Open System Fish Culture - 1977

– *William O. McLarney and Jeffrey Parkin*

Open system fish culture at New Alchemy in 1977 involved the continuation of cage culture work in Grassy Pond (Pickerel Pond), and, in addition, a series of feeding trials similar to those described in an article by McLarney, Levine and Sherman in *Journal of The New Alchemists (3)* (1976).

CAGE CULTURE

Cage culture methods were essentially no different from those used in the previous year as described in *Journal Four*, but we attempted to grow two types of fish. Unfortunately, our efforts to raise brown bullheads (*Ictalurus nebulosus*) were aborted by almost 100% mortalities which occurred soon after handling, no matter how careful we were. Bullheads obtained locally inevitably developed what appeared to be a bacterial infection of *Pseudomonas* sp. and usually died within a few days after capture. We do not know if this phenomenon would be repeated another year or whether it is a characteristic of our local populations, or of brown bullheads as a species. In our earlier experience with the very similar yellow bullhead (*Ictalurus natalis*) in Michigan, California and Massachusetts, no disease or unusual mortality was observed, even though the fish were subjected to physiological stress as a part of our experiments. We did have trouble maintaining brown bullheads in the lab. Despite the setback, we retain the conviction that the bullheads will ultimately prove among the most useful fishes for the home grower.

Those cages not devoted to short-lived bullhead experiments were stocked with a mixture of bluegills (*Lepomis macrochirus*) and "hybrid bluegills" (♂ *Lepomis cyanellus* x ♀ *L. macrochirus*). As in 1976, trials were conducted in which some caged populations were fed Purina Trout Chow (R), while others received a 100% natural foods diet. The rate of growth was compared. The only difference from the previous experiment was that we had a more consistent supply of appropriate sized earthworms, due to having a new worm culture facility at New Alchemy.

In a parallel experiment, we attempted to combine the ecological and economic advantages of natural feeds with the convenience of prepared dry feeds. Jeff Parkin, whose sophisticated food-processing equipment included a solar dryer, an ordinary kitchen oven, an electric blender (for earthworm puree), a hand-operated grinder and a caulking gun, was kept busy concocting blends of alfalfa, comfrey, soy meal and earthworms, which were dubbed "Brand X" or "Jeff-Pie." The first problem to be overcome with these feeds was to make them more attractive to the fish; they fell short of commercial feed with respect to texture, color and flotation. The fish eventually did learn to take them, but seldom with the enthusiasm we should have liked to see.

The results of the cage culture trials do not demand a presentation as detailed as that given in *Journal Four*. We continue to be disappointed in the growth and production of our sunfish, though we are encouraged to note that the fish on natural foods grew 21.7% more than those on the commercial diet. The best blend of "Brand X" (45% worms, 35% soy, 10% alfalfa and 10% comfrey) produced only 75% as much growth as the commercial diet.

No differences in growth between bluegills and hybrids were apparent, though the hybrids did seem to "fill out" better, producing a more attractive table fish. On the other hand, most observers preferred the taste of bluegills to that of hybrids.

Unlike the previous year, 1977 saw high water in Grassy Pond throughout the summer and fall, and environmental conditions in the cages appeared well suited to sunfishes. Yet all the fish went noticeably "off feed" from late summer on. Our problems were briefly mentioned in an article in *The Commercial Fish Farmer Magazine* (McLarney and Todd, 1977), which brought an offer of assistance from one of the pioneer hybrid sunfish culturists, Francis Bezdek of Aquatic Management, Inc., Lisbon, Ohio. Rather than expound on our ignorance, we will postpone further discussion for another year, by which time we will have had a chance to incorporate some of Mr. Bezdek's suggestions.

FEEDING TRIALS

The feeding trials were carried out in a battery of twelve 66-gallon solar-algae ponds located in the solar courtyard adjacent to the Ark. Tilapia (*Sarotherodon aurea*)[1] were chosen for the trials, partly to maintain continuity with earlier experiments (McLarney, Levine and Sherman, 1976) but also because of their hardiness and general excellence as a research animal.

The thrust of the feeding trials, as in the cage culture experiments, was to find a low-cost, ecologically-sound substitute for fish meal which is the principal protein ingredient of commercial fish feeds. The rationale for this has been discussed in *Journal Four* (McLarney, 1977) and in the summer workshops given by the authors.

As in the earlier study, a "standard" feed composed of grains (75% rolled oats and 25% roasted soy meal) was used as a basis of comparison. As a consequence of their environment, all the fish had access to phytoplankton as food, as well. As it seems impossible to control the intensity of phytoplankton blooms in solar-algae ponds, the best we could do was to monitor population density by the rather crude method of frequent Secchi disc readings and attempt to relate that information to growth rates. Although the mean Secchi disc readings for individual solar-algae ponds varied greatly (from 11.5 to 31.7 inches in one two-week trial, and from 16.4 to 36.8 inches in another, for example) no correlation was found between phytoplankton population density and growth rate.

The experiments carried out were intended as no more than pilot studies to suggest the most productive avenues for further research. Consequently, only a brief description and a summary of the data are given below, with no attempt at statistical analysis.

The first two-week trial sought to compare the food value of the "standard" soy-oat mixture to commercial feed (Purina Trout Chow (R)). A control series of fish received no feeding, but relied on phytoplankton for maintenance and growth.

Table 1 points out the superiority of commercial trout feed to the soy-oat mixture. It also confirms that phytoplankton had some food value for small tilapia.

Previous experiments (McLarney, Levine and Sherman, 1976) showed very significant improvement of tilapia growth when the soy-oat mixture was supplemented with midge (*Chironomus tentans*) larvae in amounts comprising 2% or 10% of the grain diet. The same approach was taken using minced fresh earthworms (*Eisenia foetida*) in place of the midge larvae (Tables 2 and 3).

In the earlier experiments with midge larvae a greater difference was seen in the growth of fish weighing less than 5 grams at the start of the experiment than in larger fish. Accordingly, in a second trial, such fish were considered separately as well as together with the others (Table 3).

It appeared that the earthworm supplement was effective in augmenting growth, but not nearly as effective as midge larvae had been in the earlier trials. Before going on, it was decided to do another set of

1. Those scamps, the taxonomists, are at it again: And we were so pleased to have a fish whose scientific name was the same as the colloquial name. But they've gone and placed most of the species in the old genus *Tilapia* in the genus *Sarotherodon*, including our old friend *aurea*. To the lay reader: Taxonomic names really do serve to alleviate confusion – most of the time. Should you care, the "official" common name for *S. aurea* is "blue tilapia."

trials with midge larvae in the same experimental system. This time, the soy-oat mixture, supplemented with midge larvae, was tested against two other diets – commercial trout feed and dried comfrey *(Symphytum pereginum)* plus midges. Comfrey was selected because it appeared to be well suited to cultivation as a food for herbivorous fishes, being productive and high in protein and vitamins. On a production per acre basis, comfrey contains seven times as much protein and eight times as much carbohydrate as soybeans. It also is the only known land plant, as of 1976, to synthesize the very essential vitamin B12. Adult tilapia at New Alchemy relish fresh comfrey, but we had yet to make use of the powdered dried form.

Nutritional content notwithstanding, dried comfrey was not an acceptable substitute for the soy-oat mixture (Table 4). The fish were slow to learn to eat it, never fed eagerly on it, and grew poorly on the comfrey-midge larvae diet. Further, in water, dried powdered comfrey almost immediately disintegrated to make "tea", which in turn seemed to suppress phytoplankton growth.

The soy-oat mixture, supplemented with midge larvae, still fell short of the "complete" diet represented by commercial trout feed.

TABLE 1. Growth of young blue tilapia in solar-algae ponds when fed on commercial trout feed or soy-oat mixture at 2% of body weight/day.

Diet	Control (no feed)	Soy-oat mixture	Trout feed
No. of fish	24	24	18
Mean initial wt. (grams)	6.51	7.71	6.66
Mean final wt.	6.69	9.58	9.53
% gain	2.75	24.22	43.04

TABLE 2. Growth of young blue tilapia in solar-algae ponds when fed on soy-oat mixture at 2% of body weight/day, supplemented with minced earthworms in amounts equal to 2% or 10% of the soy-oat diet (first of two trials).

Supplement	No worms	2% worms	10% worms
No. of fish	23	18	24
Mean initial wt. (grams)	3.17	2.97	3.14
Mean final wt.	4.84	4.73	5.01
% gain	53.15	59.36	59.42

Photo by Hilde Maingay

TABLE 3. Growth of young blue tilapia in solar-algae ponds when fed on soy-oat mixture at 2% of body weight/day, supplemented with minced earthworms in amounts equal to 2% or 10% of the soy-oat diet (second of two trials). Data for fish weighing less than 5 grams at the start of the experiment are shown in parentheses.

Supplement	No worms	2% worms	10% worms
No. of fish	21 (16)	24 (13)	24 (12)
Mean initial wt. (grams)	4.68 (3.23)	5.22 (3.57)	5.35 (3.44)
Final Wt.	5.68 (4.15)	6.70 (4.78)	7.01 (4.90)
% gain	21.39 (28.37)	28.09 (34.05)	30.90 (42.37)

TABLE 4. Growth of young blue tilapia in solar-algae ponds when fed a "complete" commercial diet, a soy-oat mixture supplemented with midge larvae in amounts equal to 10% of the soy-oat diet, or dried powdered comfrey similarly supplemented

Diet	Comfrey plus 10% midges	Soy-oat mixture plus 10% midges	Commercial trout feed
No. of fish	24	18	24
Mean initial wt. (grams)	8.20	7.59	7.83
Mean final wt.	8.61	10.02	10.89
% gain	5.03	31.99	38.99

TABLE 5. Growth of young blue tilapia in solar-algae ponds when fed commercial trout feed, a supplemented soy-oat mixture, or a supplemented soy-oat-earthworm mixture at 2% of body weight/day.

Diet	Soy-oat mixture plus 10% midges	50% soy-oat mixture, 50% minced fresh earthworms, plus 2% midges	Commercial trout feed
No. of fish	24	18	24
Mean initial wt. (grams)	10.35	9.84	10.60
Mean final wt.	11.70	11.79	12.67
% gain	12.96	19.75	19.54

In the final series of trials, carried out just before water temperatures became too cold for growth in tilapia, a feed mixture containing both worms and midge larvae was tested. The logic is as follows:

Midge larvae have previously been shown to increase significantly the growth of young tilapia when added to the diet in very small quantities (McLarney, Levine and Sherman, 1976); it has been suggested that the basis for this is a vitamin, amino acid, enzyme or other substance needed in only small amounts. It is easy to raise *C. tentans* larvae in quantities suitable for this purpose and New Alchemy has an established midge culture system (McLarney, 1974; McLarney, Levine and Sherman, 1976). However, it would not be feasible to raise them in quantities sufficient to constitute a major protein source for cultured fish.

It was suggested by an earlier trial in this series that earthworms in small quantities do not exert a growth-promoting effect comparable to midge larvae. However, as they are high in protein (as much as 71.5% of their total dry weight) and can be cultured in quantity, they might constitute an acceptable substitute for the ecologically and economically expensive animal protein components, principally fish meal, of commercial fish feeds.

Accordingly, a diet was tested in which approximately 50% of the protein, naturally supplied by fish meal, normally present in commercial trout feed was replaced by fresh minced earthworms and the other half of the diet was supplied by the soy-oat mixture. This was supplemented with midge larvae at the rate of 2% of the total diet. This feed was tested against two feeds used in earlier trials – commercial trout feed and the soy-oat mixture, supplemented with midge larvae at 10%. Results obtained with the soy-oat-worm-midge diet were virtually identical to those obtained with trout feed (Table 5).

We wish to reemphasize that these are only pilot studies and need replication. They do suggest that an acceptable substitute for costly fish feeds might be developed by substituting earthworms for the fish meal component, midge larvae for the synthetic vitamin package and a simple grain mixture for the much more complicated blend of additional ingredients. Such feeds could be produced, in small lots at least, on an on-farm basis and at low cost, with no associated ecological disruption.

We have already begun limited indoor replications of the last trial reported, and we will expand the work as soon as weather permits. We are also expanding our worm culture and seeking funds for a full-scale investigation of cultured earthworms as a fish food or feed ingredient.

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