Tilapia rendalli IN THE LAKE MONTE ALEGRE, A CASE OF PLANKTIVORY

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RESUMO: *Tilapia rendalli* no Lago Monte Alegre, um caso de planctofagia. *Tilapia rendalli*, conhecida como comedora de macrófitas, pode apresentar dieta mais generalizada, mas hábito alimentar estritamente planctófago ainda não tinha sido assinalado para esta espécie. No Lago Monte Alegre (Ribeirão Preto, S.P.) exemplares adultos (166-245 mm CP) apresentaram dieta constituída principalmente por algas planctônicas, enquanto organismos zooplanctônicos foram consumidos em menor proporção. A análise detalhada do conteúdo estomacal de 10 espécimes revelou a ocorrência de 90 espécies de algas, de comprimento entre 2 e 200 μm. Os organismos planctônicos, *Bosmina tubicen, Daphnia gessneri* e *Keratella* sp foram selecionados por *T. rendalli*. Discute-se a influência do piscívoro *Cichla ocellaris* sobre a população de *T. rendalli* e sobre seu hábito alimentar, além da influência das tilápias sobre a comunidade planctônica.

Palavras-chave: Ciclídeo, *Tilapia rendalli*, planctofagia, seletividade sobre o zooplâncton, Brasil.

ABSTRACT: *Tilapia rendalli* in the Lake Monte Alegre, a case of planktivory. *Tilapia rendalli*, known as a leaf chopper, can have a generalized diet, but strict planktivory was not reported for this species. In Lake Monte Alegre (Ribeirão Preto, S.P.) adult individuals (166-245 mm SL) fed mainly on planktonic algae, zooplankton contributing in smaller proportion. In the stomach content of 10 specimens studied in detail, 90 species of planktonic algae, whose size ranged from 2 to 200 μm, were found. The zooplankton species, *Bosmina tubicen, Daphnia gessneri* and *Keratella* sp were selected by *T. rendalli*. The influence of the piscivorous *Cichla ocellaris* on *T. rendalli* population and its feeding habit, and the influence of *T. rendalli* on plankton community are discussed.

Key-words: Cichlid, *Tilapia rendalli*, planktivory, electivity on zooplankton, Brazil.

INTRODUCTION

Tilapia rendalli, a cichlid fish native of Africa,was introduced into several regions of the world, including Brazil. It is a diurnal feeding species (Munro, 1967; Uieda, 1984) and known as a leaf chopper (Fryer & Iles, 1972). However, several studies (Roux, 1956; Munro, 1967;

Nomura & Seixas, 1970; Moreau, 1971; Arcifa *et al.,* 1988; Romanini, 1989) showed that it is less specialized than it was previously supposed.

Introduced into Lake Monte Alegre in 1957, it became the most abundant species (Nomura *et al.,* 1983). However, the Amazonian piscivorous *Cichla ocellaris* (tucunaré), introduced in 1973 in the reservoir, changed the size structure of tilapia's population (Nomura *et al., op.cit.*).

Large specimens of *T. rendalli* were distributed in the limnetic zone, in direct contact with true plankton (Arcifa & Meschiatti, 1993). As pump-filter feeders they are mainly phytoplanktivores, also exploiting zooplankton but as a minor dietary item.

This paper is a detailed analysis on the feeding of adults of *T. rendalli* of Lake Monte Alegre, referred by Arcifa & Meschiatti (*op. cit.*) as large specimens. Phyto- and zooplankton species and their sizes were evaluated in the diet and in the environment, as well as the electivity on zooplankton organisms. The influence of the fish on the plankton community is discussed.

STUDY AREA

Lake Monte Alegre (21 11'S, 47 43'W) is a small, shallow, eutrophic reservoir (area 7 ha, max. depth 5 m, mean 2.9 m), located in southeastern Brazil, at an altitude of 500 m. It was formed by damming of Laureano Creek, which belongs to Pardo River basin, in 1942. The region is characterized by two seasons - a dry-cool season of approximately 5 months (May-September) and a wet-warm season (October-April).

The reservoir does not necessarily circulate daily; it may stratify for longer periods during the year, leading to oxygen depletion at the bottom (Arcifa *et al.,*1990). The annual water level fluctuation is moderate (~40 cm) and the discharge of the dammed creek is low (maximum value = 0.0095 $m^3. s^{-1}$). The outlet of the reservoir is not manipulated by man, as the reservoir is ornamental, functioning as a small lake or a pond with inlet and outlet and having a retention time of approximately two months. This reservoir can be classified, according to LEWIS (1983), as warm discontinuous polymictic in its deeper region, with more stable stratification in spring and summer (Arcifa *et al.,* 1990). At the surface, the temperature ranges from 18 to 31C, conductivity from 47 to 96 $\mu S.cm^{-1}$, at 25C, and pH from 5.5 to 7.5 (Arcifa *et al.,*1990; Silva, 1989). Supersaturation with dissolved oxygen is common.

MATERIAL AND METHODS

Five collections were made in 1989: two in the wet season (January and February), two in the dry season (June and July), and one in the end of the dry season (September).

Sets of monofilament nylon gill nets containing 10 m lengths of 30, 40, 50, 60, 80, and 110 mm diagonally stretched mesh were made parallel to shore, fishing the entire water column from surface to bottom at 1, 2, and 5 m depths. Each meter depth was marked throughout the nets with a fine coloured string. The nets were set near sunset for a period of 3 or 4 hours. For each fish, mesh size and depth of capture were recorded. Length and weight were taken in fish preserved with formalin 10%. Standard length (SL) measurements were used for all specimens. Replicated shore seine hauls were made with a 1.4 x 8.4 m seine of 3 mm mesh from a distance about 25 m offshore to the shore edge, covering an area of approximately 210 m^2.

The stomach contents were analyzed in a counting chamber, under a stereomicroscope. Food items were grouped and the area occupied evaluated, according to Hyslop (1980). The sum of the area occupied by food items was considered as 100%. Calculations were made according to the formula:

$$P_{ij} = \frac{\sum_{i=1}^{s} P_{ix}}{N_j}$$

Where: P_{ix} is the proportion by the volume of item i in the gut of individual x and Nj is the number of individuals of tilapia.

Zooplankton organisms were evaluated in the stomach contents through counting of three 1 ml subsamples in a counting chamber.

The item "non identified" refers to any unidentifiable material as digestion remains or mucus.

Zooplankton samples were taken in one station near the 5m gill net location. These samples were collected vertically with a 70 µm mesh net (mouth diameter- 29 cm; length - 90 cm) and preserved in 4% formalin. Two or three 1 ml subsamples were counted in a counting chamber.

The stomach contents of 10 individuals (166-236 mm SL, 190-482g wet weight), caught in January and February, were analysed in detail, and compared to phytoplankton from the environment. This was sampled in the euphotic zone, with a Ruttner bottle, and fixed with a modified lugol solution (Vollenweider, 1974). The electivity index of Chesson (1978) was applied for fish predation on zooplankton species:

$$\alpha i = \frac{\frac{r_i}{P_i}}{\sum_{i=1}^{m} \frac{r_i}{P_i}}$$

where: r_i = proportion of prey *i* in diet.
P_i = proportion of prey *i* in environment.
m = number of prey types.

$$\text{with } \sum_{i=1}^{m} \alpha i = 1$$

when: $\alpha\, i > m^{-1}$ selective predation occurs.
$\alpha\, i < m^{-1}$ avoidance occurs.
$\alpha\, i = m^{-1}$ no selective predation occurs.

RESULTS

The large individuals of *Tilapia rendalli* (166 - 245 mm SL; 190 - 620 g wet weight) were exclusively caught in gill nets, in the limnetic zone (5m net), and were not abundant in the reservoir. The smallest specimens (25 - 65 mm SL; 0.6 - 12.2 g w weight) were caught by seining and the medium-sized (81 - 137 mm SL ; 20.2 - 102 g w weight) by gill netting.

According to the first maturation size given by Barbieri *et al.* (1983), all the small and medium-sized individuals were juveniles and the largest ones adults. Age determinations of tilapias of Lake Monte Alegre made by Nomura *et al.* (1983) allow us to estimate the age of our specimens from 0 to 3 years and 4 to 5 years for juveniles and adults, respectively.

The diet was homogeneous for adults, planktonic algae being the most important item, and zooplankton a minor component, representing ca. 4% of the total volume (Fig. 1). A small amount of sediment was found only in two specimens.

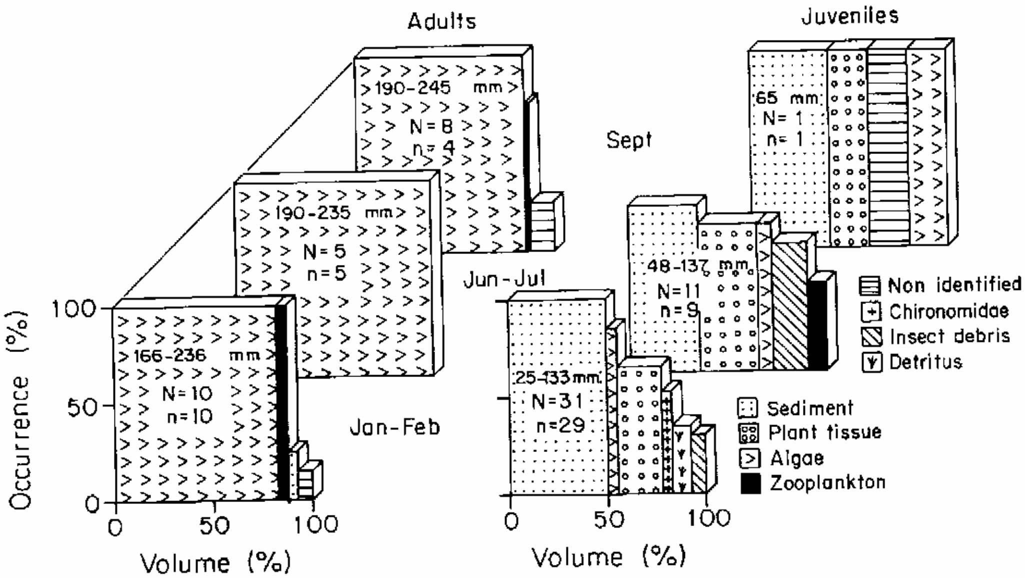

Figure 1. Frequency of occurrence and relative proportion by volume of items in the diet of juvenile and adult *Tilapia rendalli.* Measurements in standard length. N= specimens analyzed; n= specimens with stomach content.

In the stomach contents studied in detail, 90 species of planktonic algae were found, their sizes ranging from 2 to 200 µm. A comparison between the proportions of species of each size class in the stomach and in the environment, showed that the dominant classes were 2-10 and 11-20 µm (Fig. 2). For some size classes, a higher proportion occurred in the stomachs compared to the environment. This fact could be explained by the fish feeding through filtration, what allows the concentration of rare species, virtually absent from the environmental samples.

Although less important than phytoplankton in relative volume (Fig. 1), zooplankton can, however, be caught in large absolute numbers (Fig. 3). *Bosmina tubicen, Daphnia gessneri* and *Keratella* sp were selected by tilapia in two occasions, and *Ceriodaphnia cornuta, Moina micrura* and nauplii in one occasion (Fig. 4). Despite the relative abundance of copepodites and adults of *Tropocyclops prasinus* in the environment (Fig. 3), they have not been selected by tilapia (Fig. 4). Loricate rotifers present in the samples were *Keratella* and *Brachionus*, but only the first one was found in the stomach contents. Possibly, non loricate rotifers were also ingested but not found in the stomachs, as they leave no remains once digested.

Higher zooplankton densities occurred in the reservoir during January, February, and September (Fig. 3). The same pattern was found for the average number of prey per fish.

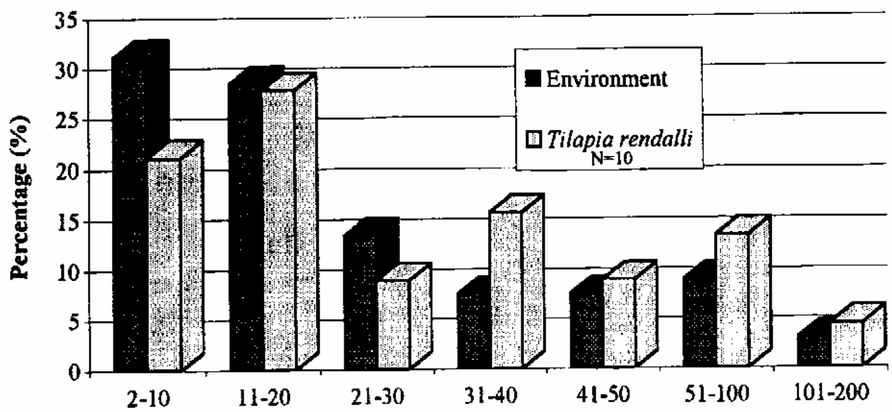

Figure 2. Size distribution of planktonic algae, in m, in the environment and stomach contents of *T. rendalli.*

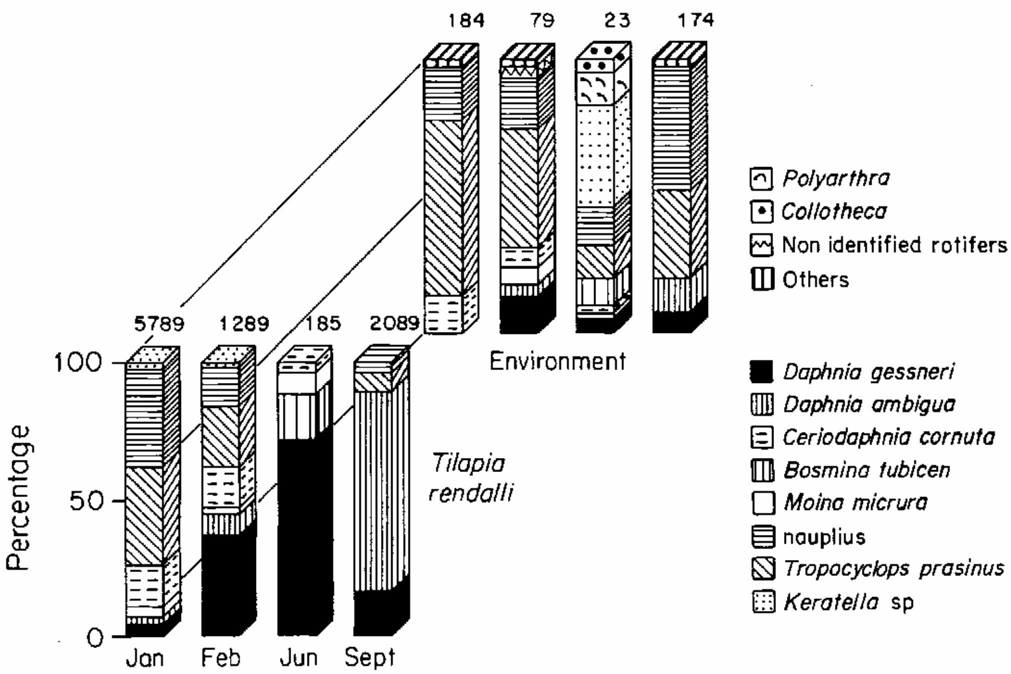

Figure 3. Proportion of zooplankton species in the environment and in the stomach contents of adult *T. rendalli.* Values on the top of the bars indicate the density in the environment (ind. l^{-1}) and the average number in fish stomach (n as in Figure 4).

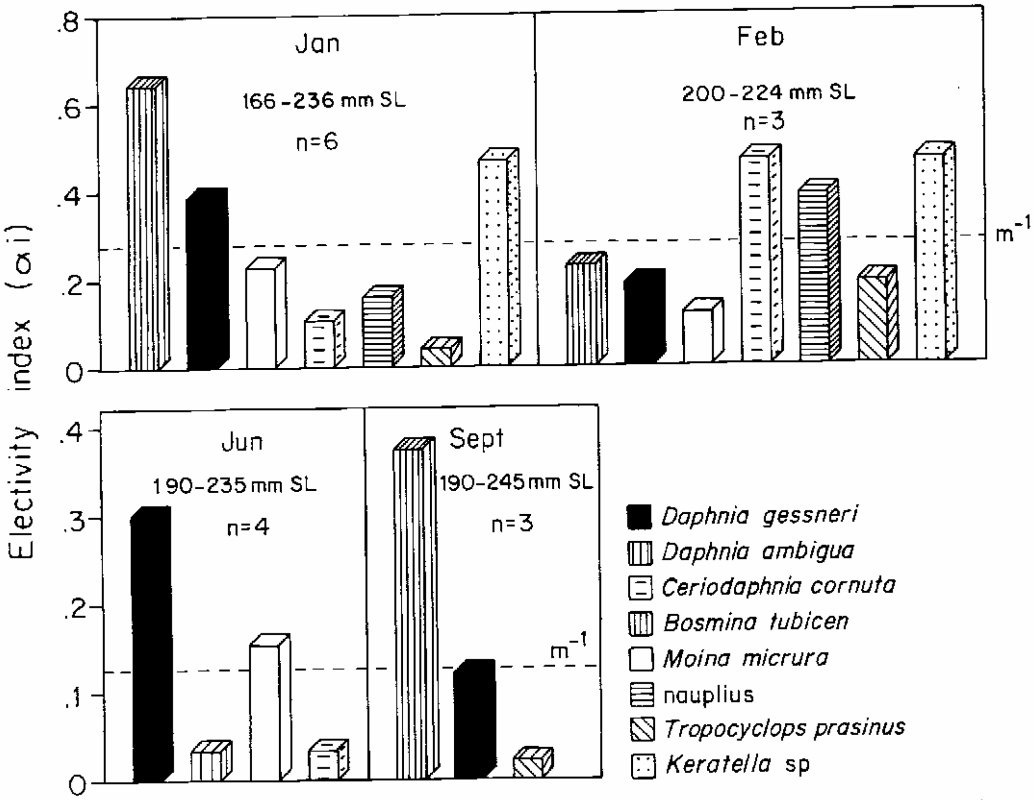

Figure 4. Electivity index values for adult *T. rendalli* on zooplankton species; n as in Figure 1.

Juveniles fed mainly on sediment, plant and insects (Fig. 1). Algae occurred frequently but in small proportions. Filamentous algae, including *Spirogyra*, diatoms and planktonic species were part of the diet. The same algae were found on stones collected in the reservoir and examined in the laboratory. It was observed that plant tissue in the contents originates from decayed and not fresh material.

The dentition of juveniles and adults is composed by an outer row of diminute bicuspidate teeth and several inner rows of tiny tricuspidate teeth. Fryer & Iles (1972) describe this kind of dentition for African leaf choppers, which include *Tilapia rendalli*, but this species, in the reservoir, has a smaller number and size of teeth.

DISCUSSION

As algae and invertebrates ingested by all nineteen adults examined are planktonic, and items collected at the bottom were rarely found, we concluded that they are feeding in the water column of Lake Monte Alegre. Juveniles, on the other hand, feed on the bottom.

Before the introduction of *Cichla ocellaris* in the reservoir, the maximum total length of tilapias attained ca. 190 mm, and their diets were composed by diatoms, filamentous algae and detritus of plant origin (Nomura & Seixas, 1970). Seven years after its introduction, the total length of tilapia increased, reaching a maximum of 277 mm (Nomura *et al.*, 1983).

According to these authors 23 to 42% was added to fish length, taken into account age and sex. They concluded that tucunaré was preying on tilapia and by reducing its population, allowed a larger individual growth, due to lower competition for food. They also noticed an increase of the number of algal species ingested, in comparison to the period before the predator introduction. Unfortunately, data on the diet was not shown. The piscivore affected not only the abundance and size structure of tilapia's population, but also induced a switch in the adult feeding habits, which started to exploit plankton, chiefly phytoplankton.

In Africa, phyto- and zooplankton can be part of *T. rendalli*'s diet, but together with other items such as higher plants (e.g. Moreau, 1971). Strict planktivory was not reported for that species. Roux (1956) found that juveniles smaller than 2 inches, included zooplankton in relatively high proportion (~ 78%) in their diets plus items caught at the bottom or near the banks. Plant material was more important for juveniles longer than 3 inches. Moreau (1971) comments the difficulties of making distinction, in the diet, between planktonic organisms and those living in plants. But this distinction is fundamental for detecting planktivory to avoid misinterpretations on plankton predation.

In experimental conditions, *T. rendalli* can be planktivore (Starling & Rocha, 1990; Lazzaro, 1991; Starling, 1993). Lazzaro (1991) reports that, in aquaria, specimens < 30 mm were visual feeders, between 30 and 50 mm were both visual and pump-filter feeders and >70 mm were exclusively filter-feeders. Starling (1993) found that specimens of 71-105 mm SL, in aquaria, were pump-filter feeders. However, at the end of enclosure experiments, individuals of 56-110 mm SL, showed signs of starvation, as they fed on invertebrates, detritus from the bottom and plants in their natural environment (Grando, 1989 *in* Starling, *op.cit.*). In Americana Reservoir specimens of 14-151 mm SL were detritivore-herbivore (Arcifa *et al.*, 1988) and juveniles of 12.7-135 mm SL were detritivore (Romanini, 1989).

Lake Monte Alegre is poor in macrophytes and relatively rich in phytoplankton, whose densities varied approximately from 4400 to 53400 ind. ml $^{-1}$, from April 1988 to March 1989, nannoplankton (2-20 μm) predominating (Silva, 1995). The same was found in the stomach content of tilapia, which is able to retain tiny particles.

T. rendalli, in the reservoir, selected zooplankton organisms with lower escape ability, avoiding copepodites and adults of cyclopoids. Our results agree with those obtained by Starling & Rocha (1990), Lazzaro (1991), and Starling (1993).Tilapia was observed, in aquaria, pumping water near the bottom or more frequently near surface (Starling, *op.cit.*). They found high constants of feeding rates for *Bosmina* spp, which are often found in the surface film. The same explanation might apply to the selection of *Bosmina tubicen* by tilapia, in Lake Monte Alegre. Starling (1993) believes that the low feeding rates of tilapia for adults and copepodites of *Termocyclops decipiens* could be related to their high escape ability, and for nauplii and rotifers by the low retention efficiency of small particles. When offered smaller prey, tilapia switched from particulate to pump-filter feeder in experiments (Lazzaro, 1991).

Apparently, no special adaptation was required by adult tilapia for exploiting phytoplankton in Lake Monte Alegre. According to Fryer & Iles (1972) all the African phytoplanktivorous cichlids belong to the genus *Tilapia*, that are very close to bottom grubbers. Several species can feed on suspended or sedimented phytoplankton. *Tilapia rendalli* is included by those authors among the leaf choppers but not among the deposit feeders. But its ability in catching insects, sediment, and plankton in addition to plants indicates a more generalized diet.

The water current used for respiration, can also be used for obtaining food. However, the mechanism and structures involved on catching plankton in tilapia have not yet been elucidated. The removal of gill rakers and microbranchiospines did not affect particle ingestion by the filter-feeding *Tilapia galilaea* (Drenner *et al.*,1987). These authors believe that cichlids can collect small particles, entangling them in mucus and forming aggregates, that are worked by the toothed pharyngeal bones and drawn to the esophagus, as suggested by Greenwood (1953) for *T. esculenta*. It is possible that the same mechanism is used by *T. rendalli.*

The influence of planktivorous tilapias on phyto- and zooplankton of the Lake Monte Alegre is apparently weak. Temporal variations in phytoplankton abundance can be mainly related to abiotic factors such as precipitation, circulation and stratification periods (Silva, 1995). Fluctuations of zooplankton populations seem to be related to food, competition and Chaoboridae predation (Arcifa *et al.,* 1992). However, predation by tilapia on microcrustaceans might represent a ultimate cause of their nocturnal migratory behaviour (Arcifa & Rodrigues, manuscript).

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