culture practice in South China has been the growing importance of grass carp, the decrease in importance of the black carp and the introduction of mud carp into pond associations. As the black carp grows better in the temperate zone than in sub-tropical or tropical areas, it is no longer an important cultivated fish in Taiwan, Fukien, Kwangtung and regions farther South. As the climate becomes hot, there is a higher incidence of disease, resulting in increased mortality; the grass carp and the mud carp, on the other hand, grow better in warm waters and the fertile land of South China supports considerable quantities of grass to feed the grass carp while the temperature in winter is not low enough to kill the mud carp, which is very hardy and can be widely acclimatized in warm water ponds.

The systems of stocking adult fish in ponds in South China do not, however, differ in general principle from those of the lower Yangtze regions. As shown in Table 8 the grass carp, the silver carp or the mud carp are the three most important species in the pond associations. Either the grass carp, the silver carp or the mud carp constitutes 25 to 40% of the total yield of the pond; the other species, though essential to production, are introduced to utilize all the available space and to clean up surplus food.

In analyzing the conditions under which each system works we find that the fish farmers' practical management stands on substantial ground. For example, in Table 8 pond A is located in the silk production area of the Canton delta, where common grass and aquatic plants are easily collected to feed the fish; in addition, the silkworm faeces and remnants of mulberry leaves constitute a nutritious diet for the grass carp. The bottom soil is fertile since it receives organic and inorganic nutrients from the surrounding watersheds, and thus the pond is capable of supporting a large number of mud carp. The common carp reared in these ponds is useful as a scavenger when present in small numbers. However, it will disturb the balance of the pond if a large number is stocked. The black carp will devour most of the snails and mussels occurring in the pond. These are the essential conditions under which the systems for pond A and B have been developed, but a fish farmer may alter the systems to meet particular local requirements.

[1] 3,922.5 — 392.25 = 3,530.25

Moderately deep ponds.—When a pond is of considerable depth and has good water bloom, and common grass is difficult to obtain, systems C and D are usually practised because the plankton (produced in the pond both naturally and through regular addition of fertilizers) will support the normal growth of the large number of silver carp and big-head and the mud carp and common carp at the same time are able to find enough food in such fertile ponds. This type of stocking is common in the thickly populated Canton delta area. Stocking systems E and F are suitable for deeper ponds with plenty of water supply.

Now, based on the information given by fish farmers in the Canton delta area concerning the average rate of growth of various carps, it is interesting to figure out how far these actual systems of stocking agree with the general principle. First let us examine pond F (Tables 8 and 9) which represents one of the most productive of the delta ponds in South China.

Under optimum conditions, the mortality would have been 25% to 50% as claimed by the fish farmer, but as a matter of fact ponds belonging to this category are few. A production of 6,000 kgs a year is considered very high but is by no means impossible since grass carp and silver carp are harvested twice a year (in July and January) thus giving more space for the rest of the grass carp and other fishes to grow faster in the fall.

Table 8

Six systems of stocking the ponds in South China (Lin. 1940).

Length of young fish in mm	No. of fishes per hectare of pond with average depth of 1½m			No. of fishes per hectare of pond with average depth of 2m		
Species	Pond A	Pond B	Pond C	Pond D	Pond E	Pond F
Grass carp .. 60-150	1,200	1,200	600	480	1,200	2,400
Silver carp .. 100	300	240	600	1,200	1,800	400
Big-head .. 100	300	240	1,200	510	1,800	400
Mud carp 75	1,800	4,800	..	2,400	3,600	7,200
Common carp .. 50	1,200	360	3,600	..	1,200	300
Black carp .. 50-100	100	24	120	60	..	150
Bream .. 75	..	..	..	600	..	..
Total	4,900	6,864	6,120	5,250	9,600	10,850
Approx. M^3 of water per fish ..	3.0	2.2	2.4	2.8	2.0	1.9
Approx. M^2 of water per fish ..	2.0	1.5	1.6	2.0	1.0	.94
Average annual production in kg. ..	2,500 to 5,000				6,000	

Table 9

Production of Pond F (one hectare).

Species	No. of fish	Total initial wt. (kg)	6-month & annual increase of wt. per fish (gr)	Total wt. of each species (kg)	Actual annual production as claimed by fish farmer (kg)
Grass carp	2,400	70			
	(800)		1,500	1,200	
	1,600		2,000	3,200	2,200[1]
Big-head ..	400	50	2,000	800	800
Silver carp	400	50	2,000	800	800
Mud carp ..	7,200	144	200	1,440	1,440
Common carp ..	300	..	1,250	375	360
Black carp ..	150	20	2,500	375	360
Total ..	10,850	334		8,190	5,960

[1] The Grass carp have 50% mortality.

Let us take 5,960 − 334 kg equals 5,626 kg as P the production of the pond (with artificial feeding) and 8,190 − 334 equals 7,856 kg as the theoretical total increase in weight; then each fish would have an increase p of approximately 700 gms per year. Thus:

$$n = \frac{P}{p} \text{ plus } V = \frac{5,626}{.700} \text{ plus } 25\% = 10,000 \text{ fish.}$$

This is quite close to the actual figure (10,850) per hectare used by the fish farmer. Of course when accurate data are available each species has to be calculated separately and feeding factors worked-out in order to arrive at somewhat more precise stocking figures.

Shallow ponds.—Ponds with water less than one metre in depth must be stocked with small numbers of fishes and are therefore not so productive as the deeper ones. By comparing Tables 8 and 10 we see that rich deep ponds with water of two metres or more can accommodate more than 10,000 yearlings and produce more than 5,000 kg/ha/annum. Shallow ponds are stocked with 3,200 to 3,600 fingerlings or yearlings and produce not more than 200 kg/ha/annum. As the water in those shallow ponds is hot during the summer months, they are not suitable for stocking with mud carp and black carp. The other carps are introduced during February and March and harvested in August to October. The fish in excess of 500 gms in weight are then marketed and the smaller ones transferred to deeper and larger ponds for further rearing. It is a general practice that when a pond becomes shallow through long period of silting, the soft bottom mud is removed and placed on the wide embankments where mulberry trees or vegetables are grown.

STOCKING SYSTEMS IN HONG KONG

The fish farmers of Hong Kong have demonstrated how brackish-water ponds can be successfully utilized for intensive fish culture on a commercial scale. Although the supply of fresh-water is inadequate in this area, they have managed to preserve rain water for continuous use through the dry winter season (Lin, 1940 and 1949).

In several coastal districts of Kwangtung, Fukien and Taiwan, and also in Japan, Hawaii and the Philippines, large tidal pools are sometimes enclosed by constructing dykes, in which a gate is built to permit the entry of brackish water at flood tide. During certain seasons the fry of the grey mullet together with the young of the sea bass, sea bream, sea perch, milkfish, etc., are carried into the enclosed area by the rising tide. When the tide begins to run out the gate is closed, so as to retain all the fish fry, the most desirable of which are, of course, the grey mullet. In some cases such foods as wheat and rice bran are used to feed the fish in captivity in order to accelerate growth, but many fish farmers prefer to let them thrive on such natural foods as are produced in the pond. The fish farmer who uses this crude method of fish farming seldom expects a good harvest of grey mullet because no precautions are taken to exclude or destroy the predatory sea bass and sea perch which devour most of the grey mullet.

Table 10

Systems of stocking and production of shallow pond with water less than 60 cm in average depth (Hoffmann, 1934).

Species	Initial wt. per fish (grams)	No. of yearlings	Pond A (one hectare) wt. of fish of 6-8 months (kg)	Total wt. of each species (kg)
Grass carp ..	50	240	1.000	240
Silver carp ..	40	1,200	0.800	960
Big-head ..	100	120	1.200	144
Common carp ..	0.5	1,680	0.200	336
Total ..		3,240		1,680
			Pond B (one hectare)	
Grass carp ..	50	480	.600	288
Silver carp ..	20	972	.600	583
Big-head ..	150	240	.800	193
Common carp ..	0.4	972	.150	146
		2,664		1,210

In about 1928 a wealthy and enterprising fish farmer of the New Territories began to improve the conditions under which grey mullet were cultured; better ponds were constructed for maintaining the water in the enclosed area at a lower salinity than that in the bay. In addition, the fry of the grey mullet is not merely carried into the pond with the tide but is supplied from a reliable source and the fish farmer is always sure, therefore, that only the right kind of mullet fry is present. Experiments have also been made in rearing the grey mullet in association with fresh-water fish.

Although many facts remain to be elucidated, the results so far obtained are exceedingly encouraging. The proper stocking of ponds is still one of the fundamental problems in pond culture and its solution will require time and patience and much practical research. After many years of experience, the owner of one of the largest fish farms in the New Territories recently discovered that the following association proved fairly satisfactory: grass carp (2-4 inches) 2,500 to 3,000; silver carp and big-head (3 inches) 5,000; mud carp (about 2 inches) 30,000 to 40,000; common carp (2 inches) 20,000; grey mullet (1 to 1¾ inches) 50,000 to 80,000; and bream (2 inches) 300 or less. In other ponds one or two of these species are absent and the number of grey mullet may be increased accordingly, but in all cases the grey mullet must be the most numerous species in the brackish-water pond.

However, as is indicated in Table 11, the farmer does not as a rule follow any hard and fast stocking method. The number of fish which it may be decided to introduce depends to a great extent on personal experience, knowledge of the ponds and the availability of spawn. When in same particular year mullet spawn is abundant, it might happen that a farmer might decide to stock his ponds with twice as many grey mullet as another in the same district, in which case he would introduce less grass carp and mud carp.

To avoid overcrowding, the grey mullet must be thinned out daily as soon as they reach a size above 5 inches and this process usually commences in June. The fish are rather sensitive to the reduction of the oxygen content of the water during hot weather, when there may be high mortality from suffocation if this gradual removal does not take place; more space is also made available for the proper growth of the remaining fish. The freshwater carps are hardier fishes than the grey mullet and they can be left in the ponds with safety. To ensure uniform growth, it is desirable to stock a pond with fry of uniform size. When the fish have been reared in a pond for four months or longer some of them will have grown faster than others; it then becomes necessary to collect them by means of a large seine and to pick out the larger specimens either for sale or for transfer to other ponds which are either not yet stocked or which contain fish of about the same size. This gives a chance to both the smaller fish left in the original ponds and the larger ones in the new ponds to grow faster. Another method is to catch every day with a cast net, retaining the larger specimens for market and returning the smaller ones to the pond.

Table 11

Three systems of stocking adopted in the brackish-water ponds in Hong Kong (Lin, 1940).

Species	Length of fry in mm	Average number of fish per hectare of pond with water from 1 to 2½ metres in depth		
		Farm A	**Farm B**	**Farm C**
Grey mullet	25-45	12,000	27,360	15,000
Grass carp	50-100	1,524	300	700
Silver carp	75	2,208	2,568	600
Big-head	75	1,536	624	600
Mud carp	50	9,600	3,120	9,000
Common carp	50	..	..	4,800
Bream	50	..	..	..
Total	..	26,868	33,972	30,700
Approx. M^2 of water surface for a fish	..	.38	.30	.32
Average annual production in kg per ha.	..	2,434	1,872	..

Table 12

Two systems of stocking as practised by farmers A and B in the New Territories.

Kinds of fish	Farm A		Farm B	
	Total No. of fish in 7 ponds (14 ha)	Approx. No. of fish per ha	Total No. of fish in 9 ponds (20.7 ha)	Approx. No. of fish per ha
Grey mullet	178,500	12,750	565,065	27,297
Grass carp	21,600	1,543	1,645	80
Silver carp	31,266	2,233	53,264	2,568
Big-head	21,756	1,554	13,195	624
Mud carp	136,645	9,760	65,455	3,120
Total ..	389,767	27,840	698,624	33,689

MALAYA AND THAILAND

As Chinese carps are among the principal fish reared in ponds in Malaya and Thailand, the general rule for stocking is similar to that practised in China. However, some modifications have been introduced to suit local conditions.

The most outstanding features are: (1) less fish are stocked in a pond and (2) the grass carp becomes the most important species in ponds. Common carp fry are obtained locally but the grass carp, the silver carp and the big-head must be imported from China; the growth rate of the mud carp is too slow to compensate the expense of bringing the spawn from China to Singapore or Bangkok. Moreover, because of the high cost of transportation the fish farmer in Malaya can only afford to purchase a limited quantity of spawn. The common grass relished by the grass carp is, however, abundant everywhere, and by taking advantage of the consistently warm climate, the grass carp are thinly stocked in association with silver carp and the big-head, and are heavily fed with grass. As a result the fish grow very rapidly and two crops of marketable fish may be harvested in a year.

Table 13 shows the four systems of stocking with variations depending on the availability of the fish fry.

Table 13

Systems of stocking Chinese carps in Malaya and Thailand.

No. of fish per hectare of pond with water 1.2—1.5 metres deep).

Species	Wt. of young fish in gms	Pond 1	Pond 2	Pond 3	Pond 4
Grass carp ..	350-600	300	320	375	500
Big-head ..	,,	100	120	75	175
Silver carp ..	,,	100	125	75	200
Common carp ..	30-60	145	150	120	250
Total ..		645	715	645	1,120
Approx. M^3 of water per fish..		20.1	18.1	20.1	13.3
Approx. M^2 of water area per fish ..		15.5	14.0	15.5	9.0

A study of the production of ponds in Malaya as compared with the stocking system is most interesting. The Malayan fish farmers claim that their ponds produce from 2,000 to 2,500 kg of fish per hectare per annum. In theory the yield of the pond is quite close to the figures shown in Table 14 obtained by multiplying the number of fish stocked by the increase of weight during the period of rearing.

Table 14

Production per hectare of the Malayan ponds stocked according to the system adopted for pond 3.

Species	(a) Av. wt. of young fish (gms)	(b) No. of fish stocked	(c) Estimated wt. of fish after 5 months (gms)	(d) Total yield c × b kg	(e) Total increase in weight (d—a × b kg)
Grass carp	500	375	1,800	675	487.5
Big-head	500	75	3,000	225	187.5
Silver carp	500	75	2,400	180	142.5
Common carp	40	120	400	48	43.2
Total ..	..	645		1,128	860.7

The total weight of the young fishes is 267.3 kg (d—e) and the total increase in weight after 5 months is, in round figures, 860 kg a year.

The fish farmer at Singapore, not being satisfied with this yield, has developed another stocking system which has increased production considerably. Instead of rearing the fish to 500 grammes in a nursery pond for a period of about 3 months, he allows the fingerlings to grow in the nursery for 8 months where they attain 1,500-2,000 grammes in weight and the fish are then placed in fattening ponds for another 6 months. Table 15 shows that such a pond can produce 2,652 kg per hectare in 14 months or 2,273 kg per hectare per year. Here the productivity of the rearing pond, which is about 2,825 kg per hectare per 8 months, is higher than that of the fattening pond and it would therefore have been more profitable on a tonnage basis to sell the fish at this stage, but unfortunately the market requirement is for bigger fish, and the fish farmer has to raise them further in order to fetch higher prices even at some sacrifice in production per hectare.

Progressive methods of fish stocking—In order to avoid unnecessary losses due to predatory fishes, frogs, snakes and insects and to provide equal feeding opportunities, it is a general practice to raise fish of about the same size in a pond. It is also advisable to use ponds of different depth and area for the production of the various stages; this procedure has several economical and technical advantages which can be summarized as follows:

Table 15

Stock figures and production per hectare of Malayan ponds.

Species	Rearing pond stocking			Adult pond stocking		
	Wt. of each fingerling (gms)	No. of fish stocked	Growth per fish after 8 months (gms)	No. of fish stocked	Growth per fish after 8 months (gms)	Total yield (kgs)
Grass carp ..	30	1,250	1,500	450	3,000	1,350
Big-head ..	40	250	2,000	150	4,000	600
Silver carp ..	40	250	1,800	175	3,500	612
Common carp ..	30			225	400	90
Total		1,750		1,000		2,652

(1) as small fishes do not need large and deep ponds as do larger fishes, it is imperative to grade them according to size as far as possible; (2) small fish require more care than larger ones and if they are kept in small ponds the enemies can more easily be kept away, the water more easily controlled and feeding more easily regulated; (3) the growth of the fish is enhanced by providing them with optimum conditions, which change with growth; (4) an old pond will

tend to become silted and a change will free the fishes from contaminated water and promote health in the new environment; and (5) the fish may be counted and weighed as they are transferred from one pond to another.

The application of the progressive method of stocking to augment the yield of a group of ponds by a Singapore fish-farmer provides an excellent example to illustrate the above points (Figure 1). The farmer owns a total of approximately 3.9 hectares of water area, which is divided into 6 separate ponds, the biggest measuring approximately 1.4 hectares, two others 8,000 sq. m each, one of 5,000 sq. m and two of 2,000 sq. m each. All of them receive good water supply. The two smallest ponds, A and B with a depth of 60 and 75cm respectively, are used for rearing fingerlings or yearlings and the rest are fattening adult ponds averaging 1.3 metres in depth.

The farmer buys a thousand spawn of about 50 mm length (500 to 700 grass carp, 150 big-head and 150 silver carp) from a nurseryman who imported them from China. They are placed in pond A for rearing for a period of a month; at the end of this period, as all the fish have grown to about 150 mm and about 30 to 40 gms each, they are caught with a seine, about 600 of the largest ones are selected for introduction into the second rearing pond B and the rest are left in the original pond. They are then allowed to grow for 50 to 90 days or longer until they attain 350 to 600 gms in weight. During these rearing days, the fry are fed intensively with rice bran, duckweed, peanut cake and later, in the second rearing pond, also with tender common grass. At the end of the second rearing period these yearlings are ready for transfer to the fattening ponds.

The fish farmers in China apply this method with some modifications, but in many cases they prefer a selective marketing method to increase production. The brackish-water ponds in Hong Kong are a good example. Also, in the deltaic regions of China, carp of different ages are reared in different ponds; some of the Shun Tak fish farmers harvest their ponds twice a year by selecting those which have reached a marketable size for sale at the middle of the year and transferring the remaining smaller ones to another pond for further rearing, stocking of the first pond commencing anew at this stage.

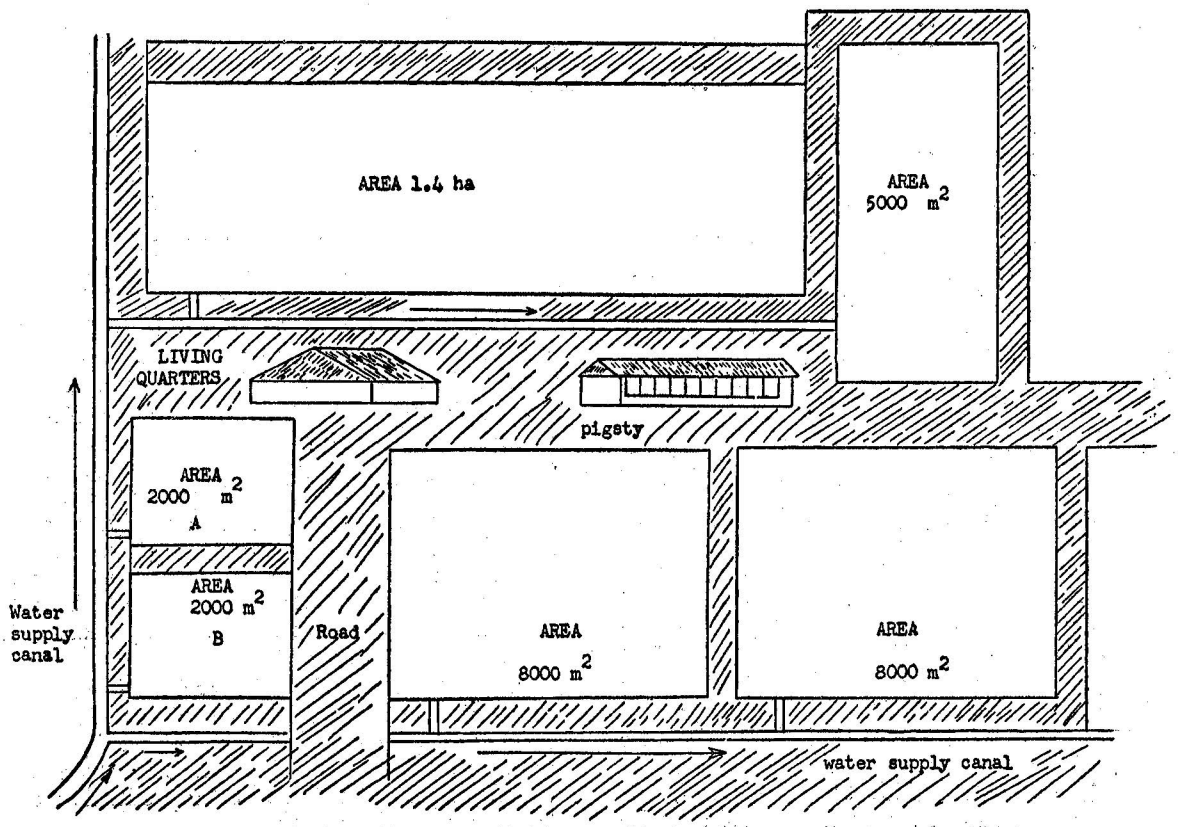

Figure 1—A diagram showing the arrangement of ponds in a fish farm in Singapore.

MILKFISH IN TAIWAN

According to Sasaki (1943) the Taiwan milkfish pond is highly productive; 4,000 fry of the previous year are introduced to one hectare of pond and reared from April to June or July and the fish are allowed to grow to about 300 gms each when they are then harvested and marketed. Meanwhile the same pond has been stocked with subsidiary new fry collected from the sea in May or June which are reared until November of the same year, attaining about 150 gms, at which weight they are suitable for sale as bait for the tuna fisheries. In this manner of management one hectare of pond with 2 stockings and 2 harvestings can produce more than 1,200 kg of fish a year.

Chen (1952) summarises the system of stocking milkfish in Taiwan ponds as is shown in Table 16.

Table 16

Stocking figures of one hectare of Taiwan milkfish ponds.

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

The 3,000 yearlings 6 to 11 cm long which were collected the year before and kept in the winter pond are introduced into one hectare of production pond in March or April. They are then reared for three months to reach a size about 300 gms and are ready for market. In April when new young fry are collected from the sea about 5,000 fish are added to the pond, and again in June when the older fish have been harvested, another 3,000 to 4,000 young fry are introduced, making a total of not more than 9,000 fish in the pond. Three months later, *i.e* in September or October, about 5,000 larger fish of about 150 gms weight are removed and sold, and the remaining 3,000 to 4,000 smaller ones will be kept in the winter ponds for next year's stocking. Most of the production ponds in Taiwan are drained and kept dry for some months in winter, so as to increase the productivity of the pond.

Besides being reared separately in brackish-water ponds, milkfish are also grown in freshwater ponds in Taiwan in association with the grass carp, the common carp, the silver carp, the big-head and the mud carp, but there appears to be no definite stocking system which has been generally adopted by the fish farmers. According to the Kangshan Fish Culture Cooperative and Chen (1952), some milkfish ponds in Taiwan may produce as much as 2,000 kg per hectare per annum.

SUMMARY

1. In raising fish for food the Chinese system of stocking appears to be very economical and efficient and at the same time provides various types of fish for market.

2. The different species of the carp family so far as known give the most satisfactory association in ponds although such fishes of other families as grey mullet, milkfish etc. are also used in slightly brackish-water ponds.

3. Among the 9 kinds of fish introduced into ponds in association in China, the grass carp, because of its feeding habit, appears to be the universally dominant one, although the black carp is important in some farms in the lower Yangtze delta area and the silver carp in the West River delta area.

4. Having learned through long years of experience and tradition the Chinese fish farmer adopts different systems of pond stocking in accordance with (1) the climate, (2) fertility of the pond, (3) condition of water supply, (4) availability of fish fry, (5) availability of feeding stuff, (6) depth of the pond, (7) market demand and (8) size of the fish used for stocking. All these important factors for pond stocking need further explanation and discussion later.

5. Better production of a pond has been actually achieved through the practice of adopting proper systems of stocking and selective catching. The practice of proper stocking and selective catching is also responsive for the better production of the Taiwan milkfish ponds.

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