# Feeding and condition factor of characidiin fish in Ribeirão Grande system, Southeastern Brazil

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**ABSTRACT.** Feeding, seasonal changes in visceral fat and condition factor were compared in two species of characidiin fishes, *Characidium lauroi* and *C. alipioi* from Ribeirão Grande system, southeastern Brazil. Five streams of Ribeirão Grande system were sampled (22º 47' 08'' S, 45º 28' 17''W). The samples were taken four times per site, from July, 2001 to April, 2002: winter (July 2001), spring (October 2001), summer (February 2002) and autumn (April 2002). Quantitative collections were made with an electro-fishing device powered by a generator with maximum capacity of 1,500 V and 8.7 A of 60 Hz alternating current. Ephemeroptera nymphs, Diptera larvae (Chironomidae, Simuliidae), Plecoptera nymphs, Trichoptera larvae (Hydroptilidae, Psychoyiidae), terrestrial insects (Coleoptera, Isoptera, Hemiptera [Heteroptera, Homoptera]), Megaloptera larvae (Corydalidae), Arachnida, Ostracoda and vegetal debris were found in both species' diets. Visceral fat declined in February, coinciding with the decline of the condition factor in both species. The increased feeding from summer to fall provides fat accumulation. During subsequent seasons, fish may utilize visceral fat reserves for maintenance and reproduction.

**Key words:** *Characidium lauroi*, *Characidium alipioi*, feeding, condition factor, Ribeirão Grande system, stream ecology.

**RESUMO. Alimentação e fator de condição de peixes characidiíneos no sistema do Ribeirão Grande, Sudeste do Brasil.** Os peixes foram amostrados quatro vezes em cada local, de julho de 2001 a abril de 2002: inverno (julho de 2001), primavera (outubro de 2001), verão (fevereiro de 2002) e outono (abril de 2002). Foram amostrados segmentos de cinco riachos no sistema do Ribeirão Grande (22º 47' 08'' S, 45º 28' 17''W). Coletas quantitativas foram feitas com um aparelho de pesca-elétrica ligado a um gerador com capacidade máxima de 1.500 V e 8,7 A de 600 Hz de corrente alternada. Alimentação, mudanças na gordura visceral e fator de condição foram comparados em duas espécies de characidiíneos, *Characidium lauroi* e *C. Alipioi* do sistema do Ribeirão Grande, sudeste do Brasil. Nas dietas das duas espécies ninfas de Ephemeroptera, foram registradas larvas de Diptera (Chironomidae, Simuliidae), ninfas de Plecoptera, larvas de Trichoptera (Hydroptilidae, Psychoyiidae), insetos terrestres (Coleoptera, Isoptera, Hemiptera [Heteroptera, Homoptera]), larvas de Megaloptera (Corydalidae), Arachnida, Ostracoda e restos vegetais. A gordura visceral decresceu em fevereiro, coincidindo com o declínio do fator de condição em ambas as espécies. O aumento da atividade alimentar durante o verão proporciona o acúmulo de gordura. Durante as estações seguintes, esses peixes devem utilizar as reservas de gordura visceral para manutenção e reprodução.

**Palavras-chave:** *Characidium lauroi*, *Characidium alipioi*, alimentação, fator de condição, sistema do Ribeirão Grande, ecologia de riacho.

## Introduction

The genus Characidium is a group of small neotropical freshwater fish that inhabit streams and creeks. Buckup (1993) and Buckup and Reis (1997) reviewed the species of Characidium in Brazil, but there are few studies on their biology and ecology. A study of the feeding ecology of these species was part of an overall investigation into the structure and functioning of characidiin fishes, component of Ribeirão Grande system.

The amount of food eaten determines the life span of fishes, and relationships between species are closely connected (Nikolskii, 1969). On the other hand, fat content is closely connected with life span (Nikolskii, 1963). Another important derivative of growth to describe fish life span is the condition factor; fish population display changes in average condition over time, reflecting seasonal fluctuations in their metabolic balance (Weatherley 1972; Weatherley and Gill 1987).

According to Allen (1969), most stream fishes are invertivores and a few are herbivores. Aquatic insects are common in diets of many freshwater fishes (McCafferty, 1981). Tropical streams fish have a preponderance of small species when compared to temperate streams, and this affects the food items; in small to mid-order tropical streams, many species feed on benthic invertebrates, primarily immature insects (Allan, 1995).

A study of Characidium lauroi and C. alipioi feeding ecology took part in an overall investigation of the community structure and functioning of the characidiin fishes at Ribeirão Grande system (Braga and Andrade, 2005). The present study aimed at documenting interaction for food and its relationship throghout the year between parapatric stream populations of characidiin fishes Characidium lauroi and C. alipioi, in the Ribeirão Grande system.

## Material and methods

### Study area

The streams that form the Ribeirão Grande system, and other systems around it, are located in the Serra da Mantiqueira slope (22º 47' 08" S, 45º 28'17"W), move between the slopes crests, built by faults during the late Pleistocene to Holocene tectonic reactivations (8,000 – 13,000 years BP) (Modenesi-Gauttieri et al., 2002), surrounded by Atlantic forest. The Serra da Mantiqueira is an east-west mountain range, composed of granitic and metamorphic rocks. Streams in the Mantiqueira uplift have steep gradients and coarse substrate, bordered by rain forest. In the low parts, the streams move in the Vale do Paraíba plain. Ribeirão Grande and other neighboring systems form a left-side Paraíba do Sul drainage basin (Figure 1).

### Sampling methods and treatments data

Fishes were surveyed in the Ribeirão Grande system (22º 47'08" S, 45º 28'17" W), a tributary of the Paraíba do Sul drainage, in the municipality of Pindamonhangaba, State of São Paulo, souhteastern Brazil. The samples were taken from July 2001 to April 2002, covering all seasons. Collections were made with an electro-fishing device, powered by a generator with maximum capacity of 1,500 V and 8.7 of 60 Hz alternating current. All specimens were preserved in 10% formalin and returned to the laboratory for identification and biometryc (Braga, 2004; Braga and Andrade, 2005).

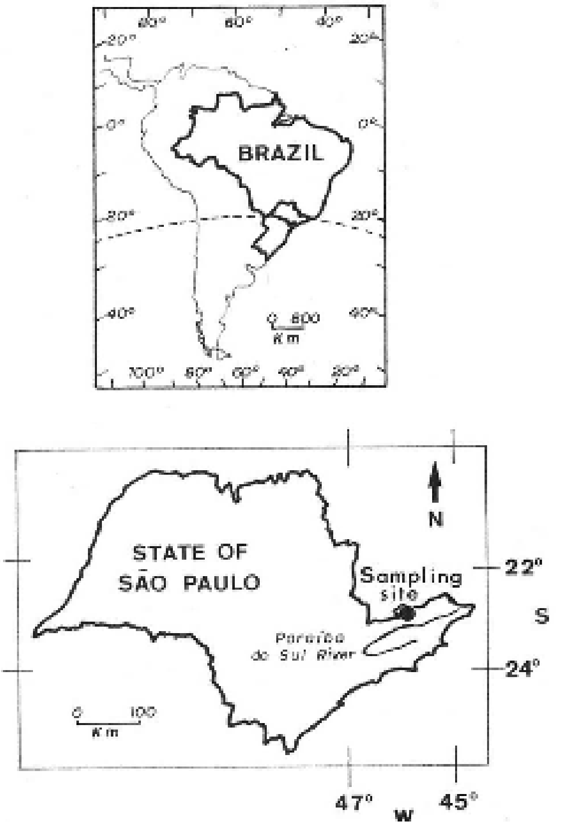


**Figure 1.** Maps of South America, Brazil and State of São Paulo, with indication of the sampling site.

In the laboratory, the stomachs were rinsed in tape water and preserved in 70% alcohol. Stomach fullness (SF) was estimated using a numerical scale from 1 to 3, where 1= empty, 2= partly full and 3= full stomach; only full stomachs were analyzed. Food items were identified to species wherever possible and then grouped in higher taxa. The importance of the eaten food in the diet was assessed by the grade of feeding preference (GFP) according to Braga (1999). Comparisons of diets between *Characidium lauroi* and *C. alipioi* were made using the Spearman rank correlation coefficient (Fritz, 1974), applied to GFP values found for each prey (P=0.05).

Total length ($L_t$) correct to 1 mm, and weight ($W_t$) correct to 0.01 g were taken. Sex was determined macroscopically, and fat content (FC) was estimated using a numerical scale, where 1= no fat, 2= a rather narrow strip of fat in the intestine, 3= intestine completely covered by a thick layer of fat.

The length-weight relationship of *Characidium lauroi* (females and males) and *C. alipioi* (females and males) were separately analyzed. The general power-function form of equation, $W_t=a.L_t^b$ (1) was used to show statistical relationship between length and weight. Since the length-weight ratio is a power relationship, logarithms (*ln*) were used, so that the exponential relation could be expressed through a linear equation: $lnW_t=lnA+B.lnL_t$ (2), and weighted least-squares linear regressions of weight on length were derived for each sample. Comparing equation (1) and (2), $a=e^A$, and $b=B$.

Analyses of variance homogeneity were carried out to test the null hypothesis of no differences between females and males of both species. After, slopes (B) were tested for homogeneity; then, if this criterion was satisfied, the elevation (A) tested, using P=0.05 (Fowler *et al.*, 1998). When the variances were different (P<0.05) a test that analyzed only slopes was carried out.

For studying the condition cycle in *Characidium lauroi* and *C. alipioi*, and its relation to feeding, females and males were treated separately, after testing the length-weight relationship between sexes. The condition factor is $K=W_t/L_t^b$, and the length-weight relationship *is* $W_t=a.L_t^b$, where the condition factor is deducted: $a=W_t/L_t^b=K$ (Braga, 1986).

## Results

62 stomachs of *Characidium lauroi*, and 79 stomachs of *Characidium alipioi* were analyzed. The results of stomachs contents analysis are shown in Table 1. *Characidium lauroi* fed on a large range of food, but Diptera larvae (Chironomidae, Simuliidae) were eaten in higher proportion (main item), whereas Ephemeroptera nymphs were a secondary item. Other preys, such as Plecoptera nymphs, Trichoptera larvae (Hydroptilidae), Odonata nymph, aquatic insects (Heteroptera, Naucoridae; Coleoptera, Psephenidae), terrestrial insects (Coleoptera, Isoptera) and Ostracoda also appeared in several stomachs.

The principal prey of *Characidium alipioi* was Diptera larvae (Chironomidae, Simuliidae, Chaoboridae and Tipulidae) and the secondary prey was Trichoptera larvae (Hydropsychidae, Hydroptilidae and Psychomyiidae). Additional items found in the stomachs included Plecoptera nymphs, Ephemeroptera nymphs, Odonata nymphs, aquatic insects (Heteroptera, Naucoridae; Coleoptera), terrestrial insects (Hemiptera – Heteroptera and Homoptera, Coleoptera,), Megaloptera larvae (Corydalidae), Arachnida, Ostracoda and vegetal debris (Table 1).

Aquatic invertebrates, mainly Diptera larvae, Trichoptera larvae and Ephemeroptera nymphs, accounted for major food proportions in the stomachs of both species (Table 1). When statistically tested, both species' diets were found to be not significantly correlated ($P_{0.05;9}=0.602$; $r_s=0.59$; $P>0.05$).

**Table 1.** Comparison of the diets of *Characidium lauroi* and *C. alipioi* collected in Ribeirão Grande system, and the respective grade of feeding preference.

| Food items | *Characidium lauroi* | *Characidium alipioi* |
|---|---|---|
| Plecoptera nymphs | 0.4 (occasional) | 0.5 (occasional |
| Diptera larvae | 2.0 (principal) | 2.0 (principal) |
| Trichoptera larvae | 0.5 (occasional) | 1.3 (secondary) |
| Ephemeroptera larvae | 1.0 (secondary) | 0.2 (occasional) |
| Odonata nymphs | 0.1 (occasional) | 0.5 (occasional) |
| Aquatic insects | 0.1 (occasional) | 0.1 (occasional) |
| Terrestrial insects | 0.4 (occasional)) | 0.1 (occasional) |
| Vegetal debris | | 0.2 (occasional) |
| Megaloptera larvae | | 0.1 (occasional) |
| Arachnida | | 0.1 (occasional) |
| Ostracoda | 0.1 (occasional) | |

For seasonal comparisons, data of stomach fullness and fat content were segregated into winter (July), spring (October), summer (February), and fall (April) (Figure 2). These data suggest that feeding may have been intense through the year and the deposition of fat in visceral cavity is more intense during the fall and winter for both species.

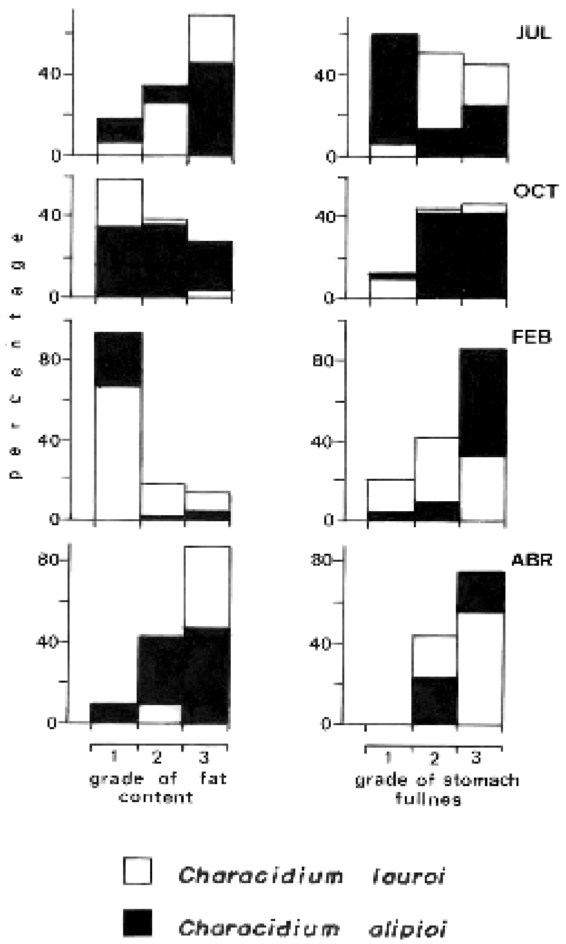


**Figure 2.** Seasonal variations of fat content (FC) and stomach fullness (SF) in *Characidium lauroi* and *C. alipioi* from Ribeirão Grande system.

The equations showing the relationship between length and weight in females and males, for *Characidium lauroi* and *C. alipioi*, are expressed below:

*Characidium lauroi* females: $W_t$=0.0095 $L_t^{3.0102}$, males: $W_t$=0.0125 $L^{2.84}$, and in the linear form of the regression line equation as: females: $lnW_t$=1.0095 + 3.0102 $lnL_t$ (r=0.9537, P<0.01), and males: $lnW_t$=1.0126 + 2.84 $lnL_t$ (r=0.9177, P<0.01). *Characidium alipioi* females: $W_t$=0.0071 $L_t^{3.1787}$, males: $W_t$=0.0088 $L_t^{3.0385}$, and in the linear form of regression line equation as: females: $lnW_t$=1.0071 + 3.1787 $lnL_t$ (r=0.9452, P<0.01), and males: $lnW_t$=1.0088 + 3.0385 $lnL_t$ (r=0.9452, P<0.01).

The data of length-weight relationship for females and males were analyzed to test whether the regression equations obtained above for both species differed significantly from each other. It is evident that the length-weight relationship both in females and males differ significantly for *Characidium lauroi* (P<0.05), but not for *C. alipioi* (P>0.05). Then, data of females and males in this species were pooled, and the new equations were: females and males: $W_t$=0.0057 $L_t^{3.2655}$, and $lnW_t$=1.0057 + 3.2655 $lnL_t$ (r=0.9762, P<0.01).

The seasonal changes in condition factor are given by the values of the intercepts (*a*) respective to each allometric equation for each period (Figure 3). A seasonal cycle in condition is to be expected, with a high level of condition during fall-winter and a low level on summer for both species. During spring, the condition decreases.

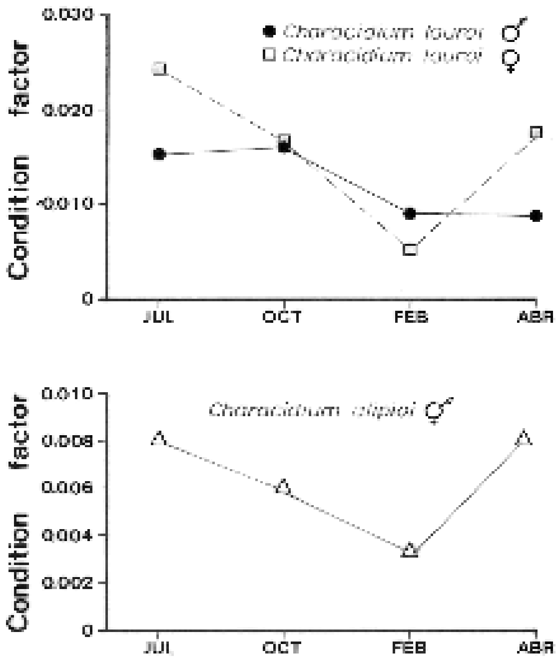


**Figure 3.** Seasonal variations of condition factor in *Characidium lauroi* (females and males) and *C. alipioi* (females and males pooled), from Ribeirão Grande system.

## Discussion

*Characidium lauroi* and *C. alipioi* ate mainly larval Diptera, Trichoptera and Ephemeroptera nymphs. Because the fish species considered in the present study involved partial isolation from each other and make similar demands of their environment (Braga, 2004), they are potentially competing for resources.

Similarity of the food eaten by species within an association usually occurs only in relation to secondary foods, the main foods being different (Nikolskii, 1969). Accessibility is important to food intake, specially when the abiotic conditions change; chironomid larvae are eaten to an extent dependent on how far they can penetrate into the mud (Nikolskii, 1969). Chironomids have an important role in the food webs of aquatic communities, representing a major link between producers and secondary consumers (Henriques-Oliveira, 2003). Characidiin fishes live near the bottom, occurring in places of faster water-flow. They developed adapted morphology to live in this ambient, such as small size, wide pectoral fin and swim bladder absence (Braga, 2004). Food is obtained near the bottom, mainly larvae and nymphs of aquatic insects that inhabit these ambients. In characidiin fish, the mouth is small, terminal and has minuscule, cylindrical teeth (Travassos, 1949; 1955). Food ingestion is made by apprehension and suction, not by bite; a majority of teleosts feeds by suction feeding (Gerking, 1994). Analysis of the food composition into the stomach confirms this hypothesis. *Characidium alipioi* is larger than *C. lauroi*, which makes easier for the former to ingest larger preys, like Megaloptera larvae and Arachnida.

Food location occurs more through vision than through smell. The objects are more visible in clear, shallow waters, while the smell is quickly dissipated by the current. The traps used in this experiment, using animal ration as bait, were not efficient in characidiin fish capture.

Costa (1987), studying the feeding habits of a fish community in a tropical coastal stream in southeastern Brazil, described the food of *Characidium* sp. as consisting almost exclusively of aquatic benthic insects. Diptera larvae (Simuliidae) frequency was higher in places where the river bed was covered by stones, gravel and sand, while Ephemeroptera nymphs frequency was higher in places where the river bed was covered by sand and silty sand. He concluded that the difference is associated with distinct river bed types.

The substrate of streams in Ribeirão Grande system differs from place to place, and the current speed affects the food resources. According to

Vannote *et al.* (1980), the hydrological classification of lotic waters is important when considering the special distribution of macroinvertebrates.

We may conclude that the feeding of both species was very similar, because they are close species, with similar morphology and ecological aspects. The difference verified in the diets of both species is due to the food present in different ambients. On the other hand, *Characidium alipioi* is bigger than *C. lauroi*, so it can capture bigger food.

The condition factor determination has been utilized in several kinds of fish population analysis: comparing populations living under similar or different condition of food, feeding activity over a period, and the duration of gonad maturation (Weatherley, 1972; Weatherley and Gill 1987). The correlation between decreased fat deposition in the visceral cavity and decreased condition has been documented in the present study. The seasonal storage and utilization of lipid reserves are important in fish metabolic activities and reproduction (Guillemot *et al.*, 1985). On the other hand, the stomach fullness of *Characidium lauroi* and *C. alipioi* were reasonable over time, suggesting that feeding activity was constant.

In many fishes, reserves are used primarily in reproduction (Shchepkin, 1971; Wooton and Evans 1972). The differences in fat content of closely related species are connected with life span (Nikolskii, 1963). The increased sexual ripeness and decreased condition has been reasonably well documented in the literature, with increased reproductive activity and depletion of bodily reserves (Stewart, 1988). There is no information concerning characidiin spawning in the literature, but it has been noticed in this study that the peak of gonadal development was found during spring-summer for *Characidium lauroi* and *C. alipioi* (unpublished data) and the fat amount rapidly decreases during summer. As stated above for the characidiin fishes, the life span reflects the specific environment conditions for each species.

## Conclusion

The diets of *Characidium lauroi* and *C. alipioi* are similar. It is recognized, however, that this analyses of alimentary tract contents does not allow a definite assertion that these species are selecting from an array of available items rather than simply picking up what is available to them. The acceleration of gonadal maturation is achieved by fat content depletion and prolonging foraging periods during the year.

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