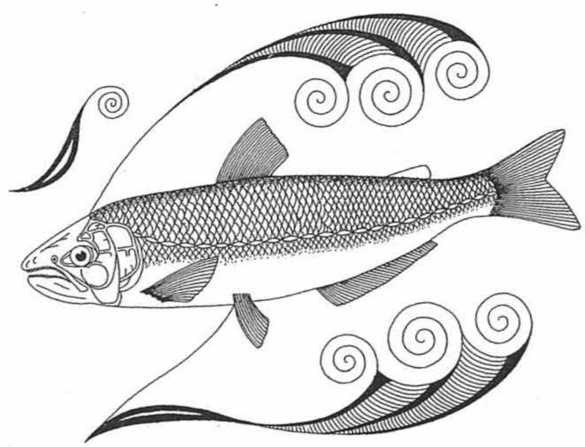
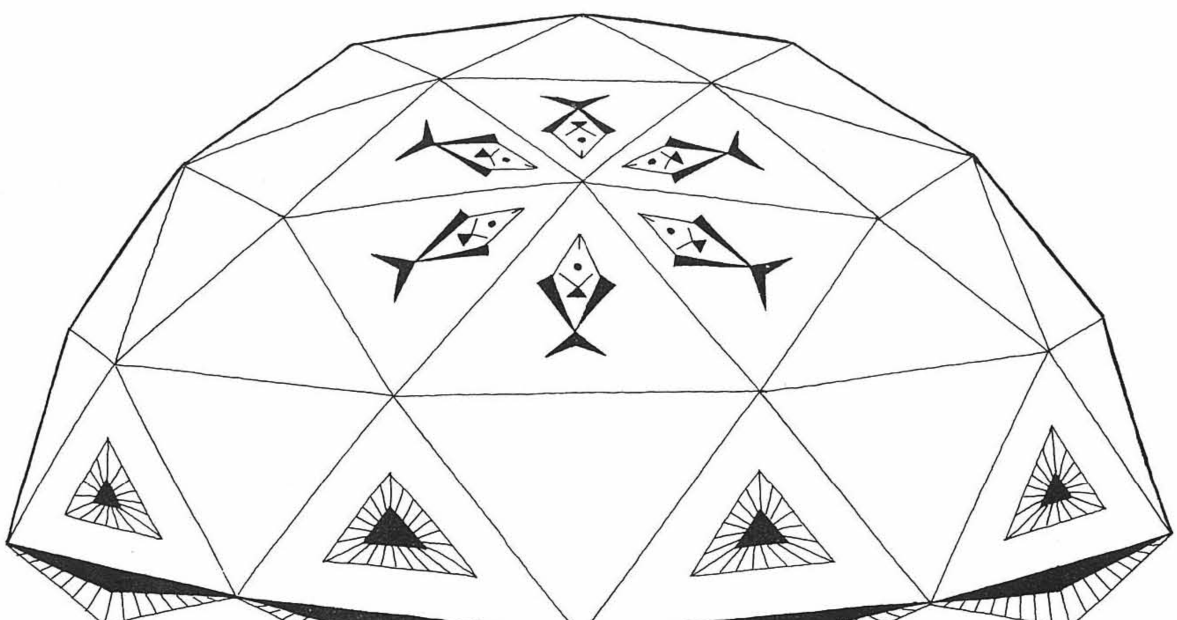


Aquaculture



Granted, none of us managed to get our picture on the cover of the Rolling Stone, but some of you may have noticed that on the cover of the second issue of Lifestyle there appeared a rather angular figure with a shock of dark hair. The figure, outlined against the side of a dome, and leaning over a pool, was that of Bill McLarney. Although Lifestyle explained that he was engaged in feeding the fish, he was actually taking a turbidity reading of the water with a secchi disc. Dr. McLarney at work is unique. He can usually be found by following the freshest trail of beer cans or by tracking the sound of a sustained irritated mutter.

He has established some unique records since the days that he was spelling champion of Cattaraugus county for two years running. He has been photographed netting a butterfly while falling backwards down a cliff. He has been trapped, suspended by his armpits on the rim of an eight foot fish tank when the saw horse that he was standing on overbalanced, and he steadfastly refused to abandon the fish he had just captured.

His field work in Costa Rica, the description of which follows, was wonderfully entertaining to watch. Clad in sun hat, fisherman's vest, shorts, and running shoes he pursued his quarry through the water with Chaplinesque élan. In both his science and his writing his standards of excellence are irreproachable but being around the work actually in process is to be part of an on-going comedy.

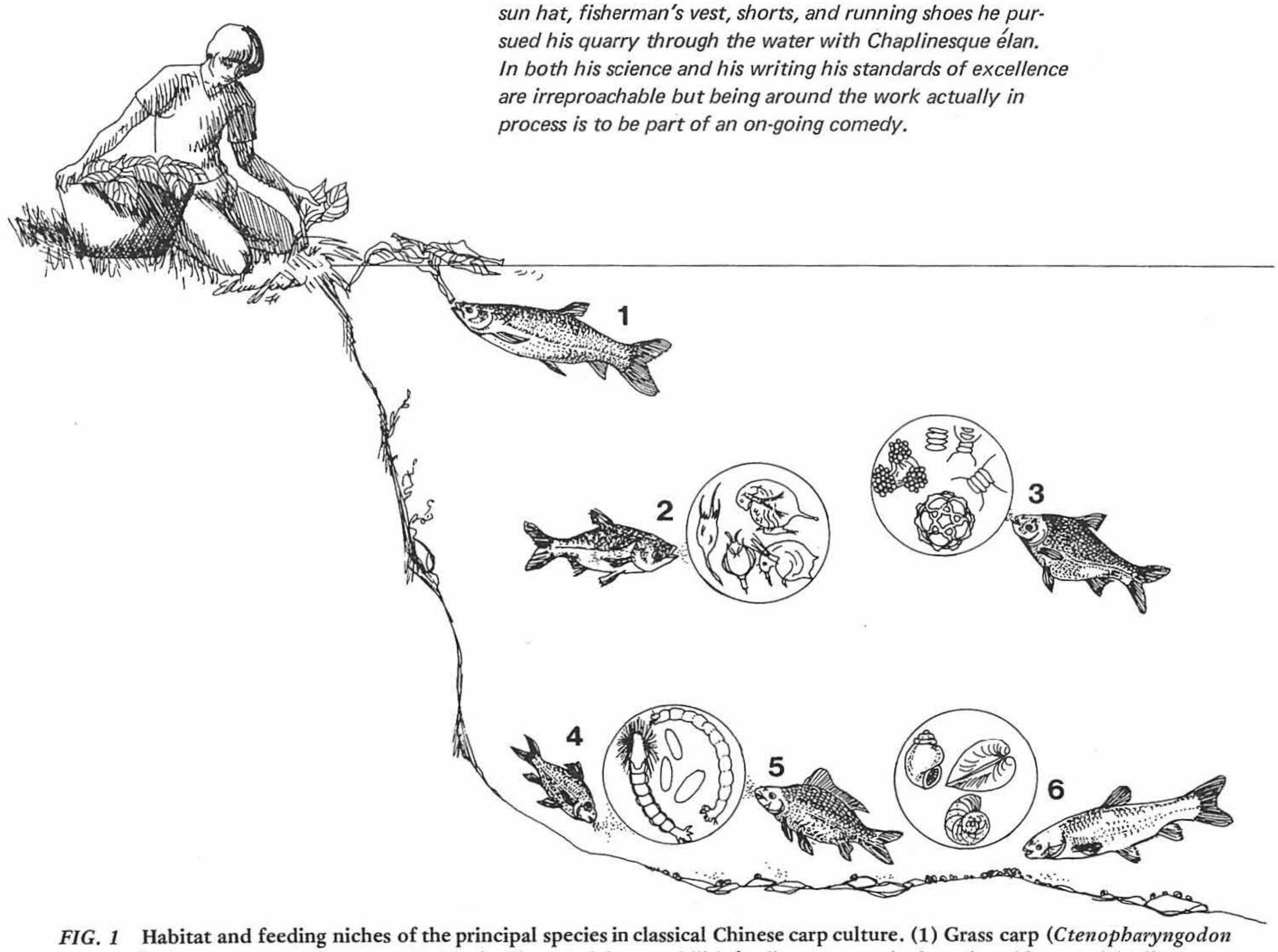


FIG. 1 **Habitat and feeding niches of the principal species in classical Chinese carp culture. (1) Grass carp *(Ctenopharyngodon idellus)* feeding on vegetable tops. (2) Big head *(Aristichtys nobilis)* feeding on zooplankton in midwater. (3) Silver carp *(Hypophthalmichtys molitrix)* feeding on phytoplankton in midwater. (4) Mud carp *(Cirrhinus molitorella)* feeding on benthic animals and detritus, including grass carp feces. (5) Common carp *(Cyprinus carpio)* feeding on benthic animals and detritus, including grass carp feces. (6) Black carp *(Mylopharyngodon piceus)* feeding on mollusks.**

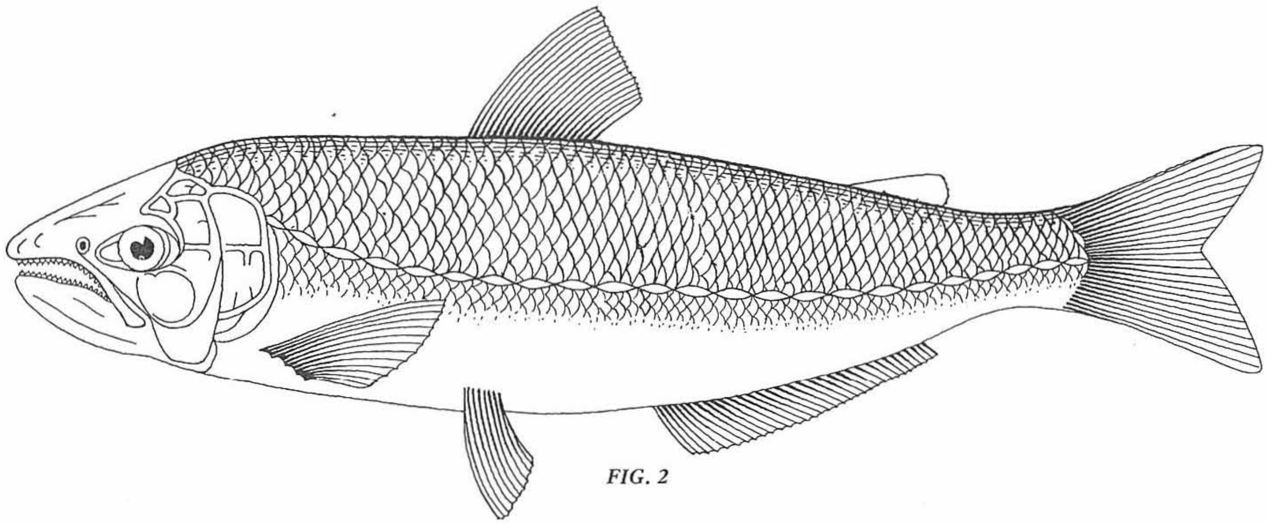


FIG. 2

Introductory Remarks

The chief nutritional problem of the peoples of Latin America is a shortage of protein. While the problem is not nearly as severe in Costa Rica as in many other countries by U. S. standards, high-protein foods are scarce and expensive. One protein source which is always mentioned when this problem is discussed is fish. The fresh waters of Latin America support a great variety of fish, many of which are utilized as food to some extent, but the rivers could never begin to support a fishery of a size commensurate with the human population.

Aquaculture has often been suggested as a means of providing protein, but few projects have been undertaken. The little that has been done has neither been aimed at enabling individuals or communities to grow their own fish, nor at providing protein for those who need it. Rather, existing installations and most aquaculture research in Latin America have dealt with raising high-priced fish for restaurant trade or for export to the United States.

It is informative to contrast the situation there with that in tropical southeast Asia, where though population density is often higher, protein deficiency is less prevalent, and cultured fish is an important component of the diet. The Asian peoples, particularly the Chinese, have over thousands of years developed methods of producing high yields of fish with low inputs of money and technology. Their success may be attributed to their recognition of two facts:

1. *"A body of water is a three-dimensional growing space. To treat it like a field, by planting only one kind of crop, is likely to result in wasting the majority of that space."*

2. *"Any fertile pond will produce a number of different fish food organisms. However, most fish are not omnivorous, but rather selective in their diet. Thus stocking single species wastes not only space but food." (Bardach, Ryther and McLarney, 1972)*

Chinese fish culturists take advantage of these characteristics of the pond environment through polyculture by stocking several types of fish, rather than just one, as is prevalent in the West (Figure 1 is a graphic illustration of polyculture in practice.) They further enhance the system by integrating the cultivation of the pond with terrestrial farming through the use of vegetable wastes as fish food and manures as pond fertilizers. Wastes and enriched water from the pond can in turn be applied to the land.

While it is the Chinese who have pioneered pond polyculture, some of the highest yields are achieved in the tropical portions of Asia, where a year-round growing season, coupled with the Chinese techniques, permits production levels which American aquaculturists, for all their technological and economic advantages, have not been able to duplicate in standing water.

There is a tremendous diversity of fresh water fishes in Latin America which could serve as the basis for an analog of the Chinese system, but this has never been tried. We have prepared a research proposal for the development of a pond polyculture system based on native Costa Rican fishes. Pending funding of this project (ca. $33,000 annually is needed), we have begun to investigate the ecology of some of the fishes which might find use in such a system. The information collected on these little-studied fishes should prove invaluable in our aquaculture efforts. The report which follows is the first published result of these investigations.

Studies of the Ecology of the Characid Fish Brycon guatemalensis in the Rio Tirimbina, Heredia Province, Costa Rica *with Special Reference to its Suitability for Culture as a Food Fish*

INTRODUCTION

"Despite the severe protein problems of the peoples of Latin America, fish culture is almost unknown in that part of the world. Most of the attempts that have been made have involved exotic fishes. However, (Latin America) supports a diverse fish fauna among which are certainly some species suitable for culture" (Bardach, Ryther and McLarney, 1972). A few efforts have been made to evaluate native species for suitability for culture (de Menezes, 1966; Lin, 1963) but only a small fraction of the available species have been considered.

Development of culture systems for native fishes of Latin America is further retarded by the paucity of information on the ecology of these fishes. From the little that is known, it would seem feasible to develop Latin American analogs of traditional Asian pond polyculture systems. Among the major components of such systems would certainly be some of the 1,350 or so known species of the family Characidae. The Characidae, according to Weitzman (1962) *"present one of the most extreme cases of evolutionary radiation and adaptation among living vertebrates"* and *"one can easily envision.... a community comprising plankton feeders, benthos feeders, herbivores, and predators - all native South American characins" (Bardach, Ryther and McLarney, 1972).*

This report is the result of a preliminary investigation of the ecology of one potential component of such a community, *Brycon guatemalensis,* (Figure 2) known in Costa Rica as the machaca (not to be confused with the famous insect of the same name). Emphasis has been placed on those aspects of the ecology which are of particular interest to fish culturists.

B. guatemalensis is one representative of a large, but little studied genus of primitive characins. A literature search going back to 1925 disclosed only 26 publications dealing with fishes of the genus *Brycon.* In all, 46 species ranging from Guatemala to Argentina are mentioned, but almost all of the studies are purely taxonomic in character, containing little or nothing of use to fish culturists.

DESCRIPTION OF THE STUDY SITE

The observations reported here were made in the Rio Tirimbina, located at an elevation of 200 m (660 feet) in Heredia Province, Costa Rica. The study area extended from the village of Tirimbina, downstream for a distance of about 3 kilometers (2 miles). At this point the Tirimbina is a riffle-pool type of stream with a moderately high gradient and a gravelly-to-rocky bottom. Water depth during the dry season (February-March) when the studies were made, varies from as little as 50 mm (2 inches) at mid-stream in some riffles, to about 2 m (6.6 feet) in the deepest pools. From the distribution of debris along the banks and in overhanging branches, it appears that during the rainy season water levels at least 1.5 m (5 feet) above this are sometimes reached. In addition to rocks, fallen trees, log jams, and some deeply undercut banks provide cover for fish. During the study period the water was almost always clear, with visibility restricted only at the bottom of the deepest pools. Such turbidity as was observed was due primarily to the presence of people in the river, rather than to meteorological events. The clarity of the water is undoubtedly partially due to the largely forested state of the watershed; about 90% of the banks in and immediately above the study area are forested, with the remainder in pasture. Water temperature was stable at 22-25°C (72-77°F) during the study period. No water chemistry was done, but the Tirimbina, like other streams in the area, is known to be soft, acid and low in mineral content.

Fish species sharing the study area with *B. guatemalensis* are listed in Table 1. Other species may have been present but escaped detection, for example *Synbranchus marmoratus* and *Rivulus isthmensis,* both of which are known from the vicinity, but have secretive habits. Still other species may enter the Tirimbina from the Rio Sarapiqui, which has a much larger fish fauna, including a number of representatives of normally marine groups. Other aquatic animals present included snakes, turtles, shrimp, and a variety of insect larvae, none of which appeared to be especially abundant.

AGE AND GROWTH

It is not possible to determine the age of tropical fishes by examination of scales or sections of bone, as is done with temperate zone fishes, since growth in the tropics is year-round and no annuli are formed. If, however, there is a short, well-defined spawning season it may be possible to determine year classes by plotting length-frequency data. The lengths of fish within each year class will cluster around the mean, so that the number of year-classes present is indicated by the number of peaks and valleys on the graph. With this in mind, a total of 130 *B. guatemalensis* were captured by seining during the period of February 23-March 11. Total length of each fish was measured and data plotted (Figure 3).

No statistical analysis was attempted on the length-frequency data, but it is doubtful if any case could be made for the presence of distinct year-classes. On the other hand, it seems extremely unlikely that fish spawned at the same time, living in the same environment, would exhibit such extreme diversity in size. It appears probable that, while spawning in *B. guatemalensis* is seasonal, the season is the rainy season, which on the Atlantic slope of Costa Rica lasts for eight months. (There are no recorded observations of *Brycon* spp. spawning, but rainy season spawning is typical of many tropical fishes. Dr. William Bussing of the University of Costa Rica has collected characin eggs, probably of *B. guatemalensis,* in the Rio Puerto Viejo, not far from the Tirimbina, at various times throughout the rainy season.) Thus, *B. guatemalensis* of the same "year-class" could differ in age by as much as eight months, which would account for the great discrepancy in size.

The only published study of age and growth in *Brycon* is that of de Gil (1949) who found that *B. orbignyanus* of Argentina and Uruguay grew slowly after the first year. One year old specimens were 75-125 mm (3.5 inches) long (standard length), but four year olds were only about 200 mm (8 inches) long. The oldest fish examined by de Gil was 17 years old and measured 604 mm (about

TABLE 1

List of Fishes Identified from the Rio Tirimbina
Near the Village of Tirimbina
February - March, 1973

Species	Family	Food	Habitat	Abundance
Astyanax fasciatus	Characidae	Mostly plant material of terrestrial origin; some insects	Pools	Very Abundant
Brycon guatemalensis	Characidae	Mostly plant material of terrestrial origin; insect larvae in young specimens. See text for details	Pools, chiefly toward the tail; undercut banks	Abundant
Phallichthys amates	Poeciliidae	Probably algae	Backwaters and shallows near shore	Abundant
Priapichthys annectens	Poeciliidae	Probably algae	In all but swift flowing water	Very Abundant
Rhamdia underwoodi	Pimelodidae	Probably carnivorous	(Only one specimen taken from pool)	Rare
Cichlasoma alfari	Cichlidae	Detritus (?)	Pools and backwaters	Common
Cichlasoma centrarchus	Cichlidae	Detritus (?); seen picking over surface of dead leaves	Pools	Common
Cichlasoma dovii	Cichlidae	Carnivorous on a wide range of organisms	In the Tirimbina, apparently ranges widely with no home territory. In Guanacaste, usually found in pools near cover, especially logs.	Occasional
Cichlasoma spilotum	Cichlidae	--------------	Moderately fast water; almost always seen within 100 mm (4 inches) of a log or rock	Common
Cichlasoma tuba	Cichlidae	Mainly algae, but may be caught using earthworms as bait	Shallow, flat-topped water, usually near shore	Common

24 inches). It should be mentioned, however, that *B. orbignyanus* lives in a temperate climate, thus growth is arrested for part of the year. According to Sterba (1963) *B. falcatus* of the Guianas *"grows very rapidly when well fed"*.

Figure 3 indicates a reduced number of fish above 90 mm (3.5 inches), but this may be due not to the actual numbers of such fish in the population so much as to greater difficulty of capturing the larger specimens. The largest fish taken in the seine measured 155 mm (6.5 inches), but individuals as long as 400 mm (16 inches) weighing up to 1.25 kg (2.5 lbs.) were taken from the Tirimbina. In the nearby, larger, Rio Bijagual diving disclosed *B. guatemalensis* which were estimated to weigh as much as 2 kg (4.4 lbs.)

Many characins less than 30 mm (about 1 inch) long were also captured, but these were not recorded, due to the impossibility of consistently distinguishing between *B. guatemalensis* and *Astyanax fasciatus* in that size range.

BREEDING

Almost nothing was learned of the spawning habits of *B. guatemalensis*. Only four of the specimens opened to examine the gut contents displayed sufficient gonadal development to permit the determination of sex. As mentioned above, there is reason to believe that *B. guatemalensis* spawns throughout the rainy season. This is slightly at variance with the suggestion by Lowe (1964) that *B. falcatus* spawned chiefly at the start of the rainy season. Von Ihering (1930) suggested that Brycon in Brazil spawned in mid-river and that the eggs floated ashore to develop amidst submerged plants.

Our meager knowledge of natural breeding notwithstanding, it seems unlikely that reproducing *B. guatemalensis* in captivity will prove a major difficulty in their culture. The technique of inducing breeding by pituitary injection, invented in Brazil (Das and Khan, 1962) has proved effective on a wide variety of characins in that country and should prove readily adaptable to *B. guatemalensis* in Costa Rica: Or, it might prove possible to duplicate the results of Lake (1967), who was able to spawn a number of Australian fishes which are characteristically rainy season spawners, by manipulating the water level.

FEEDING HABITS

The gut contents of 40 *B. guatemalensis*, ranging from 61 to 400 mm (2.3 to 16 inches) in total length were examined. This work was done under field conditions and is necessarily crude. Quantitative assessments were not made; only the presence or absence of each food type was noted. Table 2 lists the number and percentage of fish in two size categories which had consumed several types of food. As a microscope was not available, insects were identified only to order.

Of particular interest to fish culturists is the relative importance of animal and plant foods. Of the 18 larger fish, 17 - or 94.4% had eaten vegetable matter. (The one exception was a specimen with a completely empty digestive tract.) Only six (33.3%) had consumed any animal food. The preference for plant material would be even more striking if quantitative data were available; most specimens contained large masses of leaves and/or fruit pulp, while the animal constituent of the diet was usually represented only by a few small individual organisms. The smaller fish were more omnivorous; 20 of 22 (90.9%) had eaten animal matter, but 18 (81.8%) had also eaten plant matter. In no instance were the large masses of vegetable matter typical of the larger fish found in the smaller ones.

The type of animal food also varied with the size of the fish. The small fish were as prone to feed on aquatic insect larvae (13 specimens, or 59.1%) as on terrestrial insects (15 specimens, or 51.9%). Almost all of the animal food taken by the large fish consisted of terrestrial insects (5 specimens, or 27.8%). No aquatic insect larvae were found in the stomachs of the large fish, although two of them (11.1%) had eaten aquatic crabs, which were not consumed by the smaller fish.

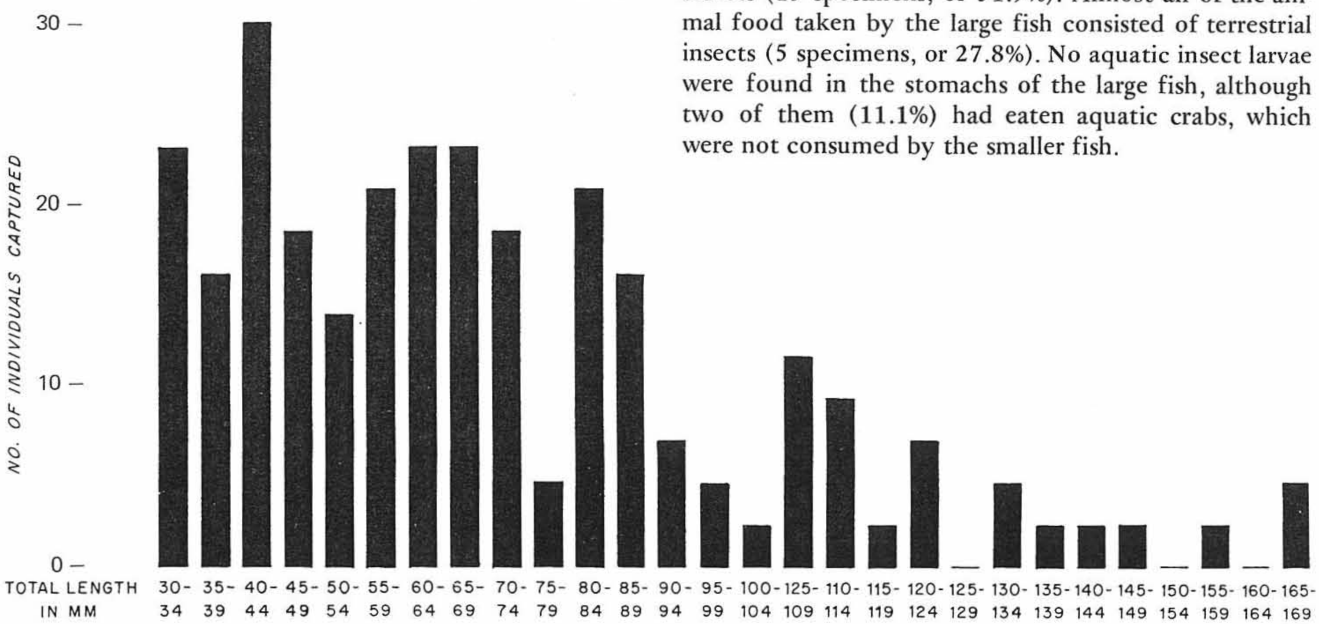


FIG. 3

The principal vegetable constituent in the diet of the large fish was tree leaves (13 specimens, or 72.2%), which were always found shredded into small triangular pieces. Apparently the unusual three-lobed teeth of *Brycon* spp.

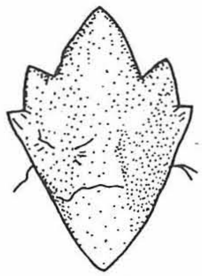


FIG. 4

(Figure 4) are an adaptation for this function. Other plant foods consisted of fruit and seeds (12 individuals, or 66.7%) and other parts, including stems, flowers, roots, and bark (5 specimens, or 27.8%). The absence of aquatic plants in the diet reflects the absence of such plants in the Tirimbina.

Only one of the smaller fish was found to have shredded leaves in its stomach, although four specimens (22.2%) contained single leaves. Other types of plant material were proportionally more important, as seven specimens (31.9%) contained fruit and/or seeds, while the same number contained other types of plant remains.

These data are in agreement with the observations of Lowe (1964) and Menezes (1969). Lowe observed *B. falcatus* in British Guiana to feed on fruit and flowers which dropped into the water from overhanging branches. Menezes studied the food habits of *B. chagrensis* and *B. petrosus* from the Canal Zone and Honduras. He found that 80.0 and 85.7% of the food, respectively, of these two species was of vegetable origin, with the remainder being made up entirely or almost entirely of aquatic insect larvae.

Although fishermen on the Rio Tirimbina believe, apparently erroneously, the *B. guatemalensis* feeds on small fish, while de Gil (1949) reported that artificial minnows were used by anglers to take *B. orbignyanus* in Argentina, Menezes' (1969) statement that *"All species in this genus show a strong preference for plant material"* seems generally acceptable.

BEHAVIOR AND HABITAT PREFERENCE

No concerted attempt was made to study the behavior of *B. guatemalensis,* but a few observations were made which may be of interest:

B. guatemalensis of all sizes were found chiefly in pools or in swift-flowing but flat-topped water. Rarely were they found in riffles and then usually only as transients. The larger individuals seldom ventured far from cover and seemed particularly fond of undercut banks.

Ample cover did not seem requisite for smaller individuals, which were often found in quite exposed locations. At first glance, small *B. guatemalensis* appeared to occur in mixed groups with *Astyanax fasciatus,* but further observation indicated that *B. guatemalensis* was found mainly in the lower reaches of pools, while *A. fasciatus* were concentrated near the heads. In one instance, a seine haul made at the tail of a pool yielded 14 *B. guatemalensis* and three *A. fasciatus;* a subsequent haul at the head of the same pool brought up one *B. guatemalensis* and 12 *A. fasciatus.* This informal experiment was not repeated, but was corroborated by rough counts taken while diving.

B. guatemalensis of all sizes were more active and more apt to be in open water during the hours just after dawn and just before dusk than at any other time. A few attempts were made to observe them at night, but there was no indication of any activity during darkness. On a few days, individuals or groups were seen feeding or rest-

TABLE 2

Occurrence of Food Types in Brycon guatemalensis Stomachs

		Terrestrial Plants					Aquatic Insects			
Length Range (mm)	No. of Fish	Leaves	Fruit & Seeds	Other Parts	Total Terrestrial Plants	Kitchen Refuse (vegetable)	Odonata (Dragonflies & Damselflies)	Coleoptera (Beetles)	Ephemeroptera (Mayflies)	Total Aquatic Insects
61-178	22	4(18.2%)	7(31.9)	7(31.9)	13(59.1)	8(36.4)	3(13.7)	5(22.7)	10(45.5)	13(59.1)
183-400	18	13(72.2)	12(66.7)	5(27.8)	17(94.4)	2(11.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Terrestrial Insects									
Hymenoptera (Ants, Wasps, Etc.)	Coleoptera (Beetles)	Lepidoptera (Butterflies & Moths)	Orthoptera (Grasshoppers, Etc.)	Unidentified	Total Terrestrial Insects	Crustacea (Crabs, Potamon)	Total with Vegetable Food	Total with Animal Food	Mud & Gravel
6(27.3)	4(18.2)	0(0.0)	0(0.0)	9(40.9)	15(51.9)	0(0.0)	18(81.8)	20(90.9)	1(4.5)
2(11.1)	2(11.1)	1(5.6)	1(5.6)	0	5(27.8)	2(11.1)	17(94.4)	6(33.3)	2(11.1)

Stomach Empty
0(0.0)
1(5.6)

ing in open water during the hours of bright sunlight, but typical mid-day activity consisted chiefly of nervous darts from cover through open water and back to cover; this was usually done by groups of 2-10 fish. Toward the end of the study period it became common to see individuals dashing through a pool at full speed, rolling and flashing their sides; this may have been connected with the approach of the spawning season. A more frequently observed mid-day behavior was migration through riffles from pool to pool. This was always done in groups of five fish or more, and always at a very high rate of speed.

Many attempts were made to observe feeding behavior, by diving and from the bank. All that was seen was *B. guatemalensis* taking floating insects or other small food items. There was never an opportunity to observe the supposed shredding action of the teeth.

There was little indication of social organization.

POND STOCKING EXPERIMENT

B. guatemalensis, and *Brycon* spp. in general, are characteristically river fishes and, so far as is known, are not native to standing waters. However, it does not necessarily follow that they will not survive in ponds and lakes. The various Chinese carps, which have been cultured in ponds for thousands of years, are not known as wild fishes from such habitats. It may be that *Brycon* spp., like the Chinese carps, are absent from ponds and lakes not because they cannot survive in them, but because they require running water to reproduce.

An indication that *B. guatemalensis* can survive in standing water was given in February, 1973, when a large metal tank located on the bank of the Rio Tirimbina was drained. The tank had been stocked in August, 1972, with an assortment of river fishes, including a number of supposed *Astyanax fasciatus.* These fish had been nelected and largely forgotten; the water in the tank was stagnant, rusty to the degree that visibility was less than 55 mm (2 inches) and undoubtedly considerably warmer than river water. No food had been provided except for such leaves and insects as fell into the tank. Several of the *A. fasciatus,* plus one 80 mm (3 inch) *B. guatemalensis* were found, emaciated but alive.

One experiment in stocking a small, shallow, mud bottom pond with *B. guatemalensis* was carried out. The pond, located at Granjas Tropicales, within a few minutes walk of the Rio Tirimbina study area, had previously been stocked with *Tilapia* sp., and a few of these fish remained, along with a few *Rivulus isthmensis.* There was a small flow of water through the pond, but it was certainly stagnant in comparison with the river, and water temperatures during the study period ran 28-32°C (82-90°F) - considerably higher than in the river.

Beginning 2/23 and lasting through 3/11, *B. guatemalensis* in the length range 30-165 mm (1-6.5 inches), captured in the course of the length-frequency study, were stocked in the pond. These fish were placed in plastic buckets immediately upon capture and transported to the pond as rapidly as possible. The buckets were covered and floated in the pond until the water temperatures inside and outside were equalized, then the fish were released. At first there was nearly 50% mortality owing to the nervous temperament of the fish, which repeatedly leaped and battered themselves against the sides and cover of the bucket. Later it was found that a few large leaves floated on the water surface greatly reduced the incidence of leaping, and mortality was reduced to around 10%. This mortality was largely confined to 30-40 mm (1-1.5 inch) fish, which were very fragile with respect to handling.

The only fish from these stockings which was sighted again was a ca. 65 mm (2.5 inch) specimen seen on 3/3. Since the last stocking previous to that date was on 2/26, this individual had survived at least five days. Repeated attempts were made to observe other *B. guatemalensis* in the pond as late as 3/30, but to no avail. Attempts were made with flashlights at night, when characins are normally inactive, as well as during the day.

There are four possible explanations for the disappearance of the stocked fish. One is that they found the habitat unsuitable and died. This appears unlikely in the light of the anecdotes above and in view of the fact that no dead specimens were ever found. It is also possible that they were present, but never seen. This also seems unlikely, since many *Tilapia* sp. could readily be seen at night, and three *Rivulus isthmensis,* by nature a secretive fish, were observed. It seems more likely that the stocked fish were eaten by predators (the pond was relatively devoid of cover); or perhaps they escaped. The pond has no inlet, but does have a small outlet. The outlet was screened, but perhaps not adequately.

It is my opinion that *Brycon* spp. will eventually be shown to survive well in standing water. The crude stocking experiment of 1973 should be repeated under better conditions.

EDIBILITY AND PREPARATION

Brycon spp. have one disadvantage as food fishes; they are very bony. Facilities for cooking experiments at Tirimbina were limited, but a few methods of frying *B. guatemalensis* were tried and the acceptance of the product noted.

Small specimens (under 100 mm - 4 inches) were gutted, headed and fried until the bones became brittle and could be chewed up along with the flesh. The result was a crispy "fish chip" which was liked by all who tried it. Some judged them to be superior to *Astyanax fasciatus* prepared in the same manner.

Larger specimens were sometimes fried in the normal manner and sometimes chopped up in small pieces and cooked as though they were small fish, that is until the bones were brittle. Everyone agreed that fish cooked by the former method were tasty, but several individuals found the bones objectionable. The other frying method produced no objection from anyone.

The subjects in the above observations were all North Americans, but the local people also make use of *B.*

guatemalensis as a food fish. They agree with the North Americans who have tried it that the flesh is excellent. No complaints of boniness were heard from Tirimbina residents who preferred *B. guatemalensis* to such other local species as *Cichlasoma tuba* which was equally available and less bony.

SUITABILITY FOR CULTURE

The work described here is of course only the beginning of evaluation of *B. guatemalensis* as a cultured food fish. It is already possible, however, to outline some of its advantages and disadvantages for this purpose:

Advantages:

1. Low position on the food chain, enabling it to be fed cheaply.
2. Utilization of readily available foods which are not wanted for other purposes (i. e. tree leaves) or to feed other fishes.
3. High quality of flesh.
4. Acceptability to Costa Ricans as a food fish.
5. Probable ease of breeding.

Disadvantages:

1. Lack of knowledge of behavior and ecology.
2. Boniness
3. Nervous temperament and delicacy of small specimens with regard to handling.

In my opinion, the known advantages outweigh the disadvantages, and the potential for culture of *B. guatemalensis,* either as a mono-crop or as one component of an analog of Chinese pond polyculture, is great. We should be beginning to attempt the culture of this species, while at the same time pursuing further investigations of the behavior and ecology of the wild form.

SUGGESTIONS FOR FURTHER STUDY

The following very briefly outlined projects were suggested by my work on the Rio Tirimbina in 1973.

1. *Age and growth of B. guatemalensis:* This would involve capturing, measuring, marking and releasing a large number of *B. guatemalensis,* then attempting to recapture and remeasure them over a long period of time, so that natural growth rates could be established. This study could be combined with a population estimate with no increase in physical labor.

2. *Ecological niches of B. guatemalensis and Astyanax fasciatus:* This study could begin with more extensive seining and diving observations of the sort reported here, which suggested that the two species are found in the tail and head of pools, respectively. It could be extended to observations of the diet, behavior, etc. until the niches of these similar species can be defined.

3. *Breeding habits in nature:* Attempts should be made to observe the spawning of *B. guatemalensis.* Should high water preclude this, it would nonetheless be valuable to know the size, date, and place of occurrence of ripe adults, drifting eggs, and/or early fry.

4. *Breeding in captivity:* Attempts should be made to reproduce *B. guatemalensis* in captivity by the methods suggested in the text. Correspondence with Brazilian fish culturists, who regularly breed many species of characins, would be in order.

5. *Pond stocking:* The 1973 pond stocking experiment should be repeated under better conditions.

6. *Food chain studies:* The food habits of *B. guatemalensis* and other fishes of small Costa Rican streams like the Rio Tirimbina should be further examined and compared with data from larger streams in the area or with temperate zone waters. It appears that the amount of fish food originating terrestrially is extremely high in small tropical streams, a piece of information which may have implications for aquaculturists or anyone else concerned with the fate of tropical ecosystems.

7. *Feeding behavior of B. guatemalensis:* If possible, *B. guatemalensis* should be observed in the act of feeding on plant materials. This could involve field observation or aquarium work. In addition to defining the manner in which the unusual teeth of *Brycon* spp. function, this study could also be used to test food preference.

8. *Cage culture:* Wire cages could be anchored in a small stream such as the Tirimbina and stocked with *B. guatemalensis.* These fish could be fed various diets and their growth compared to that of wild fish. A problem here could be high water.

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