A World-Wide Approach To Fish Culture Improvement

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IT IS GENERALLY ACCEPTED that some kind of rudimentary fishing methods were known even to nomadic peoples. Certainly, fish was a well-known source of food in the earliest civilizations.

Not only have ancient fishing implements of good design been discovered, but also these activities were rather precisely recorded in such documents as the Mayan mural in the warriors' temple at Chichen-itza (Morley, 1956) or the Egyptian one dating from around 2500 B.C. found at Giza (Chimitz, 1957b) showing fishes which are easily recognizable as mullets, catfish and

characids still in the water, while two beautiful specimens impaled on the fisherman's harpoon are as clearly identifiable as *Lates niloticus*, the Nile Perch, and *Tilapia nilotica*.

Somewhat later the idea developed first of holding and then of raising fish in ponds. Another bas-relief from Egypt (Chimitz, 1957b) shows fishes clearly recognizable as Tilapia being caught by rod and line in a well-designed pond, some time before 2000 B.C.

Much clearer indications of rational methods for the cultivation of common carp are given by Fan Li (475 B.C.) in his "Practice of Fish Culture," while methods of collecting fish fry from rivers is described by Shi-ma (140-88 B.C.) and there are actual records of fish fry collecting and transportation in 1243 and 1639 A.D. (Lin, 1949).

Asia

The Tambak type of pond, developed in Indonesia, is also relatively ancient and is mentioned in the Javanese Law Code promulgated around 1400. Over 60 per cent of the fish consumed in Java are from these flooded areas, as is easily appreciated when flying over the hundreds of miles of tambaks when traveling between Djakarta, Madura and Bali. About 200,000 acres of such artificial lakes produce about 33 million pounds of milkfish, *Chanos chanos*, each year (Schuster, 1952), with some incidental shrimp. Over the centuries, the property right of these ponds have passed from the Hindu kings through the Muslim rulers, the East India Company and the British Crown, until in 1860, the ponds were the property of the people, although a special system of supervision through the local "mantris" keeps the system alive. This is perhaps one of the most massive fish culture operations which has ever existed anywhere or at any time and it has been calculated that 500 million cubic yards of earth must have been moved by hand to give the ponds their present shape (Schuster, 1952). Chanos culture, based on the old Indonesian practice, has also been found profitable in the Philippines, Thailand and other areas of the Far East. It is perhaps not true fish culture, insomuch that the larvae produced at sea by this catadromous fish migrate to shallow brackishwater inlets and so can be systematically let in to artificial lagoons. It is surprising that similar systems are not in use in South America, since the milkfish is also found in the Eastern Pacific.

Another instance of the practice of raising fish from fry produced by wild stocks is the ancient trade which has developed, in Bengal, in the major carps of India—*Catla, Cirrhina* and *Labeo* spp. In fact, three quite separate industries support many thousands of operators: a) those who locate the migrant streams of fry and capture them in fine funnel-type nets with a cod-end and sell them to b) those who raise them from fry to fingerlings, and in turn sell them to c) those who raise these to marketable size (Job, 1951).

Again, in China several carps which are not known to spawn in captivity are captured as fry and raised in ponds, the most important being the big-head, *Aristichthys nobilis;* the silver carp, *Hypophthalmichthys molitrix;* the mud carp, *Cirrhina molitorella;* the black carp, *Mylopharyngodon piceus*, and that interesting fish, the grass carp, *Mylopharyngodon idellus*, which is the most effective eater of hard cellulose plants known and hence most useful, in combination with other fishes, in keeping the ponds free from weeds. Although until recently the grass carp was only known to spawn in the rivers of the

Canton area in China, and stubbornly resisted transplantation, recent reports indicate that it may have established itself in Japan, and it is being used in the U.S.S.R., although there is no indication that the Russian workers have successfully spawned it.

Several other species are used in the Asian systems—the minor carps of India, several species of catfish in Viet Nam and Cambodia, the Tawes, *Puntius javanicus*, and Nilem, *Osteochilus*, and several *gouramis* in Indonesia. Predators are not merely available and utilized, but can easily decimate a pond if measures are not taken to keep them out (the murrel or snake head, *Ophicephalus*, the bekti perch, *Lates calcarifer*, etc.).

In 1939 five small fishes were found by a Mr. Mudjair in a stream in Eastern Java and identified in the Netherlands as belonging to the genus *Tilapia*. Although the manner in which they were introduced to Java is officially stated to be unknown, there would seem to be no mystery about this, and it is fairly certain that this is just another case of an aquarist dumping his fish in the nearest stream before leaving for home.

However this may be, its propagation was encouraged by the Japanese during the occupation, and it became the fashion after World War II to talk of *Tilapia* as a "miracle fish," and for some reason, perhaps because FAO had a very active and efficient fish culturist there, much of the *Tilapia* which was disseminated throughout the world came from the King's ponds in Bangkok rather than from their native Africa. It has been our sad duty in FAO to call attention to the fact that *Tilapia mossambica*, the species which caused all this furor, is only one of the many different species of *Tilapia*, which in turn is just one of the numerous genera of the cichlid perches which are common to Africa, the Levant and the American tropics, and that the *Cichlidae* are only one relatively unimportant family among the host of freshwater fishes.

The great drawback to *Tilapia* in ponds is that, without very careful management practices which are usually not available to the rural farmer, the very combination of fecundity and precocity, which made it famous, soon gives rise to serious overproduction and stunting, which may result in failures in otherwise promising fish culture programs.

Notwithstanding the rather satisfactory understanding in Asian countries of the advantages of diversification, and the great contributions already made to pond culture practices, knowledge is confined to the local species (with the sole exception of Tilapia) and Asian fish culturists will stand to gain much more from a more universal approach, particularly when the full significance of the South American species is more apparent.

Europe

The history of fish culture in Europe is more recent, although common carp, *Cyprinus carpio*, appear to have been introduced as early as the middle ages. However, the common carp is not universally popular as a food fish and selected varieties, known as mirror carp, leather carp, etc., have been produced in Germany and Israel. Apart from trout and salmon, which warrant separate treatment, there has been no really significant cultivation of other species, although some work has been done with such fishes as tench, bream, etc.

As in many other fields, the U.S.S.R. is making considerable progress in fish culture. According to Wurtz (1960), "no type of fish pond culture has been neglected in the U.S.S.R.", and of special interest is the work of Montchan

and Martichev in the Ukraine with the Chinese grass carp—the first instance outside Japan where serious attention has been paid to this valuable plant-eating fish—combined with crucian carp, tench and bream, with yields up to 5 metric tons per hectare. The U.S.S.R. methods based on heavy fertilization and what would elsewhere be called over-stocking, are also in use in Bulgaria. At the Mydlniki and Ochaby annexes of the University of Cracow (Poland) experiments are being carried out on combinations of Polish carp breeds; whitefish, *Coregonus* and pike-perch, etc.

North America

In the United States, common carp, introduced in the middle of last century, is considered to have become a plague, principally because the demand today is for sports fish rather than species which are fast and efficient protein producers, but also because of an early policy of rough release, rather than the pond culture of its selected forms.

Considerable imagination was evident in the United States around the turn of the century, when great effort was expended in artificially producing many species of fish and crustaceans for release in the rivers, and even in the sea. These activities were dropped when later scientific investigations indicated that the amounts of fish so artificially produced did not in any way affect the wild stocks. There has been considerable emphasis on the combination of the largemouth black bass, a predator, with small sunfishes as fodder. Apart from some success with several species of catfish, it cannot be said that there has been any great diversification in warm water fish culture.

It is, however, perhaps not surprising that in two of the three countries of North America where the temperature drops to the freezing point in winter, great progress has been made in the cultivation of trout and salmon. We are not particularly concerned with the salmonids in this paper, because they do not lend themselves to combinations with other fishes, as do the species which are adapted by nature to warmer waters.

Artificial propagation of the trouts and salmons is a historically recent activity. Although Jacobi of Germany around 1741 developed the techniques which are still essentially those in use in most places today, it was not until approximately the turn of this century that great activity was to be observed in this respect. Around this time the importation of European, and later North American, salmonids became fashionable, brown and rainbow trout having been universally successful introductions into almost every country where the water is sufficiently cold at least during part of the year. Hatchery methods and planting policies remained stereotyped until about 1936, when, as a result of organized research in the U.S., new techniques such as malachite green as a fungicide began to be developed, and it is unfortunate that many countries with excellent climates for trout and salmon propagation still continue to breed and plant trout on the old, hit-or-miss lines which are a century out of date, and do not profit from the U.S. experience.

Africa

In Africa, there has since about 1924 been great activity in promoting the cultivation in farm ponds of several species of the cichlid perches of the genus *Tilapia*, and a good deal of work has been done on this group by the biologists of the ex-metropolitan powers, Belgium, France and the United Kingdom,

which will no doubt be continued and perfected by the fisheries workers of the newly independent countries of that Continent. Apart from some experimentation with the Nile perch as a predator, this author has no recent information in respect of diversification of species.

South America

It is surprising to find that, notwithstanding the very large number of tropical fishes native to South America, no indigenous fish culture practices have arisen and in most countries of the area this promising source of food has been completely neglected, principally because governments have not yet found it possible to finance and encourage fisheries investigations through the preparation of professionally trained people, there being little inducement at present to make a career of what is still an unremunerative field. Fortunately, there are signs of activity in Brazil, where some good work has been done and the results published in Portuguese. It is believed that Brazil may in the future make the greatest contributions, in the way of on-the-spot investigations on the life history and adaptability to cultivation of the two great groups of freshwater fishes, the Characidae and the Cichlidae, which will probably be the most promising source of new material.

I have not referred to the work which has been done in Brazil, Argentina and Chile on the larger silversides, *Atherinidae*. This was at one time promising but has apparently lapsed. The renewal of work on this group in the countries concerned, and also in Mexico with *Chirostoma estor*, another valuable but neglected atherinid, in combination with other fishes, would be valuable.

Central America

Little has been done in Central America, for the same reasons, but with more justification, the indigenous fauna being a rather poor overflow from that of South America. However, Guatemala, El Salvador and Honduras have for some years now had a freshwater fisheries investigation program with assistance from another FAO fish culturist as a result of which some work has been started with a little-known but encouraging cichlid, *Cichlasoma dovi*, which grows to a very large size in Lake Managua.

On the question of exotic introductions

Much has been written on this subject, and most of the literature is badly slanted against exotic introductions, with constant repetition of the harm done by such haphazard examples as the sparrow in North America and the rabbit in Australia, but forgetting the enormous benefits brought to the new world with domestic cattle and poultry, and the horse, which infinitely outweigh the harm which may have been done by the uncontrolled importation of useless or harmful species.

In the case of fishes, most of the introductions of trout and salmon have been into waters which previously held little or no economically important fauna. Importations of Black Bass to many parts of the world have been criticized, but in many cases (Colombia, Viet Nam) it is found on examination not to have survived, and in cases where it has (Guatemala) it has sometimes formed the basis of a valuable wild fishery where none existed.

The common carp is, of course, the villain of the piece, mostly because of the aversion in the United States to any freshwater fish which does not provide sport. This is, at present, not a valid argument in most countries, where cheap

and abundant protein is the main consideration, and no fish is superior to the common carp in this. However, it is true that only selected varieties should be used, and those in ponds, and that the common carp is not a sound introduction into any wild fishery.

Any species of fish can, in fact, be beneficial or noxious according to whether or not it is wisely used. There is certainly no point in loading up reservoirs with fish which, although not eatable, consume part of the available foods (Brock, 1952) *unless* they can subsequently serve as forage for a suitable predator.

It must, however, always be kept in mind that an introduction to wild waters which happens to thrive, is irreversible, and that in many cases just a handful of progenitors have produced billions of offspring — five Tilapia in Indonesia; fourteen bluegill and one hundred crabs in Hawaii (Brock, 1952) etc. On the other hand, if a species is proved after experimentation not to survive, there is usually little point in wasting effort in repeated trials. There is really no such thing as "acclimation" in fishes, although government officials (who should have known better) have made costly efforts to introduce prestige fish such as trout, and even Pacific salmon, into climates in which they could not thrive and where some other form would have been at the same time more successful and more useful.

The lack of co-ordination

The above brief information on fish culture which has been, and is being, performed in various parts of the world, is not intended to be exhaustive, and apologies are no doubt due, and are hereby offered, to many investigators whose work has not yet become generally known.

Rather has the intention been to indicate, firstly, the serious gaps in our knowledge regarding the many species of fish which will no doubt turn out to be valuable additions to the rather limited list of the domestic and domesticated animals at present used for human food, and secondly, the amazing fact that although there is much information, published and unpublished, on the fishes cultivated in different geographic areas, this fund of knowledge is put to little practical use outside the immediate place of origin, so that a very large number of permutations of compatible mixtures which would take maximum advantage of every ecological niche and produce an optimum (i.e. the most profitable) yield per unit of area, is neglected.

International co-operation

Over the last ten years, it has become part of the foreign policy of those countries which have achieved an "advanced" stage of technological development (i.e. those which have undergone a well-defined industrial revolution) to lend their technical skills to that other group of nations which used to be called "backward" but which are now more charitably known as "underdeveloped," or "in the process of development." This technical aid may be bi-lateral (from one government to another), or multi-lateral, i.e. channeled through the United Nations Specialized Agencies, the Colombo Plan, etc.

This is, in the great majority of cases, a one-way traffic, but in this peculiarly neglected field of fish culture as a source of food, there is as yet no one adequate source of knowledge whether in the East, West or South, and progress must therefore not depend on the usual presumption of superior knowledge, but rather on the painstaking compilation and comparative analysis of

practices which have been empirically developed all over the world. Furthermore, the most promising unknown sources of fish culture material are the "underdeveloped" countries, where competent biologists will contribute greatly to our knowledge, provided they have the tools to do the job!

There are, for instance, promising indications that, among the fauna which is broadly common to Africa and South America — the characids and cichlids —and of which only the systematics are known, there exist species which, to cite an example, are as efficient browsers on cellulose plants as is the Chinese grass carp, and probably much more manageable.

A solution

The shortcomings which have here been brought to light, neither for the first nor the last time, could be fairly easily remedied, the crux of the whole question being, as usual, who is to do the work, and, where do we find the money.

Certainly considerable funds would have to be invested in a) investigating the imperfectly understood life habits of many species of fish, especially in Africa and South America; b) compiling the existing knowledge, which is considerable; and, c) actual exchange of fishes between geographically distant countries for d) experimentation in sufficiently large pond areas with a view to discovering the best fishes for each ecological niche. It is, however, predictable that, given a "critical mass" of conscientious research, the return would add up to many hundred times the investment.

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