Subj: Hickling Article from Scientific American, May 1963
Date: Friday, June 29, 2001 2:29:40 PM
To: tilapiacol@yahoo.com

THIS IS A TYPED REPRODUCTION (WITHOUT ILLUSTRATIONS) OF AN ORIGINAL ARTICLE PUBLISHED IN SCIENTIFIC AMERICA IN MAY 1963. THIS IS THE ARTICLE WHICH GOT ME STARTED IN MY CAREER. REMEMBER AS YOU READ IT THAT IT IS MORE THAN 38 YEARS SINCE IT WAS WRITTEN AND MOST OF WHAT DR. HICKLING

SAYS IS STILL VERY TRUE.

THE CULTIVATION OF TILAPIA

THIS PROLIFIC FISH HAS BEEN INTRODUCED INTO MANY LESS DEVELOPED AREAS A CHEAP SOURCE OF PROTEIN-RICH HUMAN FOOD. A NEW METHOD FOR MAKING IT GROW LARGER IN PONDS MAY ENHANCE ITS USEFULNESS.

BY Charles F. Hickling

Tilapia, a fish native to the fish waters of Africa and the Jordan Valley in Asia Minor, seemed a few years ago to be destined for a major role in a 20th-century enactment of the miracle of the loaves and fishes. As anyone familiar with world food statistics knows, the hungry portion of the human population is starved for protein. The average per capita daily calorie intake of the two billion or so people who live in the less developed regions of the world comes to about 70 percent of that of the more developed countries. The corresponding "figure for animal protein consumption is about 20 percent." Even this low figure considerably understates the actual deficiency, because the limited supply of animal protein in the less developed regions is so unevenly distributed that hundreds of millions of people consume inadequate quantities of these vital tissue-building-foods day after day and year after year. It is hardly surprising that many persons and agencies concerned with the world food

problem have been inclined to welcome with enthusiasm almost any potential source of cheap abundant and palatable protein. Among the possibilities canvassed in the decade after World War II was the cultivation of Tilapia Mossambica.
This fish-a relative of the common North American sunfish that has been known in Europe as the bream or the large-mouthed kurpper and is now called the tilapia throughout its vastly extended range-seemed to meet all of the specifications cations. It feeds directly on the algae and other primary aquatic vegetation (and on the animal plankton as well) and so constitutes the terminus a two-step food chain from inorganic ions to proteins. It is resistant to disease, it grows rapidly and multiplies abundantly, and it flourishes under crowded conditions in fresh or brackish waters. Moreover, its potential habitat, restricted only by water temperature (minimum about 55 degrees Fahrenheit), coincides with the roughly defined belt of chronic human malnutrition that girdles the subtropical and tropical latitudes. Here, it was thought, was an excellent fish for cultivation in ponds. Under the auspices of international agencies such as the Food and Agriculture Organization of the United Nations through bilateral technical assistance programs, the work of local fisheries staffs and spontaneous development, Tilapia culture spread in a short time throughout Africa to the Island of Indonesia and the Philippines, to the Asiatic mainland in India, Malaya and Thailand, to the Caribbean Islands of Hispaniola and Jamaica and even to the southern US Before long however the remarkable fecundity of the tilapia-one of its most welcome qualities-revealed itself as a serious drawback. For reasons still unknown the pond-raised-fish become mature and start to breed when they are still very small: an ounce or less. As a result the waters of the pond swiftly become crowded with fish too small for marketing or even according to most cuisine's and tastes, eating. It would be fair to say that there has been some disillusionment: responsible authorities have been discouraging the overeager promotion of Tilapia culture as a panacea for protein efficiency and in some countries popular interest has waned. This is unfortunate,

because the Tilapia can still make a significant contribution to human nutrition. If Tilapia culture is regarded as a form of stock raising and conducted with corresponding care and thought it is possible to overcome the disadvantages of the animals fecundity by various stratagems and too harvest good yields. Meanwhile work in the laboratory has uncovered hybrid-line that is made up exclusively of male fish. The rearing of these fish in

"monosex" cultures promises to vindicate in part the enthusiasm that carried the Tilapia around the world a decade ago.
The cultivation of Tilapia in ponds for human food is anything but a recent innovation. The earliest known representation of fish-culture pond in history -a bas-relief from an Egyptian tomb dating from before 2000 BC shows a pair so small fish that can be identified as Tilapia nilotica, a species still abundant in the Nile Valley (see illustration below). In Egypt and the Holy Land the Tilapia has always been regarded as an important food fish: its deep, somewhat foreshortened body, with the body cavity placed well forward, yields triangular fillet of firm white flesh, of excellent flavor, from each flank.
The modern history of Tilapia culture can be said to have begun in 1939. In that year five fish of the species Tilapia Mozambique were discovered in a lagoon in Java. How these few fish made the journey from the native waters in mozambique on the East coast of Africa remains a mystery. In any case their arrival was fortunate, because from 1942 on wartime conditions had made the fry of the local milkfish unobtainable: in a remarkably short time the tilapia replaced the milk fish as the predominant pond cultured fish of Java. It was these experiences and similar successes elsewhere that brought the fish to the attention of food scientist at the end of the war.
The Tilapia easily qualifies for pond culture in terms of the first criterion of this branch of animal husbandry, which is, the weight of fish that can be grown per unit of pond surface. Sometimes called the maximum standing crop. The crop can be made several times larger by fertilizing the water: the addition of fertilizer to fishponds cause a threefold increase in primary plant production which in the water as on the land is the basis of flesh production. If the fish in a pond (especially Tilapias) are also

given supplementary fodder the maximum standing crop can still be increased in proportion to the amount and nutritive value of the fodder. In tropical countries a pond can support a much larger standing crop than in temperate regions because uniformly high temperatures promote a rapid and continuous turnover of materials in all of the biological processes involved, including the rate of growth of the fish. Ultimately the limit of growth in a Densely populated pond seems to result only from the accumulation of harmful metabolic products of the fish themselves.

Ordinarily in areas of where the culture of fish in ponds is an established art the fish are bred and raised to fingerling size in one pond and then transferred to raising pond for feeding up to optimum size. The raising pond can therefore be stocked with a known number of small fish of an aggregate weight well below that of the maximum standing crop. These fish can then be made to grow as fast as possible, both by fertilizing the pond and by foddering until the aggregate weight has increased to near that of the maximum standing crop. At this point the crop is harvested. Time as well as weight enters into the economics of fish culture. It sometimes pays to harvest considerably before the maximum standing crop is reached, because the rate of growth slows down as the limit is approached.

The species of fish usually cultured such as the common carp, do not normally breed in the raising ponds, or at least not until they have grown to a commercially acceptable size. The population of the raising pond is thus kept under control and the number of fish harvested is roughly the same as the number stocked. The gain is the increase in weight of the individual fish. The propensity of pond-reared Tilapias to start breeding at a small size and continue breeding all year round at frequent intervals, negates this well-established practice. In a pond stocked with Tilapias, the maximum standing crop is soon attained, not by the growth of the fish originally stocked but by the proliferation of thousands of fry and fingerlings. Moreover, the Tillapia's habit of mouth breeding-the female takes the fertilized eggs into her mouth and keeps the fry there for a short period after they have hatched-Undoubtedly-contriburtes-to the

high survival-rate of the young (see bottom-illustration on opposite page)-A case has been recorded of 150 adult Tilapias producing 15,000 fry in less than four months and another case is know in which 14 fish became 14,000 in only two and a half months.
Since most of the tilapia species feed by browsing on tiny algae and plankton, the adults have no competitive advantage over

the young, and their growth slows down as thousands of additional mouths come to share the food supply. Thus although the maximum standing_crop may be very high it_will_consist_largely of little "trash" fish. A well foddered two acre Tilapia pond in the Congo for example, yielded an excellent harvest of almost 8,000 pounds of fish. Of this total, however no less than 4,500 pounds were fish too small for marketing or fingerlings useful only for restocking. No more than 2,000 pounds of this big crop could be_described as "large" fish, and-even-these were only 16 to 24 centimeters in length and weighed from a quarter-pound to a half-pound each.
In many parts of the world, particularly in the Orient, small fish_are fried-and-eaten-whole, scales, fins and all, or cut up into chunks for stewing or made into fish paste. These dishes, nutritious as they undoubtedly are, cannot be pressed on other peoples. For the optimum yield of fish flesh as it is more often eaten, the Tilapia must be raised to large size. As in the case of many other animals, the head and body of a Tilapia grow at different rates; a larger fish has more edible body meat than a smaller fish. At one pound a Tilapia yields about 24 per cent of its weight as boneless fillet, whereas a very large fish weighing, say, five pounds gives as much as 50 per cent of its total weight as edible meat. As single Tilapia weighing two pounds produces more meat (twice as much) than eight Tilapias weighing a quarter-pound each.
Nevertheless, the production of even small fish on a massive scale per unit of pond area can make an important contribution to human nutrition. The peasant owner of a small Tilapia pond can have frequent fish meals for himself and his family and still harvest a sizable surplus to sell or trade. To maximize the yield he should feed the fish abundantly with whatever cheap and

readily available fodder can be had, and fish the pond intensively. In one small pond in the Congo, about a fortieth of an acre in surface area, the feeding of 1,200 pounds of ordinary household scraps combined with constant fishing, produced about 100 pounds of fish in a year- a yield equivalent to two tons per acre in that period of time.
Even the elementary measures of vigorous feeding and fishing, however are difficult to institute among many peasant peoples of Africa and Asia. The peasant-particularly the African peasant-takes little care of his livestock. He tends to treat his fish pond in the same way and seldom bothers to give the fish fodder. Since his four-footed beast have free range, he may also have no dung with which to fertilize his pond. The necessity for intensive fishing also presents a problem. Tilapias are easily caught with a hook and line, but this fishing method can be tedious. A large dragnet would be uneconomically expensive for the owner of a small pond. The use of the small casting net is unknown in much of Africa.
Larger fish can sometimes be obtained by raising them in saline water, which seems to have an inhibiting effect on breeding. Since most of the almost 100 known species of the Tilapia genus are able to tolerate a high degree of salinity, this practice is suitable for many of the brackish pond of Indonesia and elsewhere. Such a practice would be doubly advantageous because it would open to cultivation waters to saline too be used for irrigation.
Another method for raising larger fish is to stock a pond with smaller Tilapias of the same size and weight and force their growth by feeding until they began too breed. They are then harvested by the draining of the pond. This method requires a drainable pond as well as a separate breeding pool where the fingerlings are raised. Since the fish grown in this manner still mature when they are small they grow no larger than those produced in a free-breeding pond, but the method yields a higher proportion of larger fish.
Special feeding can also promote an increase in the average weight of individual fish. Leave of manioc, or cassava when fed to the two plant-eating Tilapia species-mellanopleura and Zilli-

seem to be more easily devoured by the adults tan by their young. Further study may reveal other foodstuffs That favor the growth of adults rather than fry.
Another stratagem is to stock the pond with predator fish. The predators will not only crop down the surplus fry and thereby permit better growth in the Tilapia population; they will also contribute to the variety and value of the total fish crop. The

successful stocking of the large new lakes create by dams in the Us is based on the predation of the black bass on the bluegill sunfish. In the reservoirs of Trinidad T. Mossambica may settle down into a similar adjustment with the native guabines, an efficient predatory fish. One reservoir has produced more than 6000 pounds a year of good-sized Tilapias weighting between three-quarters of a pound and two pounds each.
Several species of predatory fishes have been used for this purpose in other parts of the world. In East Africa the Nile perch, a fine sporting fish, has been tried; in the Cameron's the black bass and a fish related to the Tilapia called Hemichromis fasciatus have been stocked in tilapia ponds in Jamaica the local tarpon has served as an effective predator. Although it cannot be said that these experiments have been uniformly successful and that all of them are applicable to pond culture, the planting of a predator has produced in many instances a distinct improvement in the size and weight of the? Tilapia (see illustration o page 148) In order to keep the predator prey balance at an advantageous level, there must be frequent stocktaking. This requires draining of the pond, sorting out the fish and restocking with the right proportion of predator and prey. The technique is a sophisticated one, with plenty of room for error.
The one technique that allows reliable control of the population is that of stocking the raising pond with fingerlings of a single sex. Some species of the genus Taipei although not as yet the vegetable-feeders melanopleura or zilli, can be easily sorted into males and females. Either the colors are sufficiently differentiated to serve as reliable sex indicators or the structure of the anal papilla is used-the opening of the oviduct being distinguishable in the female and not present in the male. With

experience it is possible to sex even small immature fish with speed and confidence. Since males grow much faster than females, only the male fingerlings are stocked in the raising ponds and the females are discarded. A second check is made when the fish have grown somewhat larger and distinctive sex-coloration's are more discernible. Since this technique fails if there is a single female present in the raising pond, care must

be taken to ensure that there are no females left over from a previous stocking.
with the estimated maximum standing crop of the pond in mind, a fish culturist can stock as many male fingerlings as will produce the best crop of fish at a planned average mean weight per fish. In Jamaica and elsewhere the method has produced results that justify the extra care expense and effort. In order to supply fingerlings to small raising ponds on peasant farms it would probably be best to set up central breeding and sexing stations, either privately or publicly owned to produce male fingerlings. Considering the fine size ad weight attained by Tilapias under mono-sex culture and their considerable cash value per pound, such breeding stations could charge for the male fingerlings and make a profit if they were operated on a sufficiently large scale. The sexing of small Tilapias although feasible is tedious. In addition to being not entirely reliable. However since only the males are stocked there is a waste of female fish, accordingly my colleagues and I at the Tropical fish culture research Institute at Malaca in the Federation of Malaya set out in 1958 to breed "mules" of sterile fish by crossing two closely related but distinct sub species of T. mossambica. One was a purebred local variety of t. mossambica, descended from the original Tilapias first found in Java in 1939; the other was indigenous to brackish swamps on the island of Zanzibar off the coast of Africa. Too our surprise the hybrid fry of the Zanzibar males and the Java females all turned out to be males! When due care was taken to avoid contamination by uncovenanted fish, not a single female ever turned up among the hundreds of thousands of these crossbred fingerlings. These hybrids are fully fertile and it is necessary to take the usual precautions to exclude females from the raising ponds.

We are thus able to produce all-male populations to stock the raising ponds, with no waste of female fish and none of the trouble and risk of sexing the fingerlings. To cap these advantages, our hybrids exhibit hybrid vigor, growing twice as fast as either parent stock. Generally they grow to a weight of about one pond in six months and yield a crop of about 1,200 pounds per acre per year with no other encouragement than the fertilization of the pond with 20 to 30 pounds of triple superphosphate per acre. A combination of fertilization and foddering has not yet been tried, but even larger crops of uniformly large fish are anticipated. Attempts are now being made to cross breed other Tilapia species in order to obtain additional strains of all-male hybrids: it would be surprising if success is not achieved eventually.

Meanwhile foundation stocks of the parent lines of the first all-male hybrids are being made available by the institute in Malacca for establishment of the method elsewhere. The uniformly large fish that can be harvested promise to revive the interest of small-pond operators in many parts of the world where free breeding methods have failed. Tilapia may again be counted on to help in offsetting the protein deficiency afflicting such a high percentage of the world population.