

Nocturnal Behavior and Aspects of the Ecology of a Driftwood Catfish, *Entomocorus gameroi* (Auchenipteridae)

Driftwood catfishes of the family Auchenipteridae, which are largely confined to fresh waters of South America and are commonly found in the river flood plains, include more than 60 species in 21 genera (Curran 1989). The auchenipterids are nocturnal and usually measure less than 150–200 mm; most genera show secondary sexual dimorphism (Mago-Leccia 1983, Mees 1974). Very little is known about the ecology of these fishes (Goulding 1980), despite their wide geographic distribution in South America, perhaps because their nocturnal habits make them difficult to catch by conventional techniques. *Entomocorus gameroi*, which was recently described by Mago-Leccia (1983), is a small (50–70 mm standard length (SL)) auchenipterid catfish that is widely distributed along the lower Orinoco and Apure rivers in Venezuela. We document here the nocturnal behavior of the fish and some aspects of its ecology, emphasizing feeding, reproduction, and the use of various substrata as daytime shelter.

During the periods of low water (December–June) of 1986, 1987, and 1988, we sampled fish communities of flood plain lakes along the lower Orinoco River in Venezuela with an electrofishing boat similar to that described by Reynolds (1983). Most samples were collected in Lake Terecaya, a channel lake devoid of macrophytes near Ciudad Bolívar. Serial samples were collected from Lake Terecaya by electrofishing during the low-water season of 1987 on the following dates (sample sizes indicated in parentheses): 29 Jan. (28), 12 Mar. (48), 15 Apr. (45), 28 Apr. (72), and 10 Jun. (315). Additionally, single samples were collected once at the end of the 1986 low-water season on 22 May (413), and once at the beginning of the 1988 low-water season on 8 December (27). In Lake Terecaya the onset of the high-water season occurs in June, after which the water level rises rapidly; in two months lake depth increases from approximately 2 m to over 7 m, and the river, forest, plains, and lakes become broadly interconnected. During the high-water season population densities of all fish species are drastically reduced in the lake until December, when the flood recedes and the lake once more becomes isolated. During the high-water period we did not attempt night sampling for *E. gameroi*, and no individuals were captured in daytime sampling. We dissected 287 individuals to examine gonad development, and 30 more individuals for gut content analysis. Fullness estimates were made for nonempty stomachs by visually assessing the volume of stomach contents; estimates were rounded using five categories: less than 5%, 25%, 50%, 75%, and 100%, where 100% represents a full or distended stomach. We observed the behavior of *E. gameroi* in the laboratory by placing three adults (55–60 mm SL) in a large aquarium (140 liter) with a gravel bottom, deadwood, rocks, and water hyacinth, and allowing three days for acclimation.

FEEDING HABITS.—Intensive sampling of Lake Terecaya showed that *E. gameroi* is largely inactive during the daytime but swims vigorously near the water surface at night, where it feeds on zooplankton. Individual fish can ingest more than 1700 planktonic crustacea in one night, and nonplankton items are rarely consumed. The main items in the diet were cladocerans, copepods, and water mites (Table 1). Of 30 fish examined, 22 (73%) had empty stomachs. For the eight remaining fish, average fullness values were 37.5%, 25%, and 25% for the mean, median, and mode, respectively. All food items were found in the stomach, and were hardly digested. *E. gameroi* has large eyes, a moderately well developed gas bladder, a terminal, rounded mouth, short jaws, reduced teeth, and long, slender gill rakers. The ratio of intestine length to body length is less than one, as is typical of carnivorous fish (Nikolsky 1963). Combined, these features may be viewed as adaptations to visual feeding on zooplankton in pelagic waters (*cf.* Nikolsky 1963, Hyatt 1979).

The feeding habits of the auchenipterids are still largely undescribed. Some of the smaller species are known to hide in logs and crevices during the day and come out to feed during the night (*e.g.*, *Centromochlus*, Lowe-McConnell 1975; *Parauchenipterus*, Burgess 1989; *Auchenipterichthys*, *Tatia*, and *Entomocorus*, pers. comm.). Among the larger species, *Trachycorystes* (two spp., Goulding 1980) and *Tocantinsia depressa* (Carvalho & Kawakami 1984) can feed on fruits and insects, and are probably omnivorous. Members of the family seem to feed primarily on insects (Saul 1975, Goulding 1988), but fish and shrimp (Goulding 1988), and even filamentous algae and other plant material (Vari *et al.* 1984), can also be consumed, at least occasionally. To our knowledge, ours is the first report of zooplanktivory by an auchenipterid.

TABLE 1. *Gut content analysis of E. gameroi—late low-water season, 1986. Thirty specimens were examined: 15 females, 12 males, 3 undetermined. Twenty-two individuals had empty stomachs. SL of specimens: 51–67 mm.*

Items	Frequency of occurrence ^a (%)	Numerical dominance ^b	
		%	Abundance
Cladocera	100	68	335
Copepoda	75	24	118
Hydracarina	75	8	37

^a Frequency of occurrence was calculated using the formula

Occurrence =

$$\frac{\text{Number of stomachs in which an item was present}}{\text{Total number of non-empty stomachs}}$$

× 100.

^b Numerical dominance was calculated using the formula

Dominance =

$$\frac{\text{Numerical abundance of an item}}{\text{Total numerical abundance of all items}} \times 100.$$

REPRODUCTION.—On all study dates the frequency distribution of standard length was clearly unimodal, indicating that a single cohort was present in the lake, and in serial samples from 1987 the modal length consistently increased throughout the low-water season. Members of a given year's cohort were never found in the lake the following year. Dissection of specimens showed that gonad development proceeded during the low-water season until sexual maturity was reached in June; secondary sexual characteristics, particularly barbel and fin modifications in the males, were then most developed. On 10 June ova from dissected ovaries were filled with yolk (max. size = 0.79 mm), and several females released bright orange eggs into holding tanks where they were kept in the presence of males. The lake population therefore consists of a single cohort that breeds in June near the end of the low-water season, when river water enters the lake. Thus, the yearling adults must either permanently emigrate when floodwaters enter or, more plausibly, they are short-lived and perish soon after reproducing. The latter view is supported, at least for the sexually dimorphic males, by the profound osteological modifications at breeding time. Among these modifications, the considerable lengthening of the pelvic and dorsal fins might encumber locomotion and therefore condemn the fish to rapid elimination by predation, especially if the osteological changes are irreversible (Mago-Leccia 1983). Females, however, do not undergo external morphological changes, nor do they show the large investment in gonad mass characteristic of total spawners: the mean ratio of gonad weight to total body weight for 29 mature females was only 0.011. There was a continuous gradation from small yolkless white ova to large yolk-filled orange ova, which suggests that small batches of eggs are produced at frequent intervals ("small brood" spawning, Lowe-McConnell 1975). In the absence of information on total seasonal fecundity, we cannot at present evaluate the costs of breeding in females. With the exception of cyprinodontids (killifishes), there is sparse documentation of annual or nearly annual life cycles in Neotropical freshwater fishes, even though short lifetimes could be expected to occur frequently among species with small adult size. Nevertheless, small (less than 70–80 mm adult SL) and very small (less than 25 mm adult SL) species are common in Neotropical freshwaters (Weitzman & Vari 1988).

NOCTURNAL BEHAVIOR.—In the course of a 24-hr sampling session in Lake Terecaya, we captured only one individual of *E. gameroi* by electroshocking (less than 0.25% of total fish numbers) during the day,

and this individual was captured near dusk. At night, *E. gameroi* was dominant among the fish that were captured: 413 individuals were captured, and this accounted for 60 percent of the individuals of all species. In a regional survey of 19 more flood plain lakes, we found *E. gameroi* very rarely in daytime samples. When *E. gameroi* was captured during the daytime, it was always in shallow water; or, when in waters deeper than 1 m, in close association with clumps of water hyacinth (*Eichhornia* sp.). In the latter cases the fish seemed to be hiding among the submerged roots of the plant. Previously documented associations between fish and vegetation in the Neotropics include the use of specific vegetation types, matched by cryptic features (grass stems: Reid 1986), and of *Eichhornia* for shelter, forage, and transport (Sazima & Zamprogno 1985).

In the aquarium the fish swam actively in midwater at night; whereas, during the day, or under artificial light, they remained motionless after lodging in gaps in the rocks or deadwood, dropping to the bottom, or hiding within the roots of water hyacinth, to which they attached themselves by clasping the roots with their pectoral fins, aided by the serrations on the fin spines. We never observed the fish foraging within or near roots, which they seemed to use exclusively for cover. The abundance of *E. gameroi* in hyacinth-free Lake Terecaya and its behavior in the aquarium demonstrate that the fish can thrive in the absence of *Eichhornia*, probably by using wood, rocks, and other benthic substrata as alternate sources of shelter. Fish that associate with a substratum during the day, resting motionless and semi-concealed, can be made less conspicuous to visual predators than fish that remain in the water column. Daytime concealment may be advantageous in an environment where predators are both abundant (Lowe-McConnell 1975, Goulding 1980, unpublished data for Lake Terecaya) and adapted to prevailing light conditions (Muntz 1982).

To summarize, we have documented here three salient features of the ecology and behavior of *E. gameroi*. The fish feeds on zooplankton in open waters; this seems to be the first report of zooplanktivory by an auchenipterid. *E. gameroi* reaches sexual maturity in only one year, breeding once at the end of that period and perishing soon after. This finding is interesting because among Neotropical freshwater fishes, annual or nearly annual life histories have been well documented only for killifishes. Field and lab observations show that *E. gameroi* is exclusively nocturnal, and uses a variety of benthic and floating substrata for daytime shelter. We recommend that ecologists interested in studying zooplankton populations in Neotropical lakes be aware of the pitfalls that can result from ignoring nocturnal zooplanktivores such as *E. gameroi*, which may be difficult to detect using conventional fishing gear. For the Neotropics there are still no estimates of the ubiquity and abundance of these fishes, or of the strength of their interactions with zooplankton populations.

We thank I. Sazima and two anonymous reviewers for helpful criticism. Financial support for this work came from a scholarship from the National Sciences and Engineering Research Council of Canada to M.A.R., a grant from the National Geographic Society, and NSF Grant BSR 8604655. The Venezuelan Ministerio del Ambiente y de los Recursos Naturales Renovables provided logistical assistance.

- BURGESS, W. E. 1989. An atlas of freshwater and marine catfishes. TFH Publications.
- CARVALHO, F. M., and E. KAWAKAMI. 1984. Aspectos da biologia de *Tocantinsia depressa* (Siluriformes, Auchenipteridae). Amazoniana 8: 327-337.
- CURRAN, D. J. 1989. Phylogenetic relationships among the catfish genera of the family Auchenipteridae (Teleostei: Siluroidea). Copeia 1989(2): 408-419.
- GOULDING, M. 1980. The fishes and the forest. Univ. of California Press.
- . 1988. Rio Negro, rich life in poor water. SPB Academic Publishing.
- HYATT, K. D. 1979. Feeding strategy. In W. S. Hoar, D. J. Randall, and J. R. Brett (Eds.). Fish physiology, Vol. 8, pp. 71-119. Academic Press, Orlando, Florida.
- LOWE-McCONNELL, R. H. 1975. Fish communities in tropical freshwaters. Longman.
- MAGO-LECCIA, F. 1983. *Entomocorus gameroi*, una nueva especie de bagre auquenipterido (Teleostei, Siluriformes) de Venezuela, incluyendo la descripción de su dimorfismo sexual secundario. Acta Biol. Venez. 11: 215-236.
- MEES, G. F. 1974. The Auchenipteridae and Pimelodidae of Suriname (Pisces, Nematognathi). Zool. Verh. (Leiden) 132: 1-256.
- MUNTZ, W. R. A. 1982. Visual adaptations to different light environments in Amazonian fishes. Rev. Can. Biol. Exp. 41: 35-46.
- NIKOLSKY, G. V. 1963. The ecology of fishes. Academic Press, Orlando, Florida.
- REID, S. B. 1986. Cryptic adaptations of small juvenile catfishes *Sorubim lima* (Pimelodidae) in Venezuela. Biotropica 18: 86-88.

- REYNOLDS, J. B. 1983. Electrofishing. In L. A. Nielsen, and D. L. Johnson (Eds.). Fisheries techniques, pp. 147–163. Amer. Fish. Soc.
- SAUL, W. G. 1975. An ecological study of fishes at a site in upper Amazonian Ecuador. Proc. Acad. Nat. Sci. Phila. 127: 93–134.
- SAZIMA, I., AND C. ZAMPROGNO. 1985. Use of water hyacinths as shelter, foraging place, and transport by young piranhas, *Serrasalmus spilopleura*. Environ. Biol. Fishes 12: 237–240.
- VARI, R. P., S. L. JEWETT, D. C. TAPHORN, AND C. R. GILBERT. 1984. A new catfish of the genus *Epapterus* (Siluriformes: Auchenipteridae) from the Orinoco River basin. Proc. Biol. Soc. Wash. 97: 462–472.
- WEITZMAN, S. H., AND R. P. VARI. 1988. Miniaturization in South American freshwater fishes; an overview and discussion. Proc. Biol. Soc. Wash. 101: 444–465.

Marco A. Rodríguez, Susan E. Richardson, and William M. Lewis, Jr.

Center for Limnology
Department of Environmental, Population, and Organismic Biology
Campus Box 334
University of Colorado
Boulder, Colorado 80309
