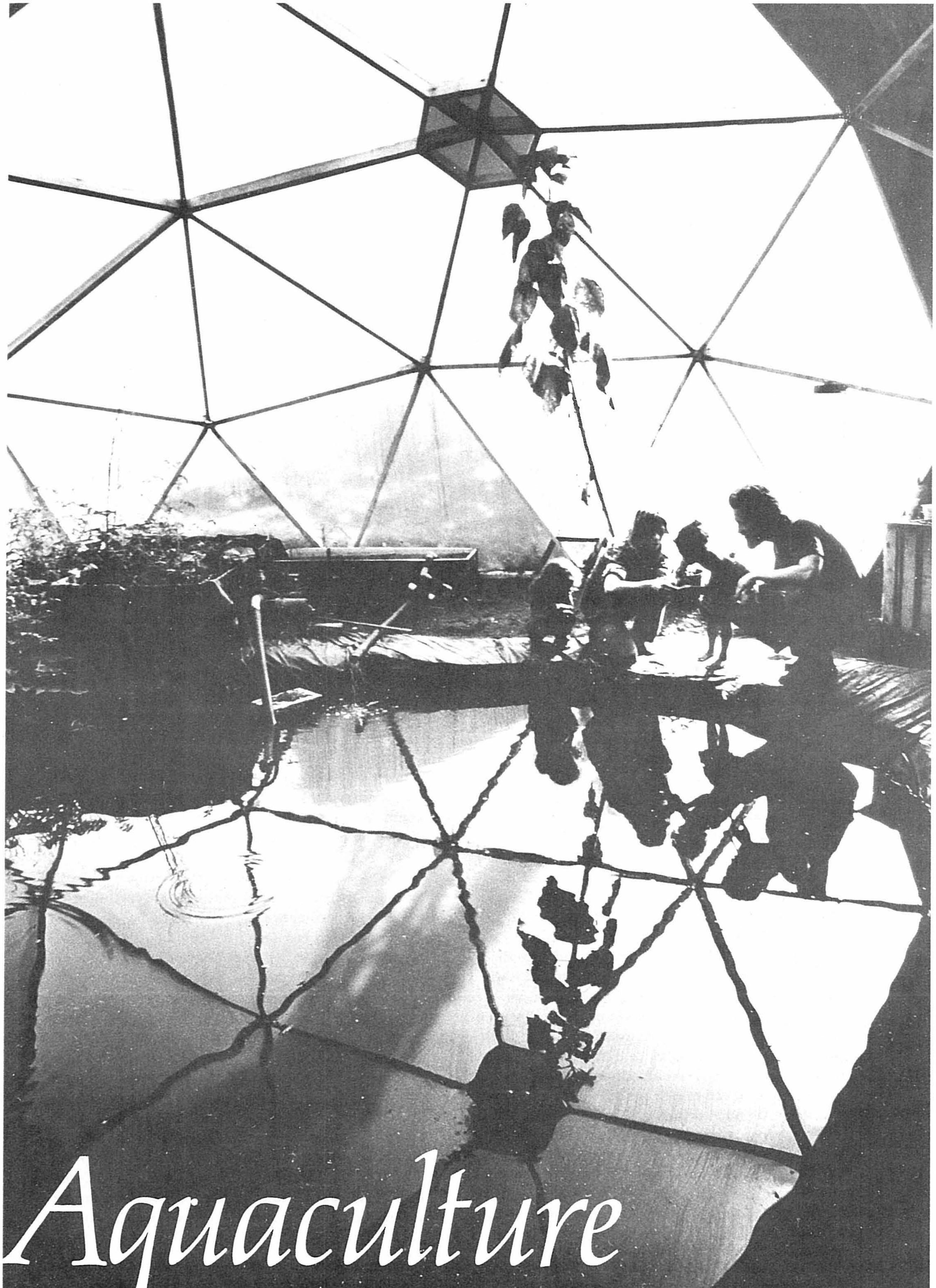
The Aquaculture section for this issue contains one paper based on a project done at the Cape Cod Center and two articles for which the work was done elsewhere. The report entitled "Midge Culture" is a scientific description of the research done by Bill McLarney, Marcus Sherman and Joe Levine on chronomid tetans or midge larvae. As this particular paper is concerned with the growth-promoting attributes of the midge larvae, a point which is not discussed at length is the prolific quantities in which Bill and Marcus have learned to grow them. An estimate of the 1974 results is that 10 square meters of pond surface could satisfy the protein requirements of some 80,000 young fish. This would seem to make midge larvae well worth considering as an economical and nutritious protein source for fish.

The second paper is a translation by Bill McLarney of a report by Professor Anibal Patiño R. of the Universidad del Valle, Cali, Colombia. Professor Patiño's work speaks for itself. I can only add that most of us have found it heartening to learn that the thinking in aquaculture in Colombia is so advanced and that its application is being so carefully considered, holding as it does the prospects of greater self-sufficiency and higher nutritional levels for small farmers throughout much of Central and South America.

The third article, although not a scientific paper, seems an appropriate follow-up to that of Professor Patiño. In many areas of the world, one of the major obstacles to aquaculture seems to be the inability of a pond, once dug, to hold on to the water. In Journal One (page 35), John Todd described the work of Russian biologists in reproducing "gley" a sort of biological plastic similar to the sub-strate of bogs which, of course, do very well at retaining water. This seemed at the time, and still does, an important breakthrough. We were anxious for corroboration of the Russian results. A fortuitous opportunity for doing so was provided by a rather muddy hole in Sarapiqui in Costa Rica, known as McLarney's Folly. It had been dug as a preliminary step to an aquaculture project. The work had not gotten underway because the pond, unobligingly, had refused to hold water. Bill and Bob Hunter decided to adapt the Russian methods. It is their efforts which are described in "A New Low-Cost Method of Sealing Pond Bottoms."

— NJT

Photo by Fritz Goro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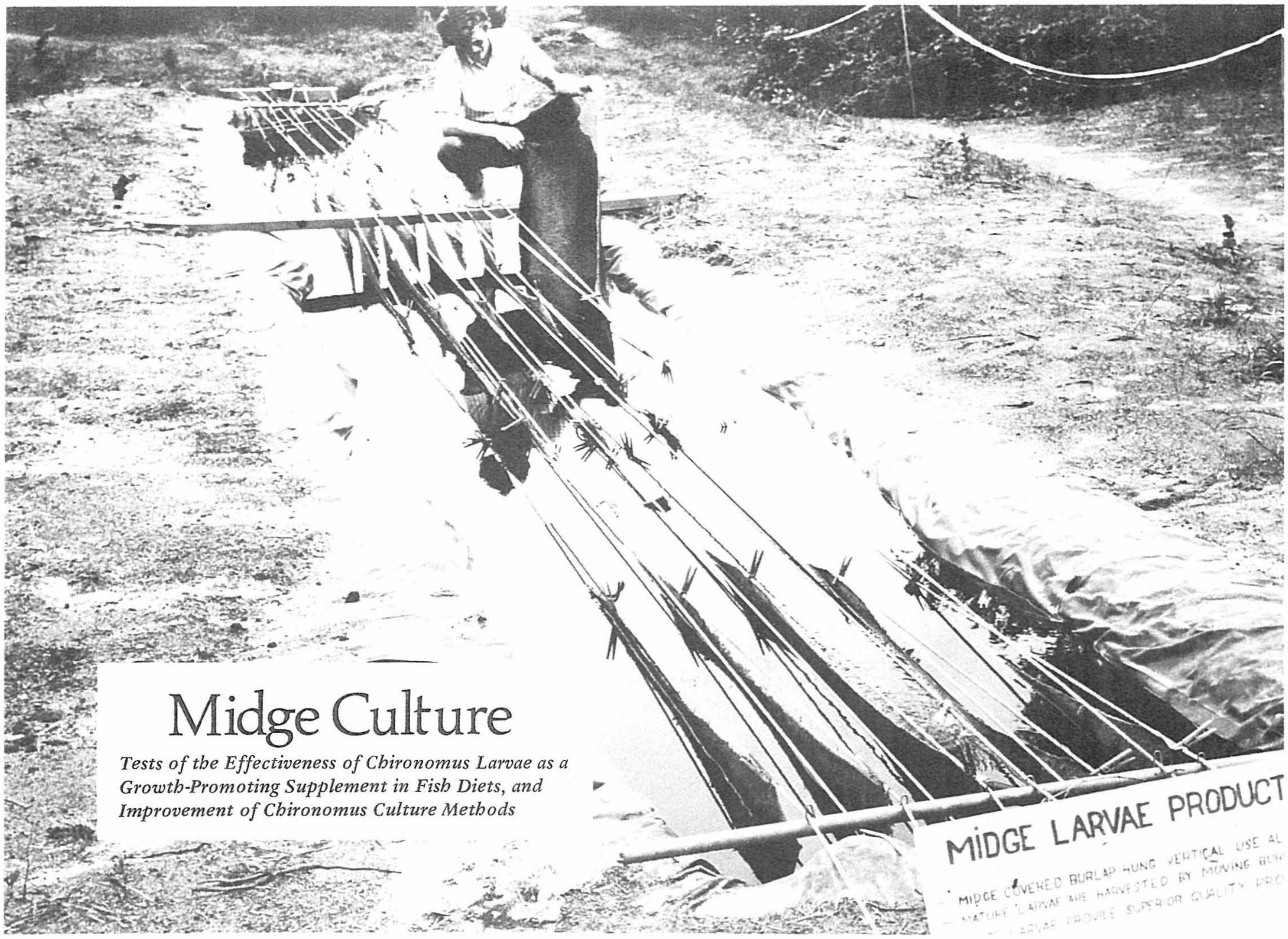


Midge Culture

Tests of the Effectiveness of Chironomus Larvae as a Growth-Promoting Supplement in Fish Diets, and Improvement of Chironomus Culture Methods

Photo by Fritz Goro

INTRODUCTION:

Our work with midge *(Chironomid)* larvae in 1974 concentrated on two areas: further improvement of culture methods and tests of the effectiveness of the larvae as a growth-promoting supplement in fish diets.

For details of the technique used in our low labor midge culture system, as developed in 1973, see McLarney, Henderson and Sherman (1974) and McLarney (1974). A major change in the culture system in 1974 was the adoption of a two stage culture system utilizing nursery ponds and growth ponds. Burlap culture substrates were first laid horizontally in small pools for natural inoculation by wild adult midges. These ponds were fertilized with a mixture of Milorganite (R), soy meal, pond mud and fine sand which settled onto the burlap to provide an optimal substrate for larval attachment and growth. After a culture of early stage larvae had developed, the burlap substrates with attached larvae were transferred to deeper ponds where they were hung vertically until the larvae grew to optimum size for fish food. Using this two stage method it appears that some improvement was made over 1973 yield rates. However, due to circulation problems in the high volume growth pools and significantly increased labor in the two stage system, we are currently doing further research with simpler methods before publishing details of an optimum cost and labor-effective midge larvae culture technique.

The feeding trials (McLarney, Levine and Sherman, in preparation) were very successful and will be reported here in some detail.

Our research has been predicated on the "hunch" of some aquaculturists that *Chironomid* larvae are not merely good fish food, but have unusual growth-promoting qualities, even when fed in very small quantities. This assumption was tested, on a pilot scale, by Yashouv (1956) and Yashouv and Ben Shachar (1967), but their samples were not large enough to provide definitive information. Our studies represent the first statistically meaningful test of the food value of midge larvae.

We tested our cultured midge larvae (*Chironomus* sp., a member of the *C. tentans* Fabricius group) on *Tilapia aurea* (Steindachner) and Israeli carp *(Cyprinus carpio* var. *specularis* Lacépède), the two major fish varieties cultured at New Alchemy East. Concurrently, Joseph Levine of the Boston University Marine Program tested our larvae as a food for juvenile American lobsters *(Homarus americanus* Milne-Edwards). *T. aurea* is generally considered to be highly herbivorous, but it has been shown that the young feed extensively on invertebrates (McBay, 1961). Israeli carp are omnivorous at all life stages, while lobsters are largely carnivorous.

FISH FEEDING TRIALS:

Methods: Both species of fish used in the experiments were housed in a series of twelve fifty-five gallon aquaria kept in a plastic greenhouse. The tanks were aerated, but filtration was not provided. Cleaning was effected by siphoning off twenty-five per cent of the water weekly and replacing it with fresh tap water; most fecal matter and other detritus was removed in this process.

Each group of fish received a standard diet composed of seventy-five per cent rolled oats and twenty-five per cent roasted soy meal. The standard diet was fed at the rate of two per cent of the total weight of fish, six days a week. As the tanks all soon developed dense green algae blooms, the fish were able to augment their diet by filter feeding. In four control tanks, the fish received no additional food. In a second group of four tanks, the fish received a supplement of midge larvae (*Chironomous* sp., a member of the *tentans* group) comprising two percent by (wet) weight of the grain diet. The final four tanks received midge larvae at the rate of ten per cent of the grain diet. Each group of fish was weighed three times at the start of the experiment, two weeks later, and four weeks later. All fish were fin-clipped so that individual, as well as group, growth rates could be determined. Data from the full four-week period of the tilapia trials and the first two-week period of the carp trials are presented here.

Test groups of fish were chosen to have approximately the same total weight of fish in each tank at the start of the experiment. In the first experiment with *T. aurea*, six fish were stocked per tank and weights of individual fish varied from 0.7 to 18.0 g; group weights were 31.1 to 48.0 g. In the second *T. aurea* experiment, only five tilapia were stocked per tank, and these fish were chosen to be more nearly uniform in size than those in the first experiment. Individual weights ranged from 1.0 to 7.3 g; group weights from 16.1 to 23.5 g. The carp trials involved six fish per tank. Total weight of groups ranged from 58.3 to 72.3 g and weight of individuals from 2.3 to 21.2 g.

Water temperatures were 22 to 33°C during the first *T. aurea* experiment, 27 to 33°C during the *T. aurea* experiment and 20 to 32°C during the carp experiment.

Results: In the first *T. aurea* experiment, there was a slight increment in growth rate with the amount of midge larvae fed, but the difference was not significant and certainly would not justify any effort to provide midge larvae for young *T. aurea.* However, if the fish are broken down into two size groups, the differences in growth rate are more striking. Since it is well known that younger fish generally have a greater need for animal food, the data for all fish weighing less than 5 g at the start of the experiment were considered separately. Among these fish, those receiving a two per cent midge larvae supplement increased their weight considerably more than those receiving no midges. Those receiving a ten per cent midge larvae supplement grew faster than those receiving a two per cent supplement, but the difference was not as great as between the fish receiving a two per cent supplement and those receiving no larvae.

It was decided to repeat the experiment using more uniform sized, smaller fish. The results are similar to those obtained with the small fish in the first experiment. Results of all the *T. aurea* trials are shown in Table 1.

For purposes of statistical analysis, growth data from the smaller fish in the first trial were combined with those from the second trial. Each set of three aquaria (those receiving 0, 2% and 10% midge supple-

TABLE 1
Feeding trials with *Tilapia aurea*

	First Trial June 1-28			*First Trial June 1-28**			*Second Trial July 5 - August 2*		
	No Midges	*2% Midges*	*10% Midges*	*No Midges*	*2% Midges*	*10% Midges*	*No Midges*	*2% Midges*	*10% Midges*
No. of Fish	24	23	24	11	9	12	20	20	20
Final Weight (grams)	236.1	241.8	235.1	53.1	43.6	69.2	144.8	149.5	151.1
Initial Weight	163.5	162.9	153.9	32.2	21.9	32.2	88.5	80.0	74.2
Gain in Four Weeks	72.6	78.9	81.2	20.9	21.7	37.0	56.3	69.5	76.9
Per Cent Gain	44.4	48.4	52.8	64.9	99.1	114.9	63.6	86.9	103.9

*Fish weighing five grams or more at start of experiment excluded.

TABLE 2

Per cent weight increments of *Tilapia aurea* in eight sets of experimental aquaria and their rank within sets.

	No Midges		*2% Midges*		*10% Midges*	
Set No.	*% Gain*	*Rank*	*% Gain*	*Rank*	*% Gain*	*Rank*
1	55.4	3	79.0	2	112.2	1
2	72.0	3	116.4	2	126.0	1
3	51.8	2	43.9	3	57.3	1
4	100.0	3	151.2	2	184.5	1
5	43.5	3	58.0	2	63.6	1
6	69.2	3	73.1	2	107.0	1
7	95.8	2	84.7	3	141.6	1
8	104.6	3	145.2	1	115.2	2
Sum of Ranks		22		17		9

ments) was considered separately and the total gain in weight of the fish in the three members of the set was ranked (Table 2). Applying the Kendall Coefficient of Concordance (Siegel, 1956) to the ranked data, s = 86, $x^2 = 10.752$ and the differences in the weight increments of the three experimental lots of fish are significant at the 1% level.

TABLE 3

Feeding trials with Israeli carp, August 12-30

	No Midges	*2% Midges*	*10% Midges*
No. of Fish	24	24	23
Final Weight	290.5	292.5	279.9
Initial Weight	260.8	252.5	241.4
Gain in Two Weeks	29.7	40.0	38.5
% Gain	11.4	15.8	15.9

Growth rate of Israeli carp in the experiment was markedly less than that of *T. aurea* (Table 3). This can probably be ascribed to the fact that the carp were very nervous and did not adapt to aquarium life as readily or as well as the tilapia. The mean weight increments for the three experimental lots of carp differed in the same manner as for the tilapia, but the difference was not significant.

The difference in growth rate between carp receiving midge larvae and the controls was greater after two weeks than at the conclusion of the experiment. The decline in growth during the latter half of the experiment may have been due to an infestation of anchor worm during that time. About half the fish were affected, and four individuals lost weight during this period.

LOBSTER TRIALS:

Methods: The lobster trials will not be described in as much detail as the fish trials, on the assumption that lobster culture is of less interest to our readers than culture of fish which are potential staple protein sources. However, the results further support the hypothesis that midge larvae are an excellent growth-promoting food. Full details of our procedures can be found in McLarney, Levine and Sherman (in preparation).

The test lobsters were juveniles, 6.0 to 6.5 mm in carapace length, and were fed a standard diet of commercially available frozen brine shrimp *(Artemia)* at the rate of 0.018 g dry weight/lobster/day. This constituted the entire diet of the controls; test animals received *Chironomus* larvae in amounts equivalent to two per cent and ten per cent by dry weight of the brine shrimp diet. Experimental feeding was continued until the animals had molted twice, and the growth increment was calculated by comparing intermolt period length, carapace length and total weight measured immediately after each molt.

Results: Lobster results are summarized in Table 4. As expected from previous work, there was no significant difference in the lengths of the intermolt periods due to large sample variance.

Increase in carapace length was noticeably higher in both experimental groups than in the control. The mean increase shows 0.5 mm increments between the experimental groups (Table 4). Weight gain and percentage weight gain, on the other hand, indicate significant differences between both groups given midges and the controls, but not between the midge-fed groups themselves.

DISCUSSION:

The results of these experiments argue for the feasibility of culturing midge larvae, using the hanging substrate method (McLarney, Henderson and Sherman, 1974; McLarney and Sherman, in preparation), as a dietary supplement for food animals. In the fish experiments, not only were *Chironomus* larvae an effective growth promoter, they appeared to be more effective with the smaller fish tested.

TABLE 4

Feeding trials with American lobsters, including significance values determined by T-test for independent samples

	Average Intermolt (days)	*Increase in Carapace Length (mm)*	*Absolute Weight Gain (gms)*	*Per cent Weight Gain*
Control (*Artemia* only)	18.6±3.2	1.0±0.4	0.05±0.0	27%±4
	NS	.05	.05	.01
	NS	.01	.01	.01
Artemia + 2% Larvae	19.3±1.5	1.5±0.3	0.18±0.10	77%±33
	NS	.05	NS	NS
Artemia + 10% Larvae	16.0±7.4	2.0±0.4	0.19±0.06	76%±25

The early life stages are at once the most critical period for the fish culturist, and the time when it is easiest to provide a relatively high percentage portion of larvae.

The difference in growth between fish receiving the ten per cent midge supplement and those receiving the two per cent supplement was in all instances less than the difference between those receiving the smaller supplement and the controls. In interpreting this data, it should be kept in mind that while rolled oats and roasted soy meal are essentially dry, eighty-six per cent of the weight of a live *C. tentans* larva is water. On a dry weight to dry weight basis, then, the rates of dietary supplementation with midge larvae in the fish experiments were 0.28 per cent and 1.40 per cent. Such a pronounced effect on growth rate from such small weights of midges suggests that we are dealing, not with the effect of increased quantity of protein, but with a vitamin or amino acid effect.

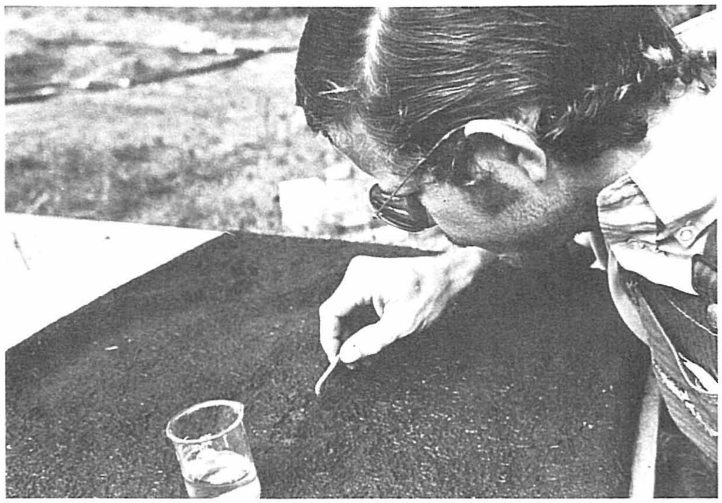
In the lobster trials, both absolute and percentage weight gain showed the same effects observed in the tilapia. The carapace length data, however, show significant differences not only between the controls and the experimental groups, but also between the two experimental groups. This apparent discrepancy can be explained by observing that carapace length alone, though a standard measurement in the literature, does not reflect possible differences in claw size and length of abdomen.

While the weights of midge larvae and frozen brine shrimp used in the lobster trials were reckoned on a dry weight - dry weight basis, the differences in growth rates of midge-fed and control lobsters are greater than one might expect. To postulate a protein or amino acid effect here does not seem satisfactory. Chemical analysis of larvae of the midge *Chironomus plumosus* and various other invertebrates cultured for use as fish foods in the U. S. S. R. (Ivleva, 1969) did not indicate that *C. plumosus* larvae differ notably from the rest, except in that *Artemia salina* do not contain Vitamin A. It should also be noted that Chironomids are unusual among invertebrates in containing large amounts of hemoglobin.

Artemia are a standard component in the diet of many cultured aquatic animals. In some cases, including some lobster cultures, they are the sole food. It has been shown recently that in such cultures, live *Artemia* are superior to frozen (Schleser and Gallagher, in preparation). No technical explanation has been advanced for this phenomenon, but it has historical precedent in the "live food mystique" of aquarists. It is possible that some nutrients are lost in the freezing process. If this were true, the addition of a small amount of live food, e. g., the midge larvae in our experiments, might provide a factor critical to the growth of cultured animals.

In the present instance the picture is further complicated by the results of studies in which lobsters were reared in the same system used in these experiments and fed on one hundred per cent live food diets. Percentage weight increment of our two experimental groups reared on frozen *Artemia* and small amounts of live midges (seventy-seven per cent ± thirty-three; seventy-six per cent ± twenty-five) did not differ significantly from that of lobsters reared on a *Ceramium - Jassa - Mytilus* association (eighty-one per cent ± twenty) (Levine, in preparation) and on high density *Capitella capitata* cultures (seventy-one per cent ± fourteen) (Mencher, in preparation).

From the results of work done to date, we cannot say whether or not there is a unique growth-promoting component or combination of components in midge larvae, or what that component or combination of components might be. We can say that midge larvae added in small quantities to standard fish and lobster diets resulted in significant enhancement of growth and that the ease of their cultivation and utilization renders them desirable for use in many forms of aquaculture.



We do not recommend midge larvae for culture as the principal food for any type of fish. There are many other good foods which can be provided more easily in bulk. As can be seen from our work, the effectiveness per weight of midge larvae is greatest when they constitute only a small proportion of the total diet. We do recommend their inclusion as a supplement in the diets of cultured fresh water and marine animals. If we assume a larval production rate of 100 g/m^2 of water surface/week (which we have attained in our best pools), then 10 m^2 of ponds could provide a two per cent supplement continually for eighty thousand young fish averaging 5 g each. If the increment in growth of the fish were comparable to that achieved in our experiments, a midge culture system would certainly be a worthwhile expenditure of time and space.

ACKNOWLEDGMENTS:

As in previous years, the midge work was done under the auspices of the Woods Hole Oceanographic Institution, and both sets of feeding trials were carried out on the Woods Hole Oceanographic Institution's premises. To offer a blanket acknowledgment of that Institution, however, would be to overlook the massive bureaucratic interference and the attitudes of certain scientists and administrators which nearly prevented our 1974 work from being carried out – a fine example of the sort of frustration which added impetus for some of us to leave "establishment" science and join forces in New Alchemy. We do wish to give special thanks to Dr. Derek Spencer of the Department of Chemistry, who was instrumental in overcoming the institutional pettiness which threatened our work. Drs. Jelle Atema and John Ryther provided facilities for the fish and lobster work, respectively. Camas Lott was especially helpful with the tedium of setting up the experiments, maintaining and weighing fish. Dr. Woolcott Smith made valuable suggestions concerning the analysis of the data.

– William O. McLarney
Joseph S. Levine
Marcus M. Sherman

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A New Low-Cost Method of Sealing Fish Pond Bottoms

In no part of the world is aquaculture less developed than in Latin America, despite its great potential there and the shortage of protein foods in much of the region. One of the constraints on the development of Latin American aquaculture has been the porosity of many of the soils – a problem which is by no means limited to Latin America. Such was the case with a 200 m^2 pond constructed in 1973 at Finca El Uno, located at Tirimbina, Provincia de Heredia, Costa Rica. Compaction of the soil alone was not enough to enable the pond to hold water. The soil at the pond site appears to contain quite a high percentage of clay, but there is a porous, sandy layer at a depth of 2-3 feet. Rainfall in the area is about 120 inches annually.

Similar problems have been solved in a variety of ways in the United States and other affluent countries. Bentonite clay is the most common sealing agent; when mixed with the pond bottom soil in the proper proportions it forms a colloidal seal. A similar effect may be achieved through the application of certain chemical salts. Many American fish farmers have lined their ponds with sheets of polyethylene, butyl rubber, and other synthetics, which are then buried. In extreme cases, small ponds may be cemented.

All the sealing methods mentioned so far share the characteristic of being expensive. This is a disadvantage anywhere, but in situations where capital is a major limiting factor, the expense can be prohibitive. We were able to circumvent this problem by applying a virtually cost-free method of sealing at Finca El Uno. The technique does not originate with us, but is of Russian origin and has not been well publicized. We became aware of it when Marsha Zilles of Santa Barbara, California, sent us a copy of an abstract from an architectural design journal briefly describing how Soviet scientists had sealed ponds by artificially inducing the formation of a "gley" or "biological plastic", as occurs naturally in bogs.[1] The process, as adapted for use in Costa Rica, proceeded as follows:

1. The pond bottom was completely cleared of debris, rocks, etc.

2. The bottom and sides were covered completely with wastes from nearby hog pens. Care was taken to apply the material to the vertical sides of the pond as well as to the bottom. This layer and each subsequent layer of material was added in quantities sufficient to just cover the previous layer.

3. The hog pen waste was completely covered with freshly cut grass and banana leaves, plus a few discarded cardboard cartons.

4. A third layer, of soil taken from near the pond site, was added and tamped down firmly.

5. After between 2 and 3 weeks, the pond was flooded.

The pond retained water immediately upon filling, with no leakage whatsoever. The cost of sealing was limited to labor costs; the materials used were all "wastes" which would have been discarded in the course of normal farm operations.

The process involved in forming the seal is a bacterial one, which requires anaerobic conditions. It is possible that plastic and rubber pond liners actually act in the same way. While great care is taken to prevent punctures in the installation of such liners, it may be that their long-term effectiveness is, in fact, a result of the creation of anaerobic conditions underneath the liner. The suggestion is that a variety of waste materials, if properly applied, would seal porous soils, thus enabling the Russian method to be adapted for use practically anywhere.

So far as we know, the experience reported here is the first test of the gley formation method of pond sealing in the tropics, or anywhere outside the U. S. S. R. If its application turns out to be universal, as appears likely, the implication is that many areas of the world which, up to now, have been closed to aquaculture (except perhaps by large corporations or government agencies) can now be opened to this method of food production. We would very much like to hear about any experiences our readers may have with pond sealing.

– William O. McLarney
J. Robert Hunter

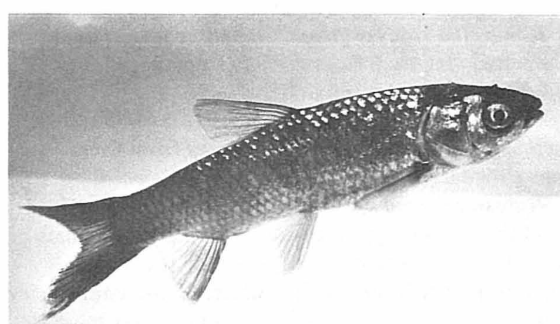


Photo by Fritz Goro

1. *The Journal of the New Alchemists (1) p. 35.*

Cultivo Experimental de Peces en Estanques

PREFACE

While one of the roots of New Alchemy lies in the disenchantment some of us feel with the framework of institutional science, we do not wish to present the attitude that there is little of value in the work being done in universities and research stations of the world. Science and technology do make important contributions and from time to time we shall describe some of the work which seems especially relevant from a New Alchemy point of view.

Such an editorial effort is handicapped by the impossibility of keeping up with all the scientific literature in even one field. We are indebted to Sr. Alberto Donadio, of Medellin, Colombia, for bringing to our attention the work of Prof. Anibal Patiño R. of the Universidad del Valle, Cali, Colombia.

Professor Patiño's work is especially gratifying to me, since he has arrived independently at many ideas similar to my own for the development of tropical aquaculture (McLarney, 1973a), and has demonstrated that they will work – biologically and economically.

The following account, which should be of interest to anyone involved in tropical ecologies or economies, is excerpted and paraphrased, with Professor Patiño's kind permission, from his paper "Cultivo experimental de peces en estanques", which appeared in Cespedesia, Vol. II, No. 5, pp. 75-127. For information on obtaining the original paper (in Spanish), write Cespedesia, Jardin Botanico del Valle, Apartado aereo 5660, Cali, Colombia.

INTRODUCTION

Professor Patiño's work parallels New Alchemy schemes for tropical aquaculture in four respects:

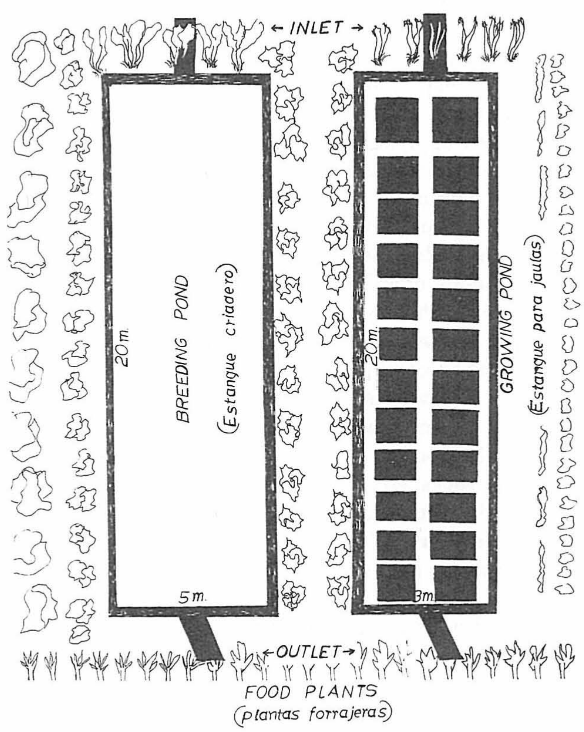
1. He advocates polyculture of certain species of *Tilapia* and local fish species.
2. The primary foods for the fish, apart from those produced by fertilizing the fish pond, are weeds, agricultural wastes or various plants which can be cultivated with a minimum of effort.
3. Selected fish are grown to market size in cages. The remainder are left, essentially unmanaged, in a pond which serves as a hatchery.
4. Excess small fish are fed to other farm livestock, such as hogs and chickens. The wastes from these animals are used to fertilize the pond.

Professor Patiño has demonstrated the economic feasibility of this approach for the campesino (small farmer). He has also outlined plans for the implementation of this sort of fish culture in the countryside.

We shall discuss these features of Professor Patiño's work in the order listed above. All of the work described was carried out in four ponds fed by the Rio Tulua in El Jardin Botanico del Valle, Mateguadua, Colombia. The ponds, each 10 m x 30 m x 1.2 m, were lined with polyethylene and fertilized with cow manure. Professor Patiño and four students from the Universidad del Valle accomplished all of the work from the construction of the ponds with pick and shovel to the conclusion of the experiments in a year and a half.

POLYCULTURE

Four species were chosen for the initial studies: *Tilapia mossambica* Peters, *Tilapia rendalli* Boulanger (= *Tilapia melanopleura*), and two native characins, the bocachico (*Prochilodus reticulatus magdalenae* Steindachner) and the jetudo or patalo (*Ichthyoelephas longirostris* Steindachner). The two tilapia were chosen because of the ease with which they may be cultured, and because of their different feeding habits. As both species are already established in the Rio Cauca drainage, which includes the Rio Tulua, there are no ecological objections to the use of these exotics. The native species were chosen because both are valuable food fishes currently threatened by environmental change, and because they might fill ecological niches complementary to the tilapia.



To describe briefly the four species:

T. mossambica is omnivorous, but feeds mostly on phytoplankton and benthos. It is a mouthbreeder and multiplies very rapidly, which leads to overcrowding and sometimes enables it to out-compete valuable, but less prolific or aggressive species. *T. rendalli* is herbivorous by preference. Though not a mouthbreeder, it is, nevertheless, more prolific than either of the characins studied. Both species of tilapia are considered good food fishes.

The bocachico is economically the most important fish in the Cauca valley. It feeds on algae and detritus, obtained by sucking up mud and periphyton. In the Cauca valley, it may compete with *T. mossambica.* The bocachico lives mostly in standing or slow-moving waters, but requires running water to breed.

The jetudo, in nature, is entirely a creature of swiftly flowing waters. It feeds primarily on algae attached to rocks and river bottoms and is described as having a "delicate" flavor.

Professor Patiño has only begun to investigate the possibilities of culturing the two native species, but he has raised two important questions:

1. What is the behavior of the jetudo when confined in standing water?
2. What is the effect on growth of the bocachico in ponds when combined with *T. mossambica* or *T. rendalli?*

With respect to the first question, it was demonstrated that the jetudo will survive and grow in standing water. This is also true of another edible characin, the machaca, *Brycon guatemalensis,* which occurs naturally only in flowing waters (McLarney, 1973b). Sixty-four jetudo, with a mean weight of 69.3 g, were introduced into one of the ponds. Over a period of twelve months they grew to a mean weight of about 115 g. Only four died. Prior to the introduction of the fish the pond was fertilized with commercial 14-14-14 fertilizer and planted densely with *Elodea canadensis* to maintain high levels of dissolved 0_2. The lowest concentration recorded during the experiment was 6.8 ppm. This experiment was disrupted somewhat by the accidental introduction of some young *T. mossambica,* which may have competed for food with the jetudo.

Two ponds were used in the tilapia - bocachico experiments. One was stocked with 150 juvenile bocachico with a mean weight of 34.7 g and 100 *T. mossambica* with a mean weight of 6.0 g. The other pond received an identical lot of bocachico plus 80 *T. rendalli* with a mean weight of 47. 6 g. (It should be noted here that a possible limiting factor in culture of the bocachico is its delicacy with respect to handling. Mortality of bocachico during capture, transport and stocking was thirty-five per cent, that of tilapia less than five per cent.) Prior to stocking, both ponds were fertilized with 14-14-14 at the rate of 1 kg/pond; at the time of stocking the water in both was light green. The *T. rendalli* pond was densely planted with *Elodea canadensis.* Three months later, *Elodea* was placed in the *T. mossambica* pond as well, to aid in oxygenation.

Periodic examination of the stomach contents of sample fish showed that there was more overlap between the feeding niches of the bocachico and *T. mossambica* than between bocachico and *T. rendalli.* While the ponds differed in such respects as size and reproductive rate of tilapia, dissolved 0_2 concentration, provision of supplementary food (leaves of various plants supplied daily to the *T. rendalli*), and abundance of aquatic plants, the evidence suggests that the combination bocachico – *T. rendalli* is complementary, while the combination bocachico – *T. mossambica* – is not.

This conclusion is more strongly supported by the relative growth rates of the bocachico in the two ponds. After twelve months the bocachico confined with *T. mossambica* had reached a mean weight of about 94 g, while those in the *T. rendalli* pond had reached a mean weight nearly double that – about 175 g.

If bocachico or jetudo are to be used in practical fish culture, they must be bred in captivity. This has not been done to date, but Professor Patiño does not foresee this as a serious problem. He thinks that the process of pituitary injection, which has been successful in inducing many other typically rheophilic South American fishes to spawn in standing water (de Menezes, 1966), is likely to succeed with these species also.

The remainder of the work was carried out solely with the two *Tilapia* spp. Some of this work has further implications for polyculture.

USE OF AGRICULTURAL WASTES OR WEEDS AS FISH FOOD

A variety of terrestrial and aquatic plants were tested for acceptability for food for *T. rendalli.* Fifteen, including the aquatics *Elodea canadensis, Potamogeton crispus* and *Chara* sp. were consumed readily. Ramos (1971) and Huet (1970) offer additional lists of plants accepted by herbivorous tilapia. Hickling (1971) states that *T. rendalli* will accept a daily ration of 15% of its weight in yuca leaves (*Manihot esculenta*) or 33% in *Colocasia.* The difference reflects the water content of the leaves.

Of the plants tested, Professor Patiño recommends yuca, bore (*Alocasia macrorhiza*) and chayamansa (*Cnidoscolus chayamansa),* an edible euphorb shrub indigenous to Mexico. He lists four advantages of these plants:

1. Their leaves are high in protein (17.2 per cent, 23.25 per cent and 24.2 per cent, respectively).
2. They are easy to grow and can be propagated vegetatively.
3. They grow rapidly and produce large amounts

of useable vegetation.

4. They are tolerant of poor soils.

Professor Patiño suggests the consumption of aquatic plants by *T. rendalli* might be useful in weed control. I would like to suggest that in some instances they could be "pastured". In general, the provision of vegetable foods for tilapia should be left up to the individual farmer who best knows his local resources. If the leaves of a plant, such as yuca or banana, which can also provide the farmer with food or a cash crop, can be employed, so much the better.

CULTURE OF *T. RENDALLI* IN CAGES

The major problem in tilapia culture is overpopulation resulting in stunting. Three solutions have been applied.

1. Careful selection of only male fish for the culture pond.
2. Production of "monosex" hybrids — one hundred per cent male or nearly so.
3. Careful use of predatory fishes to thin, but not eradicate, the tilapia.

These techniques all require inputs of energy and managerial skill which cannot ordinarily be expected of the Latin American campesino embarking on a completely new food-raising enterprise. Cage culture solves the problem more simply. The eggs of all species of tilapia sink and are initially deposited in a nest dug in the bottom of the pond. When the fish are confined in wire cages suspended off the bottom, the eggs pass through the cage bottom out of reach of parental care. The pond in which the cages are placed or preferably, another pond, can be used as a natural "hatchery" in which tilapia are left to multiply virtually unmanaged. From time to time, stock can be selected from this pond for intensive culture to market size in the cages.

Other advantages of cage culture include:

1. Intensive culture with minimal labor and materials.
2. Technological and economic feasibility for the campesino.
3. Facilitation of feeding, inspection of the stock and harvest.
4. Continual harvest and replenishment of growing stock.
5. Rendering many types of water bodies useable for fish culture.

The first two cages constructed by Professor Patiño and the students were made of galvanized wire mesh and chanu or chano (*Humiriastrum procerum*) a local water-resistant wood. The cages, 2 m x 1 m x 1 m, were situated on legs which raised them 25 cm off the pond bottom. Later cages were constructed more economically by making four of the sides from such indigenous materials as cane. Wire was used for the bottom so that enough light could penetrate to permit the growth of oxygenating plants underneath the cage.

The cages were placed 1 m apart in one of the ponds, over a dense growth of *Elodea.* Each cage was stocked with 50 or 100 three month-old *T. rendalli* with a mean weight of 22.5 g. Each cage received a handful of bore leaves twice daily. Two cages received an additional daily supplement of wheat bran. At the beginning of the experiment each cage was given ½ kg of bran daily. This was gradually increased to 1 kg/day.

The result was excellent growth and low mortality (four per cent). For the first month the young fish, which had been reared previously on commercial pelleted food, refused to eat the bore leaves. Subsequently they accepted the leaves and grew rapidly. After five months in the cages, when the fish were eight months old, the mean weight of the fish not receiving the bran supplement was 165 g. Those receiving the supplement averaged 200 - 250 g. Growth slowed considerably after five months, indicating the logical time to harvest.

After five months, the tilapia which did not receive the bran supplement had increased their weight by a factor of 7.33. The comparable factor for the supplemented fish was 8.89 - 11.11.

For purposes of comparison, Professor Patiño cites Kuronuma (1968) who describes the cage culture of various marine fishes in the fertile Inland Sea of Japan. Kuronuma considered an annual production of 29 kg/m^2 remarkable. These fish were fed a high quality dry food with a conversion ratio of 1.6. In Professor Patiño's experiments, the unsupplemented *T. rendalli,* stocked at 100 fish/cage, produced 28.5 kg/m^2 of pond surface in five months. While no attempt was made to determine the conversion ratio of bore leaves, it was undoubtedly much higher than 1.6. At New Alchemy East we have achieved a good conversion rate of 1.5 with *Tilapia aurea* and *Tilapia zillii,* and believe that part of our success is due to small amounts of animal protein (earthworms, insects, etc.) in their diet, particularly when the tilapia are small (McLarney and Todd, 1974).

"One-upmanship" in terms of weight/surface area data is an occupational disease of fish culture. Undoubtedly the production achieved by Professor Patiño could be bettered by using concentrated foods or by technological improvements. What matters is not competition among fish culturists, but the fact that his technique is inexpensive and does not require great sophistication on the part of the farmer, yet can result in the production of hundreds of kg of fish in a short time within a small area.

INTEGRATION OF FISH CULTURE WITH CULTURE OF HOGS AND CHICKENS

Professor Patiño points out that, while Colombian farmers commonly raise chickens and hogs for sale or their own use, growth of these animals is limited by their diet, consisting chiefly of corn, platano peels, minced sugar cane and table scraps, plus whatever the animal can forage. Such a diet is usually deficient in animal protein. Colombian campesinos cannot afford to make up this deficit by the use of concentrates, as is done in more affluent countries. Professor Patiño suggests that excess small cultured tilapia could fill this gap. For this purpose he recommends *T. mossambica,* which can be maintained without supplemental foods on plankton in fertilized ponds, and multiplies more rapidly than *T. rendalli.* The two species could be grown in polyculture, or a separate small pond could be set aside for *T. mossambica.* The pigs or chickens could be maintained near the fish pond so that the ponds can be fertilized with their manure.

Young *T. mossambica* were tested for acceptability as food for chickens and pigs. The tests on chickens were preliminary and established only that chickens prefer cooked fish. Tests with hogs were more extensive. These animals eagerly accepted whole, raw young *T. mossambica.* They had no difficulty with bones or fin rays.

One quantitative feeding experiment was conducted with hogs. Four one month-old Duroc Jersey hogs were divided into two pairs (one male and one female per pair). The control pair, which had a mean weight of 8.6 kg, was fed twice daily with cooked platanos (including peels) and minced sugar cane, in increasing quantities as the animals grew. The experimental pair, with a mean weight of 7.5 kg, received the same diet, plus a daily ration of whole, raw *T mossambica* measuring up to 8 cm in total length. The daily tilapia ration was 100 g per hog at the start of the experiment and was increased to 250 g over the experimental period.

After four months, the hogs were weighed again. The mean weight of the control animals was 16.5 kg, that of the test animals 24.5 kg, or 33.1 per cent more, even though they had started the experiment being slightly smaller. The mean weight gain of the controls was thus 7.9 kg, or 48 per cent, while the hogs whose diet was supplemented by tilapia had a mean weight gain of 17.0 kg, or 69. 4 per cent.

Professor Patiño does not consider the final weight of either pair of hogs satisfactory, due to irregularities in the feeding regime. Neither can his results be considered statistically significant. Nevertheless, the experiment indicates what might be achieved.

THE "CAMPESINO FISH CULTURE UNIT" AND ITS ECONOMICS

Based on the results of the experiments described here, Professor Patiño has drawn up a plan for a "Unidad Piscicola Campesina" (Campesino Fish Culture Unit), using *T. rendalli,* with the potential to accommodate additional species. The physical layout of such a system is illustrated in Fig. 1.

His plan for the UPC, as he calls it, includes the following instructions:

1. Select a pond site with the help of an expert. New Alchemy's new method of pond sealing should render site selection easier (McLarney and Hunter, see page 85).
2. Plant the area around the pond site with fish food plants. Professor Patiño suggests one hundred stalks of yuca, one hundred roots of bore, chayamansa and other suitable plants as available locally. These need occupy less than ½ hectare. It is important to plant before beginning pond construction, so that the plants are producing by the time the fish need food.
3. Build two ponds:
   a. A nursery pond ("estanque criadero"), 5 m x 20 m x 1 m, connected by a ditch to a good water source, with another ditch for drainage. When filled, the nursery pond should be fertilized. When the water turns green, add five hundred to one thousand juvenile *T. rendalli.*
   b. A growing pond ("estanque para jaulas") near the nursery pond, also provided with inlet and outlet ditches. The growing pond should be at least 3 m x 20 m, and 1.5 m deep. Plant this pond with aquatic plants and introduce twenty-four cages, each measuring 1 m x 1 m x 1 m, spaced equidistantly. Each cage should be equipped with legs to keep it 30 cm off the bottom.
4. When the tilapia start to grow, select individuals 6-8 cm in total length and stock them at 200 per cage. All the cages can be stocked at once, or stocking can be staggered to suit the culturist.
5. Feed the fish in the cages twice daily, in the morning and late afternoon, with leaves of the food plants. Feed as much as the fish will consume, but no more. If feasible, supplement their diet with wheat or rice bran.
6. Inspect each cage monthly to determine if health and growth of the fish are satisfactory. For this purpose, the cages may be lifted slightly so that the quantity of water in them is reduced. They should not be lifted completely out of the water or held up too long, as the fish will become very excited and subsequent losses due to jumping out may occur.
7. Harvest after five months, or when the fish have reached the desired size.

Using the costs reported by campesinos who have built ponds in the vicinity of Mateguadua, and the results of the experiments reported here, Professor Patiño makes the following economic projection (Table 1).

According to Professor Patiño's projection, in the first year, with only one harvest and all of the initial costs of construction, a profit of $1,740 Colombian dollars could be realized. In subsequent years, with harvests up and expenses down, the projected profit would be $10,980 Colombian, with only two harvests per year. To any such evaluation the benefit of in-

TABLE 1: PROJECTED INVESTMENT IN AND INCOME FROM A CAMPESINO FISH CULTURE UNIT

Investment (in $ Colombian):

Pond construction, with pick and shovel	$ 800
Construction of inlet and drainage ditches	400
Cost of twenty-four cages, at $40 each	960
Food plants	300
Unforeseen costs	540
Total Investment	$3,000
Annual Maintenance Cost:	
(Including repair of cages)	$1,500
TOTAL	$4,500
Income	
Net Production per cage, first year..... 26 kg	
Production of twenty-four cages, first year ....624 kg	
Value of harvest, first year (assuming a price of $10/kg of fish)....................................	$6,240
Value of the harvest, second year (minimum of two harvests)......................................	$12,480

As of Summer, 1975, $28.50 Colombian was the equivalent of $1.00, U. S. Funds

creased nourishment provided by the fish to the campesino family and to their livestock must be added.

DISCUSSION

Professor Patiño envisions that such ponds could be set up not only on campesino farms, but also "in grammar and high schools, in training schools, vocational agricultural institutes, in SENA, and even in the universities" where they would serve educational, scientific and recreational functions, as well as provide food. He suggests that the crop could be used in school cafeterias or shared among the students. "The development of fish culture should be conceived as a great crusade operating throughout the national educational system," he writes, "How much more useful and functional this type of activities and educational experiences would be than the bland and repetitive textbook instruction which is now given in our centers of education."

I can only add that the need for the type of education and action urged by Professor Patiño extends far beyond Colombia. The lack of effective aquaculture programs in most of Latin America is obvious. Those few which have been proposed or enacted are mostly concerned with taking advantage of long growing seasons and cheap labor supplies to produce a product for export or sale to the relatively affluent, and confer economic benefit only to the entrepreneur and a handful of laborers. A few plans which have taken better aim at the important economic, nutritional and ecological problems have foundered for a variety of reasons – biological bottlenecks, lack of research funds, failure to approach the problem at a level meaningful to the campesino, etc. Professor Patiño has surmounted these problems to design and test a fish culture system that is ecologically and economically sound with great potential to alleviate some of the problems of Latin America.

– Anibal Patiño R.

Précis by William O. McLarney

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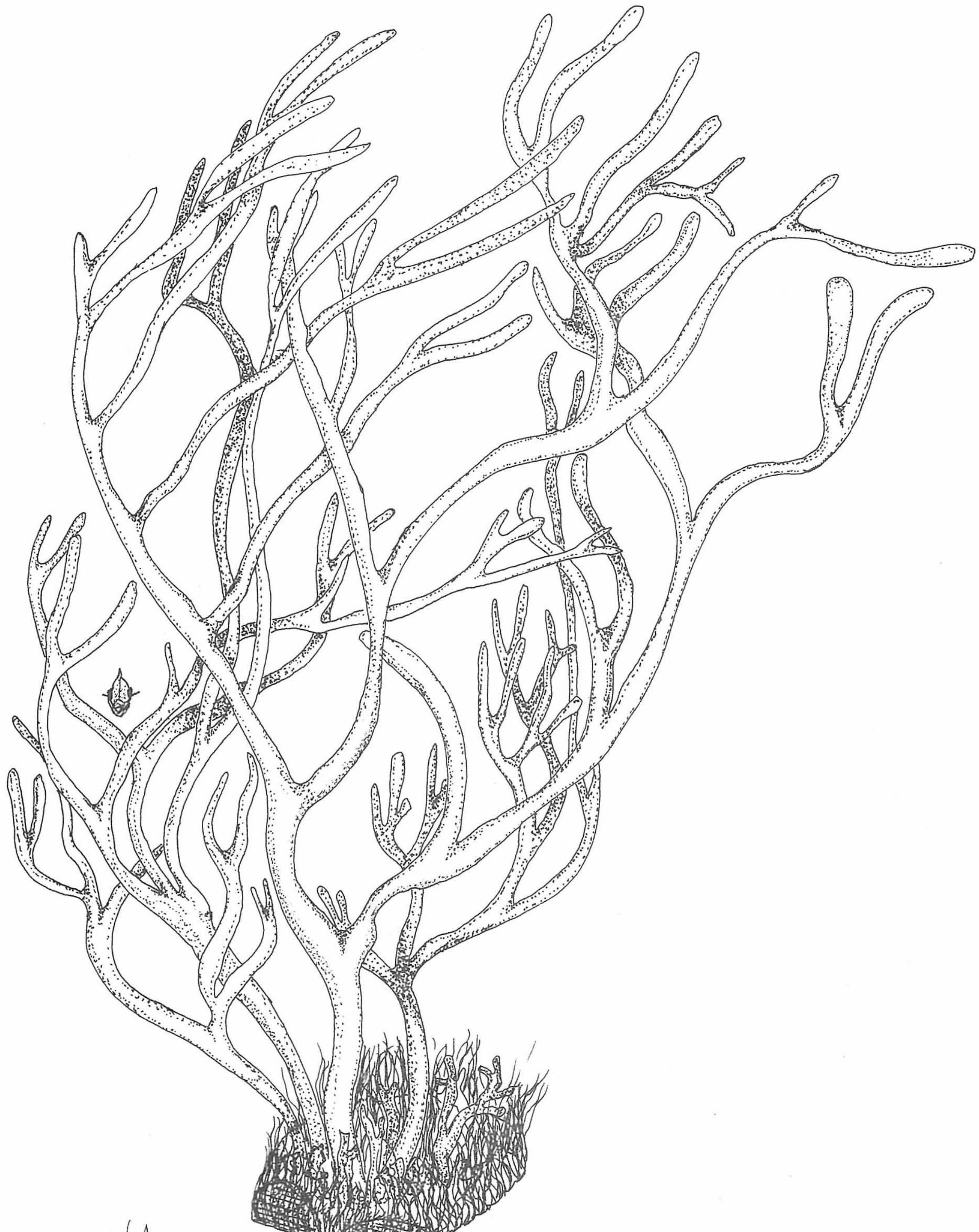

NA

The poem "Populist Manifesto" by Lawrence Ferlinghetti, which opens this section of Explorations, was a totally unexpected windfall. Apparently Ferlinghetti had given the poem, without copyright, to a few of his close friends and favourite publishers trusting that they would know where to place it. Happily for us, we share a friend with Ferlinghetti, and it was our mutual friend, Sasha Hoffman, who gave us the poem for publication in the Journal.

With "Meditations on the Dark Ages, Past and Present" by William Irwin Thompson, we move into heady terrain indeed. Bill Thompson, one of the visionaries of the New Age, is known for his books, "At the Edge of History" and "Travels About Earth", and as the founder of the Lindisfarne Association. Like so many Irishmen, he is a spellbinding talker, but in his case his words are backed by profound knowledge of cultural history and a unique ability to bring together and synthesize apparently disparate ideas and philosophies.

The second article was prompted by a meeting one afternoon with an old friend, Ruth Hubbard, and her co-worker, Nancy Milio. We were so impressed with the potentialities of their ideas for offering genuine alternatives in health care that we asked them to write a short description of them for the Journal. The concept of a demystified, decentralized preventive approach to medicine is surely as critical as that of appropriate technology and, so far, has received far less attention. We hope that their project will be a giant first step toward change in both the practice of medicine and the maintenance of health.

My own article "Women and Ecology" was written for the 1974 summer session of the Social Ecology course given by Murray Bookchin at Goddard College in Vermont. Quite a lot has happened in the year since it was written. It is too soon to know what, if any, the far-reaching consequences of the United Nations Women's Year will be. The authoritarianism of Indira Gandhi gives little encouragement to the idea that the emergence of the feminine voice will result in fundamental change but what I think we are beginning to see is a groundswell of hitherto unknown participation by women in human affairs. It may be a generation or so before we shall be able to assess the results.

—NJT