

SPECIALIZED PETIOLE FEEDING BEHAVIOR IN
CICHLASOMA TUBA (MEEK, 1912)
(CICHLIDAE)

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ABSTRACT

Results from field and laboratory studies show that the cichlid *Cichlasoma tuba* forages preferentially on leaf petioles. This preference might be due to the high protein content present in this part of the leaf. A sympatric characid, *Astyanax fasciatus* has a more generalized diet, but is excluded from taking leaf petioles by *C. tuba*.

Behavioral studies have only recently attempted to deal with the ecological aspects of feeding by fishes (Pietsch, 1978; Baskin *et al.*, 1980; Bray, 1980; Cadwallader *et al.*, 1980; Dussault and Kramer, 1981; Kilambi and Zdinak, 1982; Hoenicke, 1983). Studies on feeding behavior of tropical freshwater fishes are few, due mainly to the technical problems involved in performing field observations which can be complemented with laboratory studies. However, fishes that feed on objects dropped on the surface of the water provide an opportunity to conduct such studies. Bussing (1975) presented the results of analysis of the stomach contents of thirty three adults of the cichlid *Cichlasoma tuba* (Meek, 1912). His data reveal that this species is predominantly herbivorous (92% by volume of food ingested), terrestrial leaves (40%) and bryophytes and algae (34%) were the main food items. The means by which *C. tuba* obtains terrestrial leaves has yet to be described.

Materials and Methods

C. tuba is known only from the Atlantic slope of Costa Rica, where it is common in lowland rivers or large streams which have moderate to considerable current (Bussing, 1975). I worked at the Rio Puerto Viejo, near "La Casa de Rafael" (16°25'N and 84°00'W), about 300 m upstream from the Organization for Tropical Studies field station at La Selva. There was a semi-submerged log (about 4 m long) which had a longitudinal opening (approximately 1.5 m long and 0.4 m wide) in the side that faced the riverbank. During two days of observations in July 1981, the opening was occupied by one individual of *C. tuba* and one of the characid *Astyanax fasciatus* (Cuvier, 1819). The *C. tuba* was 160 mm, and the *A. fasciatus* 70 mm long.

Before the experiments, I had observed that *C. tuba* came out from the log and took only petioles that had fallen on the surface of the water between the log and the nearest riverbank. These petioles from various tree species fell from the surrounding trees as a result of ant predation on leaves. These ants (*Arta* sp.) are leaf cutters that eat the leaf excluding the petiole, which accelerates the decay of the latter. *A. fasciatus* behaved similarly but showed a preference for complete or incomplete leaves that dropped on the water. In both cases the food was taken into the log where it was presumably eaten.

Field and laboratory studies were conducted to test the hypothesis that *C. tuba* is in fact a petiole-eating specialist. In the field, 90 different food items of five different types (18 of each type) were dropped on the surface of the water between the semi-submerged log and the riverbank during two days of observations. The food items were dropped at 5 min intervals. The type and order of the items dropped was: 1 complete leaf (about 200 mm long), 1 incomplete leaf (25 to 75%, but with petiole), 1 petiole, 1 stick (leaf size), and 1 piece of bread (about 8 cm³). The cycle was repeated eight times in each day of observation. All observations were made between 0700 and 1130 hrs, and between 1330 and 1600 hrs. Some leaves and petioles also fell naturally onto the surface of the water during the experiments, and were also included in the data. Two time intervals were measured: 1) from the moment the food item hit the surface of the water to the moment an investigating fish took it or turned away; and 2) from the end of the first-time interval to the moment a fish disappeared into the log. A 35 mm camera with a telephoto lens was used to record the item taken by the fishes. During the observations I was prone on the bank; the fishes never came out from the log while I was standing.

In the laboratory, four individuals of *C. tuba* (mean size = 150 mm, range 140 – 160) and four individuals of *A. fasciatus* (mean size = 95 mm, range 90 – 100) which were collected in the same area as the field observations, were placed in pairs composing one individual of each species in a 2.5 x 1.5 m arena tank, which was partially covered (about 25%) with a piece of wood. A television camera connected to a monitor was placed about 3 m above the surface of the water. Kinds of items presented, the order in which they were dropped and the time intervals measured were as in the field studies.

To test whether *A. fasciatus* failed to take petioles because of competition with *C. tuba*, the same laboratory procedures were repeated using single individuals of this characid.

Results

Cichlasoma tuba had a marked and significant preference for petioles both in the field and the laboratory (Table 1) (Kendall rank-order correlation coefficient ($n = 20$, $\text{Tau} = 0.2500$, $p < 0.01$); *A. fasciatus* had a more generalized diet but did not take petioles. *Astyanax fasciatus* was slower leaving the log and the covered area.

of the tank, but returned to them faster (Wilcoxon matched-pairs signed-rank test, $n = 72$, $p < 0.01$) (Table 2). It was observed that the *A. fasciatus* usually left the log (or the covered area of the tank) after the *C. tuba* had approached the object dropped. When feeding alone individual *A. fasciatus* included petioles in their diet and did not show any significant preference toward any of the food items present (except for sticks which never were taken) (Kendall's $n = 90$, $\text{Tau} = 0.3243$, $p < 0.05$) (Table 3) suggesting that it was excluded from doing so previously by competition with *C. tuba*. In the laboratory experiments both species remained in the shaded area for about 90% of the time.

Discussion

The hypothesis that the *C. tuba* individuals observed were petiole specialists was confirmed. Although records of fishes that display specialized foraging on leaves, flowers, and fruits are not rare (Honda, 1974; Smith, 1981, p. 63), this is the first report of a preference for petioles. However, it has been reported among other vertebrates, and this has been explained on the basis of a high protein content present in this part of the leaf (Struhsaker, 1975, p. 131). All individuals of the species are not necessarily similarly specialized, clearly other food items are often taken, as suggested by the stomach content studies (Bussing, 1975). Moreover, the diet of any individual may shift with time as has been shown for other tropical fishes (Zaret and Rand, 1971). The petiole-eating specialization could be specific to the study area. Results for *A. fasciatus* are not surprising since it is known to be an omnivorous fish for which bread is used as bait (Romero, 1984), and whose survivorship can be facilitated by leaf cutter ants (Hoenicke, 1983). Results in Table 3 supported the suggestion that *A. fasciatus* had no opportunity to eat petioles because *C. tuba* had arrived first and consumed them.

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Resumen

Estudios de campo y laboratorio sugieren que el ciclido *Cichlasoma tuba* puede mostrar preferencia hacia peciolas caídas en el agua sobre cualquier otra fuente alimenticia. Dicha preferencia puede ser debida al alto contenido proteínico en esta parte de las hojas. El carácido *Astyanax fasciatus* que se observó en la misma zona de estudio mostró una dieta más generalizada, si bien fue excluido de obtener peciolas debido a la competencia mostrada por *C. tuba*.

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Table 1. Number of food items taken by *C. tuba* and *A. fasciatus* (N = number of times items were offered).

Fish species	Bait	Complete leaves	Incomplete leaves	Petioles	Sticks	Bread
A) in the field		(N = 20)*	(N = 19)**	(N = 20)*	(N = 18)	(N = 18)
<i>C. tuba</i>		1	2	16	0	1
<i>A. fasciatus</i>		14	14	0	0	16
B) in the lab***		(N = 16)	(N = 16)	(N = 16)	(N = 16)	(N = 16)
<i>C. tuba</i>		0	2	14	0	0
<i>A. fasciatus</i>		13	11	1	0	15

- * Two of them fell naturally from the surrounding trees
- ** One of them fell naturally from the surrounding trees
- *** Four items of each type per individual fish.

Table 2. A) time from the moment the food item was dropped on the surface of the water to the moment the fish takes it or turns away; B) time from the end of the first time interval to the moment the fish disappears into the covered area of the tank.

Fish species	Time A (secs.)			Time B (secs.)		
	\bar{x}	SD	Range	\bar{x}	SD	Range
A) in the field						
<i>C. tuba</i>	3.833	0.809	2.9 - 4.8	3.344	0.627	2.5 - 4.2
<i>A. fasciatus</i>	4.900	0.022	4.7 - 5.1	2.900	0.158	2.7 - 3.1
B) in the lab						
<i>C. tuba</i>	2.455	0.270	2.0 - 2.9	1.633	0.158	1.4 - 1.9
<i>A. fasciatus</i>	2.800	0.122	2.7 - 2.9	1.500	0.150	1.3 - 1.7

Table 3. Number of food items taken by a total of four individuals of *A. fasciatus* when placed alone in the arena tank (N = number of items offered).

Complete leaves (N = 18)	Incomplete leaves (N = 18)	Petioles (N = 18)	Sticks (N = 18)	Bread (N = 18)
12	11	13	0	16