Mem. Inst. Oswaldo Cruz, Rio de Janeiro, Vol. *85* (1): 35-38, jan./mar. 1990

BIOLOGICAL CONTROL OF *BIOMPHALARIA TENAGOPHILA* (MOLLUSCA, PLANORBIDAE), A SCHISTOSOMIASIS VECTOR, USING THE FISH *GEOPHAGUS BRASILIENSIS* (PISCES, CICHLIDAE) IN THE LABORATORY OR IN A SEMINATURAL ENVIRONMENT

MARCIA WEINZETTL & PEDRO JURBERG*

Instituto Oswaldo Cruz, Departamento de Biologia, Laboratório de Comportamento Animal, Caixa Postal 926, 20001 Rio de Janeiro, RJ, Brasil *Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

In order to investigate a possible method of biological control of schistosomiasis, we used the fish Geophagus brasiliensis *(Quoy & Gaimard, 1824) which is widely distributed throughout Brazil, to interrupt the life cycle of the snail* Biomphalaria tenagophila *(Orbigny, 1835), an intermediate host of* Schistosoma mansoni. *In the laboratory, predation eliminated 97.6% of the smaller snails (3-8 mm shell diameter) and 9.2% of the larger ones (12-14 mm shell diameter). Very promising results were also obtained in a seminatural environment. Studies of this fish in natural snail habitats should be further encouraged.*

Key words: biological control – *Geophagus brasiliensis* – *Biomphalaria tenagophila* – schistosomiasis

The greatest advantage of biological control is the possibility of interrupting the life cycle of a harmful organism using another living organism without any substances or other factors that may damage the environment. In addition, this is the least expensive method of control that could be used. However, in order to avoid future ecological disasters such as the predation of useful or commercial species in the regions where biological control is applied, it is advisable to carry out the study in 4 stages: initial laboratory tests, systematic laboratory tests, tests in a seminatural environment, and tests in a natural environment (WHO, 1984).

Several investigators (Lagrange, 1953; Michelson, 1957; Azevedo et al., 1960; Menezes, 1962; Aragão, 1967; Barnish, 1971; Gouveia & Motta, 1971; Berg, 1973, McMullen, 1973; Ferguson & Ruiz-Tiben, 1978; Jordan et al., 1980; McCullough, 1981; Feitosa & Milward-de-Andrade, 1986) have reported the introduction of predatory species at snail breeding sites, and some of them have used fish for the biological control of mollusks.

Among the fish utilized, those of the family Cichlidae are widely distributed throughout the tropical and intertropical regions of the two Americas and of Africa, representing 6% of the continental fish fauna in South America (Lowe-McConnell, 1975). The euryaline species *Geophagus brasiliensis* (Quoy & Gaimard, 1824) is abundant in rivers and lakes along the coast and in the hinterland of the State of São Paulo (Guimarães, 1930a, b), all of Southern Brazil (Pellegrin, 1908), the Santa Catarina coast, Paraná, Espírito Santo and Rio Grande do Sul (Magalhães, 1931), from the Amazon Basin and the Orinoco to the Rio da Plata, Rio Grande do Sul and Uruguay (Axelrod & Schults, 1955). The fish is currently know by the common names of "caraúna", "acaraúna", "acará", "acará-ferreira" and "papa-terra" (soil eater), the last name being due to the animal's habit of looking for food on or in the river or in the lake bed.

The objective of the present study was to determine the snail-eating potential of this species under laboratory and seminatural conditions for a later evaluation under natural conditions, as proposed by the WHO (1984).

MATERIALS AND METHODS

Laboratory environment

Animals and material used – We used 4 adult specimens of the fish *G. brasiliensis*

Research supported by CNPq.

Received July 10, 1989.
Accepted November 17, 1989.

from the Camorim Lagoon, Jacarepaguá, Rio de Janeiro, Brazil, measuring 9 to 13 cm in lenght and maintained in a 97 x 36 x 48 cm aquarium filled with water maintained for 48 h in a reservoir for dechlorination, and containing a biological filter.

We also used *B. tenagophila* snails measuring 3 to 14 mm in shell diameter, obtained from a watercress garden in the Caramujo neighborhood, Niterói, Rio de Janeiro, a natural snail breeding site. The snails were maintained in 67 x 43 x 27 cm aquaria filled with stabilized water and containing a substrate consisting of red soil, oyster meal and calcium carbonate.

Procedure – Without submitting the fish to food deprivation, we introduced daily 4 groups of 30 specimens each of *B. tenagophila* measuring 3 to 5 mm, 6 to 8 mm, 9 to 11 mm and 12 to 14 mm of shell diameter, respectively, for a total of 120 specimens.

The snails were introduced at the same time every day (14:00 h) through one of the corners of the aquarium and all at once. After 1 h we recorded the number of snails of each size range that had been preyed upon by counting the survivors. Air temperature was kept at 25 °C and water temperature at 25 °C throughout the experiment.

Seminatural environment

Animals and material used – For these studies we utilized 2 (2.75 x 2.5 m x 50 cm) deep cement tanks, each with a ramp on one side. The tanks were set up outdoors side by side in the Department of Biology of the Instituto Oswaldo Cruz. Tank I, which contained snails but no fish, was used as control, and tank II, which contained both snails and fish was used as the experimental tank.

Both tanks contained substrates and plants from the site where the fish had been collected.

We used 6 specimens of *G. brasiliensis* fish measuring 8 to 18 cm in length, and *B. tenagophila* snails from the same garden as mentioned in part "animals and material used".

Procedure – In the laboratory we divided the snails into 2 equal groups, the first consisting of 250 snails 3 to 5 mm in shel diameter and the second of 250 snails 6 to 8 mm in shell diameter in each group (experimental and control). We then introduced the selected snails and the plants into the tanks for a 4 day period of acclimatization, after which we started the sampling phase by introducing the fish into tank II.

The determination of the number of snails not preyed upon the fish was facilitated by using 125 m^2 squares for a total of 110 squares per tank. Approximately 30% of the squares were selected at random for each of the 3 sampling days.

Live snails of each diameter were counted on the selected squares but were not moved. Mean water temperature was constant at about 27 °C.

Field data – *G. brasiliensis* were collected from the Camorin Lagoon, Jacarepaguá, Rio de Janeiro to increase our breeding stock. We analyzed the stomach content of 8 animals averaging 5 cm in length.

RESULTS

Laboratory environment – The mean number of snails preyed upon within 1 h was 97.8% for diameters of 3 to 5 mm, 88.2% for diameters of 6 to 8 mm, 55.9% for diameters of 9 to 11 mm, and 9.2% for diameters of 12 to 14 mm (Table I).

Snails measuring 3 to 8 mm in diameter were bitten and crushed by the mouth of the fish, which spat out crushed parts of the shell a few seconds later. Snails measuring 9 to 11 mm in diameter were often bitten and spat out repeatedly, but were not ingested. Finally, the fish was unable to bite snails measuring 12 to 14 mm in diameter. Indeed the diameter of the fish's mouth was smaller than the diameter of these snails. On rare occasions, snails measuring 12 to 14 mm in diameter were preyed upon when their cephalopodal mass was distended. In these cases, the fish would bite and ingest the cephalopodal mass and leave the shell behind.

Analysis of the data by the chi-square test (Siegel, 1956) showed a significant difference between the 3-5 mm and 12-14 mm diameters of *B. tenagophila* used in the laboratory test, with preferential preying on snails measuring 3 to 5 mm in diameter (Table I).

TABLE I

Amount of *Biomphalaria tenagophila* (N = 120) snails of different diameters preyed upon by *Geophagus brasiliensis* (N = 4) during 9 days of observation. Means (x), Standard deviation (s) and (x) are also given

Days of observation	Diameter of snails preyed upon			
	(30) 3-5 mm I	(30) 6-8 mm II	(30) 9-11 mm III	(30) 12-14 mm IV
1	29	20	10	05
2	25	17	08	01
3	30	25	13	00
4	30	30	18	00
5	30	29	17	00
6	30	29	21	05
7	30	29	27	05
8	30	30	18	03
9	30	29	19	08
	97.8% x = 29.33 s = 1.65	88.2% x = 25.33 s = 5.02	55.9% x = 16.77 s = 5.57	9.2% x = 2.77 s = 2.80

I – II: $x = 2.27$; $p > 0.05$ – no significant difference.
I – III: $x = 8.43$; $p > 0.05$ – no significant difference.
I – IV: $x \doteq 22.18$; $p > 0.05$ – significant difference.
II – III: $x = 3.58$; $p > 0.05$ – no significant difference.
II – IV: $x = 14.68$; $p > 0.05$ – no significant difference.
III – IV: $x = 15.31$; $p > 0.05$ – no significant difference.

TABLE II

Numbers of *Biomphalaria tenagophila* snails of two different diameters (N = 1000) that survived predation by *Geophagus brasiliensis* (N = 6) under seminatural conditions (water temperature = 27 °C)

Days of observation	Surviving snails 3-5 mm		Surviving snails 6-8 mm	
	CG	EG	CG	EG
1	56	04	80	14
2	33	00	80	06
3	35	00	78	01

CG – control group; EG – experimental group.
Mann-Whitney U Test – comparison of CG and EG.
3-5 mm – n 1 = 3, n 2 = 3, U = 0, p = 0,050 – significant difference.
6-8 mm – n 1 = 3, n 2 = 3, U = 0, p = 0,50 – significant difference.

Seminatural environment – Sampling conducted over a period of 3 consecutive days showed a marked reduction in 6 to 8 mm snails and total elimination of 3 to 5 mm snails. Even the few snails present on the ramp placed in the tank, which was analogous to the slopes occuring in natural bodies of water where the snails breed, were preyed upon.

When the control group was compared with the experimental group by the Mann-Whitney U test (Siegel, 1956), a significant difference was detected in the 2 different size range groups (3-5 mm and 6-8 mm) analyzed.

Three weeks after the full elimination of snails in the tank, we noted the birth of *G. brasiliensis* alevins.

Field data – When we analyzed the stomach content of the 8 fish from the Camorin Lagoon, we detected the presence of the snail *Littoridina* (Souleyet, 1852), which commonly occurs in the Lagoon, in 2 of them.

DISCUSSION

Most of the studies carried out thus far for the biological control of schistosomiasis were mainly based on laboratory tests (Milward-de-Andrade & Antunes, 1969; Coelho et al., 1975; Daffala et al., 1985). Thus, as stated by Altmann (1974), these studies would have only internal validity, i. e., their applicability would be of value only in a laboratory environment. Studies of this type may lead to erroneous conclusions since they do not take into account the feeding preferences of the fish in the field but simply offer the snail as the only food available.

In the present study we noted that *G. brasiliensis*, in addition to feeding on snails in the laboratory, also feeds on snails in a seminatural environment in which a wider variety of food is available. On the basis of the data observed, the biometrical relationship between fish size and preferential size of the snails preyed upon by them was 11 to 5 cm.

The snail-eating habit of many fish has been studied before. Among such fish are *Umbra pygmacacea* and the cichlid *Pelmatochromis aff kribensis* (Lagrange, 1953), *Engraulicypris brevianalis* (Barnish, 1971) and *Astronotus ocellatus* (Menezes, 1962). However, no specific study on the snail-eating habit of *Geophagus brasiliensis* had been conducted before. The references found only concerned growth, lethal temperatures, evolution and general biology of this species (Guimarães, 1930a; Barbieri, 1974, 1975; Rantin, 1978).

Considering its wide distribution as well as its tolerance to salinity and temperature

(Rantin, 1978) and the fact that it feeds on animals found at the surface, on slopes or in substrates covered with clay, a behavior shared by other planorbids (Pieri et al., 1980), and that fishes collected in nature had the *Littoridina* mollusk in their stomach, we can state, in accordance with the WHO guidelines for the choice of predators of these vectors, that *G. brasiliensis* has promising characteristics. On this basis, the study of this fish for the biological control of snail vectors of schistosomiasis at natural breeding sites should be encouraged.

REFERENCES

ALTMANN, 1974. Observational study of behavior: sampling methods. *Behavior, 49:* 227-265.

ARAGÃO, M. B., 1967. Equilíbrio da natureza e controle biológico. *Rev. Bras. Mal. D. Trop., 19:* 655-695.

AXELROD, H. R. & SCHULTZ, L. P., 1955. *Handbook of Tropical Aquarium Fishes.* Macgrave-Hill Book, New York, 634 p.

AZEVEDO, P.; ALCKMIN, G. J. R.; MALDONADO, J. M.; VAZ, J. O.; PARREIRA, W. V. & ROJA, S. J. T., 1960. *Peixes como auxiliares de combate a esquistossomose.* 23 p. datilogr. (Trabalho apresentado ao Depto. de Produção Animal e à Sociedade Brasileira de Zootecnia, em 30 de maio de 1960).

BARBIERI, G., 1974. *Crescimento do Geophagus brasiliensis (Quoy & Gaimard, 1824) na Represa do Lobo.* Tese de Mestrado. Instituto de Biociências, USP.

BARBIERI, G., 1975. *Sobre o crescimento relativo de* Geophagus brasiliensis *(Quoy & Gaimard, 1824) na Represa do Lobo. Estado de São Paulo.* Instituto de Biociências, USP. Tese de Doutorado.

BARNISH, G., 1971. An investigation into the schistosome host snail *B. pfeifferi* (Krauss) by the fish *Engraulicypris brevianalis. Rhodesia Agri. J., 68:* 63-66.

BERG, C. O., 1973. Biological control of snail-borne diseases: a review. *Expl Parast., 33:* 318-330.

COELHO, P. M. Z.; BOSON, F. C. B. & GERKEN, S. E., 1975. Potencialidade de predação de *Biomphalaria glabrata* (Say, 1818) por duas espécies de quelônios sul-americanos *Platemys spixu* (Dulmeril e Debron, 1935) e *Chrysemys traguemys* (Dorbignie e Dibron, 1935). *Ci. e Cult., 27:* 301-303.

DAFFALA, A. A.; ELIAS, E. E. & AMIN, M. A., 1985. The lung fish *Protopterus annectans* (Owen) as a biological agent against Shistosome vector snail. *J. Trop. Med. Hygiene, 88:* 131-134.

FEITOSA, V. R. & MILWARD-DE-ANDRADE, R., 1986. Atividade predatória de *Astronotus ocellatus* (Ciclidae) sobre *Biomphalaria glabrata* (Planorbidae). *Rev. Bras. Malariol. D. Trop., 38:* 19-27.

FERGUSON, F. F. & RUIZ-TIBEN, E., 1978. Review of biological control methods for schistosome-bearing snail. *Ethiop. Med. J., 9:* 491-493.

GOUVEIA, J. A. G., & MOTTA, J. G., 1971. Capacidade malacófaga de alguns peixes. *Gaz. Med. Bahia, 71:* 52-54.

GUIMARÃES, J. R. A., 1930a. O acará *Geophagus brasiliensis,* Quoy & Gaimard. *Rev. Ind. Anim.,* São Paulo, *6:* 658-662.

GUIMARÃES, J. R. A., 1930b. O acará *Geophagus brasiliensis,* Quoy & Gaimard. Notas sobre sua evolução. *Bol. Agr.* São Paulo, *31:* 1329-1339.

JORDAN, P.; CHRISTIE, J. D. & UNRAU, G. O., 1980. Schistosomiasis transmition with particular reference to possible ecological and biological methods of control. *Acta Trop.,* Brasil, *37:* 95-135.

LAGRANGE, E., 1953. La lutte biologique contre les planorbes. *Ann. Soc. Belg. Med. Trop., 33:* 227-236.

LOWE-McCONNEL, R. H., 1975. *Fish communities in tropical freshwaters: Their distribution, ecology and evolution.* Logman Inc., London and New York, 337 p.

MAGALHÃES, A. C., 1931. Classificação de famílias de peixes fluviais. In *Monografia brasileira de peixes fluviais.* Graphicars-Romiti Lanzara & Zanin, São Paulo, 260 p.

McCULLOUGH, F. S., 1981. Biological control of the snail intermediate hosts of human *Schistosoma* sp: review of its present status and future prospects. *Acta Trop., 38:* 5-13 p.

McMULLEN, O. B., 1973. *Biological and environment control of snail. Epidemyology and control of Schistosomiasis (Bilharziasis).* S. Karger, Brasil.

MENEZES, R. S., 1962. Informações sobre alimentação de peixes na bacia do Rio Parnaíba. *Bol. Soc. Cear. Agron., 3:* 55-60.

MICHELSON, E. H., 1957. Studies on the biological control of schistosoma-bearing snail predators and parasites of fresh water Mollusca: A review of the literature parasit. *Parasit, 47:* 413-426.

MILWARD-DE-ANDRADE, R. & ANTUNES, C. M. F., 1969. Combate biológico: *Tilapia melanopleura dumeril* versus *Biomphalaria glabrata* (Say), em condições de laboratório. *Rev. Bras. de Malariol. e D. Trop., 21:* 49-58.

PELLEGRIN, J., 1908. Les poissons deau douce de la Guyana Française. *Rev. Coloniale, 67:* 557-591.

PIERI, O. S.; JURBERG, P. & RAYMUNDO, J. S., 1980. Estudo sobre o comportamento dos planorbídeos. I. Uma técnica de observação e registro comportamental por cinematografia. *Mem. Inst. Oswaldo Cruz, 75:* 57-63.

RANTIN, F. T., 1978. *Temperaturas letais, aclimatação e tolerância térmica do Acará* Geophagus brasiliensis *(Quoy & Gaimard. 1824). Represa do Broa, Represa da Universidade de São Carlos – Estado de São Paulo.* Tese de Mestrado, 181 p.

SIEGEL, S., 1956. *Nonparametric statistics for the behavioral sciences.* Mc Graw Hill International Book Company, Tokyo, ix + 312 p.

WORLD HEALTH ORGANIZATION (WHO), 1984. Report of an informal consultation on research on the biological control of snail intermediate hosts. Document WHO/BCV-SCH/SIH/84.3, Geneva, 49 p.