Effects of habitat on physiological indicators in Leporinus friderici (Pisces, Anostomidae) in the influence area of the Corumbá Reservoir, Goiás, Brazil.

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ABSTRACT: Effects of habitat on physiological indicators in Leporinus friderici (Pisces, Anostomidae) in the influence area of the Corumbá reservoir, Goiás, Brazil. The physiological variables, indicative of the use of energy by fish, were analysed during habitat changes caused by the impounding of the Corumbá reservoir. Samplings were undertaken prior to the formation of the Corumbá reservoir (March 1996 - August 1996, river phase), during impounding (September 1996 - February 1997, transition phase) and after its formation (March 1997 - February 2000, reservoir phase). Each specimen was analysed Stomach Fullness Index (SFI), Gonadosomatic Index (GSI) Condition Factor (K') and Caloric Content. Alterations in environment affected the physiological indicators analysed for L. friderici. These indicators were distinct for each sex, while positive changes (an increase in mean SFI and K') and negative ones (decrease in mean standard length, GSI and energy), conditioned to the species's ecological plasticity, may still occur. Total of positive variations of fitness warrants the species's success in the occupation and in the maintenance of the recently formed environment. It should be emphasized that impact intensity is a mitigating factor on the stress borne by the species.

Key words: Fish, Leporinus friderici, impact, Paraná river, energy.

RESUMO: Efeitos do habitat sobre os indicadores fisiológicos de Leporinus friderici (Pisces, Anostomidae) na área de influência do reservatório de Corumbá, Goiás, Brasil. As variáveis fisiológicas, indicativo do uso de energia por peixes, foram analisadas durante modificações no hábitat provocadas pela formação do reservatório de Corumbá. Foram realizadas amostragens antes da formação do reservatório de Corumbá (março de 1996 – agosto de 1996 - fase rio), durante o enchimento do reservatório (setembro de 1996 - fevereiro de 1997 de fevereiro - fase transição) e após sua formação (março de 1997 – fevereiro de 2000 - fase reservatório). Para cada indivíduo foram calculados os índices de Enchimento do estômago (IEE), Gonadossomático (IGS), Fator de condição (K') e conteúdo calórico. Alterações no ambiente afetaram os indicadores fisiológicos de L. friderici, os quais foram diferentes para cada sexo. Mudanças positivas (incremento na média de IEE e K') e negativas (redução da média do comprimento padrão, IGS e energia), condicionadas a plasticidade ecológica da espécie, ainda podem ocorrer. A somatória das variações positivas do "fitness" garante a espécie o sucesso alcançado na ocupação e/ou manutenção do ambiente recém formado. É importante enfatizar que a intensidade do impacto é fator atenuante sobre o "stress" a ser suportado pela espécie.

Palavras-chave: Peixe, Leporinus friderici, impacto, rio Paraná, energia.

Introduction

Research has been done on the effects caused by the damming on the ichthyofauna. It is accepted as rule that some expected consequences of the damming are: decrease of the number of species; mortality of fish; reduction of the recruitment rate; substitution

of the fauna for species of short life cycle, of such minor and low economical value (Bacalbasa-Dobrovici, 1991; Agostinho et al., 1992). The understanding of the phenomenon, assistance in mitigation of impacts and in the rational exploration of resources have been studied by a lot of researchers (Tundisi, 1981; Agostinho & Júlio Jr., 1999; Tundisi & Straskraba, 1999; Henry, 1999). However there are few studies about the effects of the damming on the allocation of the energy in the affected communities (Duque et al., 1998).

Growth, maintenance and survival of a certain species in its habitat are closely related to the allocation of the energy from the ingested food. Understanding the distribution of the ingested energy for the fish maintenance is fundamental considering that in certain conditions the distribution of energy may reveal a source of conflict for the organism (Pianka, 1982), especially in impounded environments. The stored energy results from intraspecies limitations and interspecies interactions in a certain ecological situation. The evaluation of costs and benefits of species belonging to a determined trophic levels and development phases, is decisive to the understanding and elaboration of models of the energy flow and to an adequate management of the ecological system (Winberg, 1970; Calow, 1985; Wootton, 1990).

Physiological indices, like condition factor, of Leporinus friderici (Bloch, 1794), one of the most abundant species in experimental fishery, have been analysed to evaluate the impact of the Corumbá Reservoir, state of Goiás, Brazil (UEM NUPELIA/FURNAS, 1997). Leporinus friderici is considered an omnivorous species and uses a wide range of food items, mainly grass and seeds (Silva, 1988; Andrian et al., 1994), besides fishes and invertebrates (UEM NUPELIA/FURNAS, 2001). This species presents total spawning (Suzuki, 1992) has seasonal short-distance migration (Agostinho et al., 2003) and slow growth (Barbieri & Santos, 1988). So, while the above biological characteristics give a physiological profile of the species, it shows high tolerance to the environment changes. In this context the present study aimed to analyse the effects of the alterations of the habitat in the area of the Corumbá reservoir, on some physiological indicators in males and females of L. friderici.

Material and methods

Samples were taken monthly prior to impounding (from March 1996 through August 1996 - river phase = RIVER); during impounding (from September 1996 through February 1997 - transition phase = TRANS) and after the formation of the Corumbá Reservoir (from March 1997 through February 2000 - reservoir phase: from March 1997 through February 1998 = RES-1; from March 1998 through February 1999 = RES-2; from March 1999 to February 2000 = RES-3). Nine sampling stations were established and distributed throughout the influence area of the Corumbá Reservoir (Fig. 1).

Gillnets with different mesh sizes (2.4 to 16 cm between opposite knots) were used. Data on standard length (Ls), total weight (Wt), gonad weight (Wg) and stomach weight (Ws) of 11,559 specimens were obtained. Sex and stage of gonad maturation were identified by macroscopic inspection (Vazzoler, 1996). Only resting specimens were analysed with objective to exclude the interference of gonadal maturation on inspected variables. Male and female fish were analysed separately since they may respond differently to the same impact (Shearer, 1994).

Muscle samples, close to the insertion of the first dorsal fin, were removed for caloric content determination. Samples were kept in ice and processed in the laboratory of Energetic Ecology of the Research Nucleus in Limnology, Ichthyology and Aquaculture (Nupelia) of the State University of Maringá. Samples were then dried at 60° C until constant weight, macerated and their caloric density determined in a Parr Model 1261 oxygen bomb calorimeter.

Stomach fullness index (SFI = $Ws.Wt^{-1}.100$, being Ws = stomach weight and Wt = total weight), Gonadosomatic index (GSI = $Wg.Wt^{-1}.100$, Wg = gonadal weight) and Condition Factor (K'= $(Wt-Wg).Ls^{-b}.100$, where "b" is the angular coefficient of Ls x Wt) were determined for each specimen. Length-Weight (Ls-Wt) relationship was obtained by the minimum

square method and linear regression was established for either sex and each study phase. For each "b" a t-test (Zar, 1974) was used to determine whether b = 3.

Trends shown by average values of calorimetry and standard length were investigated and one-way ANOVA was used for possible differences among averages for each study phase, and in the identification of such differences it was used post hoc Tukey's test in the identification of such differences.

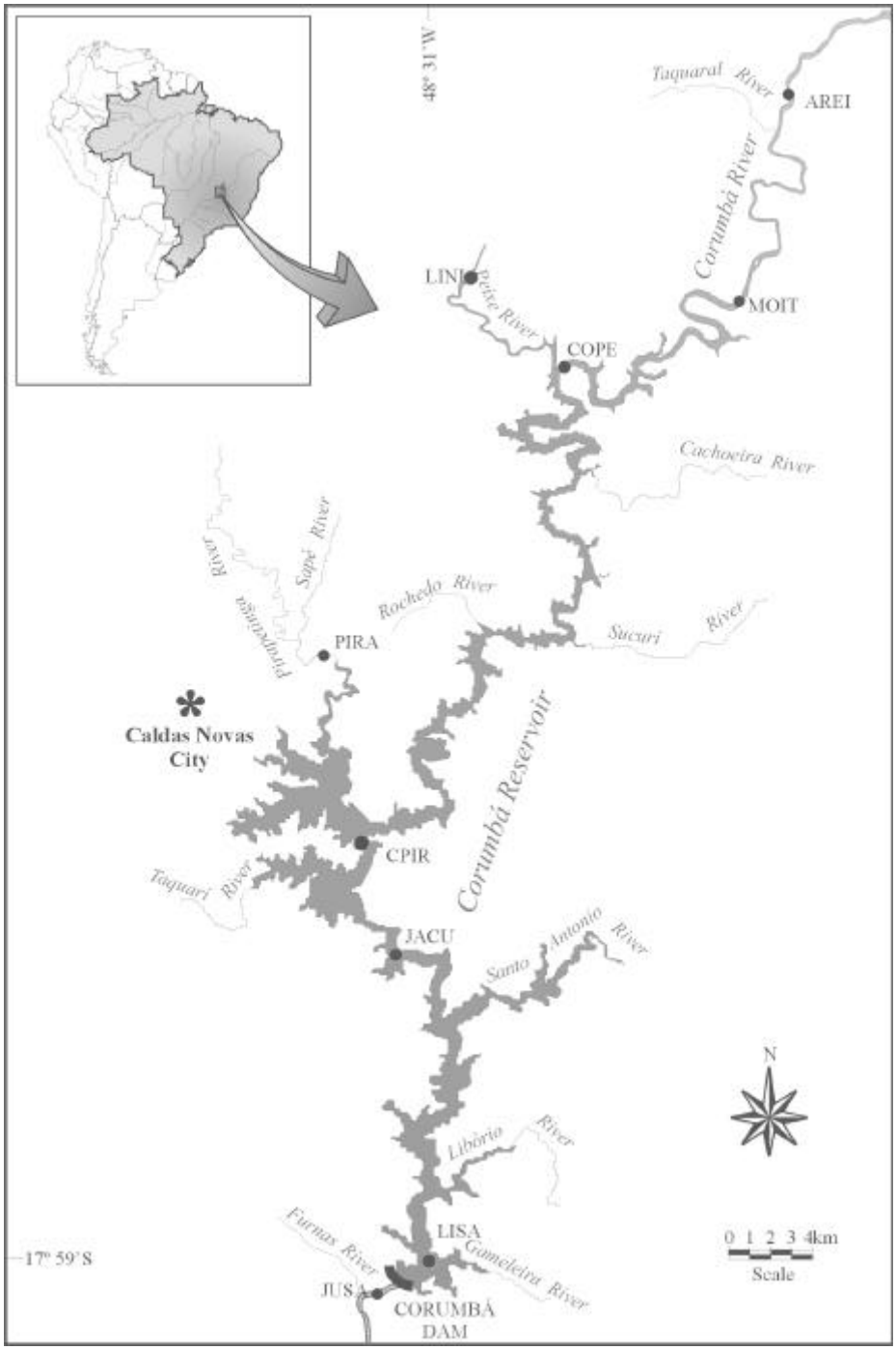

Figure 1: Map showing position of sampling areas (●).

Results and discussion

The length-weight relationship has been used to estimated the growth curve in weight and to define fish condition (Barbieri & Barbieri, 1983). Coefficients (r^2) of Ls-Wt relationship, established at each study phase, were higher than 98%. When the values of b are very close to 3, it is assumed that the growth of the analysed species is of the isometric type. However, when we tested and verified that the value of the exponent (b) is significantly different from 3, the growth is denominated of allometric type (Benedito-Cecílio et al., 1997). In this study, the values of "b" ranged between 2.91 and 3.04 for males and between 3.01 and 3.14 for females. In fact, "b" value differed significantly from 3 in several periods, before and after impounding (Tab. I). The same species sampled in the Itaipu Reservoir presented b = 3.14, while species growth was allometric (Benedito-Cecilio et al., 1997). Parameter values of Ls-Wt relationship may vary for fish in different sites or at different growth phases and are only constant for the species in similar conditions (Goulart, 1981). In this study, isometric growth (b = 3) occurred only in females at RES-1. During the same period the males showed the lowest "b" value.

Table I: Length-Weight relationship parameters and related statistics for males and females of L. friderici sampled prior to impounding (RIVER), during impounding (TRANS) and after the formation of the Corumbá Reservoir (RES-1, RES-2 and RES-3) (a is linear coefficient and b is angular coefficient of regression Ls x Wt).

			Males				Females			
Period	**Ls (cm)**	**Wt (g)**	**n**	**r^2**	**a**	**b**	**n**	**r^2**	**a**	**b**
RIVER	3.7 – 32.5	3.7 – 1124.5	325	0.99	-1.69	3.04*	311	0.99	-1.81	3.14**
TRANS	3.7 – 33.0	1.35 – 1046.1	1016	0.99	-1.69	3.03**	921	0.99	-1.81	3.14**
RES-1	4.1 – 34.5	1.47 – 1183.1	2213	0.98	-1.55	2.91**	1959	0.99	-1.65	3.01
RES-2	3.4 – 32.5	0.94 – 980.5	1692	0.99	-1.62	2.97**	1851	0.99	-1.69	3.04**
RES-3	2.8 – 32.2	0.58 – 1054.0	621	0.99	-1.65	3.03**	640	0.99	-1.75	3.12**
TOTAL			5,877				5,682			

Significance: *p< 0.05; **p< 0.01

Considering the physiological variables analysed (Figs. 2 and 3), only SFI for females (ANOVA: males - GL = 4; F = 1.35; p = 0.248) and caloric content from muscles of both sexes (ANOVA: males - GL = 4; F = 1.95; p = 0.188; females - GL = 4; F = 1.69; p = 0.206) were not significantly different among periods. Resting females with full stomachs in different phases of the study indicate that food input was not impaired by environmental changes due to the damming process. For males was observed that SFI increase after impoundment. Diet plasticity warrants stomachs frequently full with food. Adult specimens in the RIVER phase mainly consumed fish (UEM Nupélia/FURNAS, 1997), whereas in the transition and reservoir phases the item was replaced by grass in equivalent proportions (UEM Nupélia/FURNAS, 2001). Analyses of isotopic ratios ($d^{13}C$ and $d^{15}N$) of muscles from L. friderici during the third year of impounding showed significant contributions of carbon from grasses C_4 (up to 47.7%) (Benedito-Cecilio et al., submitted). On the other hand, the omnivorous trait of this species is very complex in tropical ecosystems, making difficult its position in the food network (Lowe-McConnel, 1999). Results of $d^{15}N$ showed that, at this phase, the species lies between the second and third trophic level (Benedito-Cecilio et al., op. cit.).

This trophic position may be the same occupied by L. friderici during the other periods in the current research, since the caloric content for fish was not significantly different in phases RIVER, TRANS, RES-3, with mean values for all periods of study of

5.378±0.332 and 5.503±0.520 Kcal/g dry weight, for males and females, respectively (Figs. 02 and 03). Values were close to those found by Doria & Andrian (1997) for Schizodon borelli (herbivorous) and Pimelodus maculatus (omnivorous) in the floodplain of the Paraná river, Brazil. Species belonging to higher trophic levels showed lower caloric values (Pereira et al., 2001; Dourado et al., 2004). This indicates a decrease in the energy content with a rise in the trophic position (Odum, 1988).

Mean standard length was lower at phase RES-2 and higher in the next period (RES-3) for both sexes. However, only females showed significant differences (p = 0.0129). Although specimens analysed were at rest, the year in which impounding occurred was characterized by the marked ingress of younger specimens with an increase in length and weight during the following year. These population renewals could be seen inconspicuously during earlier periods (TRANS and RES-1).

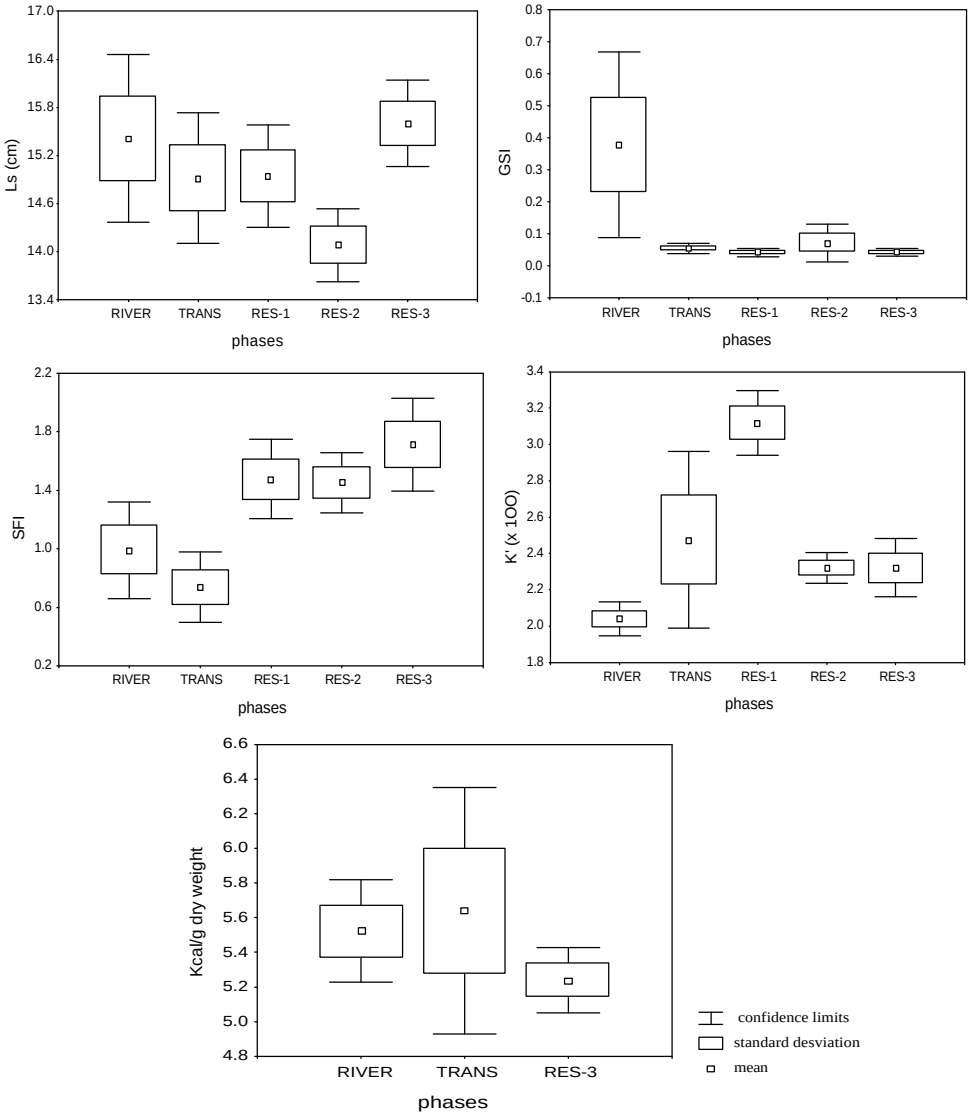

Figure 2: Distribution of values of standard length (Ls), Gonadosomatic Index (GSI), Stomach Fullness Index (SFI), Condition Factor (K') and calorific content (Kcal/g dry weight) of males of L. friderici for period of study (River phase = RIVER; transition phase = TRANS; Reservoir phase = RES-1, 03/97 - 02/98; RES-2, 03/98 - 02/99; RES-3, 03/99 - 02/00).

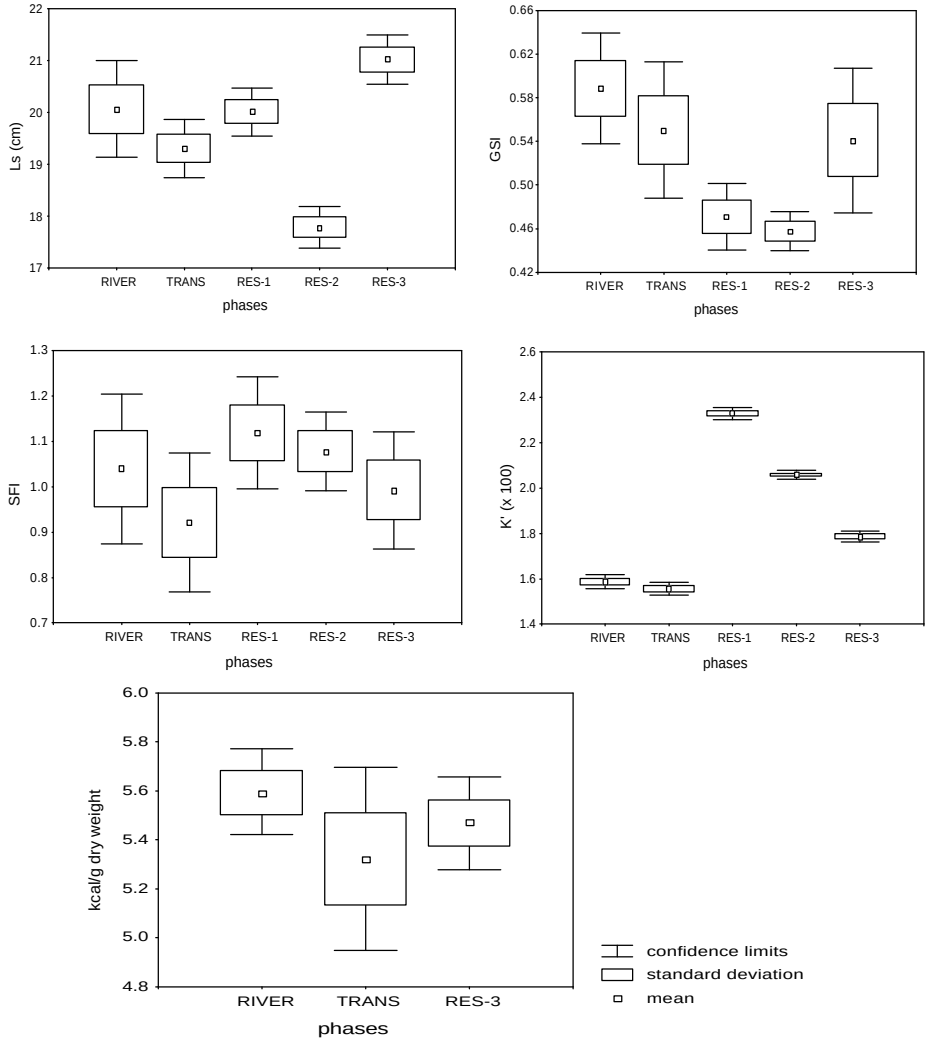

Figure 3: Distribution of values of standard length (Ls), Gonadosomatic Index (GSI), Stomach Fullness Index (SFI), Condition Factor (K') and calorific content (Kcal/g dry weight) of females of L. friderici for period of study (River phase = RIVER; transition phase = TRANS; Reservoir phase = RES-1, 03/97 - 02/98; RES-2, 03/98 - 02/99; RES-3, 03/99 - 02/00).

In the river phase, the GSI of males had a wider variation and means were significantly different from those of the other periods. Higher values coincide with a greater size variation in this phase. It is possible that in the phase river, the individuals of the species, widely distributed in the area, they could be captured in different size classes and age, due to own diversity of available habitats. With the formation of the reservoir, the spatial limitation of the species promoted a clear reduction of the size classes, being verified a prevalence of the smallest individuals to the second year after the impoundment. Lopes et al. (2000) identified that the population of L. friderici, was constituted of 70% of youngs in the second year after the formation of the Corumbá reservoir and that the size of first maturation gonadal suffered a little decrease. This fact seems to be peculiar the species, once in the Itaipu reservoir the reduction of size of first maturation was also observed. It was still verified, that in RES-3 males and females showed superior sizes those sampled in the phase river, what can indicate a possible restructuring of the population, as verified by Lopes et al. (2000) for the Itaipu reservoir.

A large female has a greater number of oocytes (Blay, 1981; Duarte & Alcaraz, 1989) and therefore may have heavier gonads. However this fact disagrees with the low GSI values and high mean values of standard length recorded for females during the first year of the formation of the Corumbá Reservoir.

It is well known that the period immediately after the transformation of a river into a reservoir is critical for fish assemblages (Benedito-Cecilio & Agostinho, 2000). There was no drastic effect on fish assemblage due to the formation of the Corumbá Reservoir in contrast with what occurred in the formation of the Itaipu Reservoir, state of Paraná, Brazil, especially with regard to the same species (Lopes et al., 2000). Reproduction is sensitive to environmental factors, such as temperature, photoperiod and conductivity (Benedito, 1989). High sensitivity of the reproductive activity, specially for females (spawning sites, maturity length, towards environmental), may explain the decrease of mean GSI values of the river phase with regard to RES-2. It was only during the third year after impounding that GSI mean values became again. Contrastingly, SFI and K' had their highest values in the first year after impounding. This fact shows that food intake has not been impaired by the environmental impact. On the contrary, during this period greater resources were available (Ferreira, 1984; Agostinho et al., 1992).

It should be emphasized that although significant differences in caloric variation during the years under analysis have not been recorded, impounding had contrary effects between the sexes. In the transition period males accumulated higher caloric contents which, in their turn, declined in the third year after impounding, while females maintained minimum values in the transition period. This latter factor may possibly mean high reproduction impairment (Narahara et al., 1985).

So, impounding provoked changes in the habitat affecting the physiological indicators of L. friderici, for both sexes. Impact from impounding caused positive (increase in SFI and K') and negative (decreasing mean values of Ls, GSI and Kcal/g dry weight) changes conditioned to the species's ecological plasticity limits. Total positive variations of fitness are a guarantee to this species for its success in the occupation and maintenance of the recent environment. It should be emphasized that the intensity of impact and the specific environmental factors proper to each habitat are a mitigating factor on the stress borne by the species.

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