BIOLOGICAL ATTRIBUTES OF *Steindachnerina insculpta* (Fernandez-Yepez, 1948) (Curimatidae) IN TWO RESERVOIRS OF MIDDLE PARANAPANEMA RIVER, BRAZIL*

HELENO BRANDÃO[1], ANA PAULA VIDOTTO-MAGNONI[1],
IGOR PAIVA RAMOS[2] e EDMIR DANIEL CARVALHO[3]

Recebido em 18.03.2013 e aceito em 02.07.2013.
[1]Autor correspondente, Pós-doutorando do Programa de Pós-Graduação em Ciências Biológicas, ênfase em Zoologia. Laboratório de Parasitologia de Animais Silvestres (Lapas), Departamento de Parasitologia, Instituto de Biociências de Botucatu – UNESP, Distrito de Rubião Júnior s/n; 18.618-970 - Botucatu - SP. e-mail: heleno_brandao@hotmail.com; anavidotto@gmail.com
[2]Docente do Centro de Ciências Biológicas, Universidade Tecnológica Federal do Paraná -UTFPR, Estrada para Boa Esperança km 04; CEP 85660-000, Dois Vizinhos - PR. e-mail: igor.paiva.ramos@gmail.com
[3]Docente do Instituto de Biociências de Botucatu – UNESP, Distrito de Rubião Júnior s/n; 18.618-970 - Botucatu - SP. *Em memória.*
*Financial support: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)

RESUMO: O objetivo deste estudo foi avaliar os atributos biológicos de *Steindachnerina insculpta* em duas represas do médio rio Paranapanema. Os peixes foram coletados com redes de espera bimestralmente em quatro áreas da represa de Salto Grande e trimestralmente em cinco áreas de Chavantes. Após a confirmação da espécie, foram obtidos os dados biométricos, comprimento padrão, peso total e o sexo. Estas informações foram utilizadas para avaliar os atributos biológicos (abundância, razão sexual, relação peso-comprimento, fator de condição e a distribuição em classes de tamanho) para cada área. Para ambas as represas a proporção sexual diferiu de 1:1 e o tipo de crescimento foi alométrico positivo. O fator de condição e as classes de tamanho variaram entre as áreas amostradas. Para as duas represas a classe de tamanho mais representativo foi entre 9,1 e 10,5 cm. Este trabalho demonstra que os atributos biológicos das populações de *S. insculpta* variam ao longo das áreas das duas represas, refletindo a capacidade de ajuste da espécie.

Palavras chave: Distribuição espacial, represa de Salto Grande, Represa de Chavantes.

ATRIBUTOS BIOLÓGICOS DE *Steindachnerina insculpta* (Fernandez-Yepez, 1948) (Curimatidae) EM DUAS REPRESAS DO MÉDIO RIO PARANAPANEMA, BRASIL

ABSTRACT: The aim of the present study was to evaluate the biological attributes of *Steindachnerina insculpta* in two reservoirs of middle Paranapanema River. Fish were collected with gillnets every two months at four sites of the Salto Grande Reservoir and quarterly at five sites of the Chavantes Reservoir. After confirmation of the species, were obtained biometric data, standard length, total weight and sex. This information was used to assess the biological attributes (abundance, sex ratio, length-weight relationship, condition factor and size class distribution) for each area. In both reservoirs, the sex ratio of the total samples differed from 1:1 and growth was positive allometric. The condition factor and length varied between sites. The most representative size class at all sites was 9.1 to 10.5 cm. This study demonstrates that the biological attributes of populations of *S. insculpta* are modified along the areas of the two reservoirs, reflecting the ability to adjust the species.

Key words: Spatial distribution, Salto Grande reservoir, Chavantes reservoir.

INTRODUCTION

The fish species *Steindachnerina insculpta* (Fernandez-Yépez, 1948) belongs to the family Curimatidae and has wide geographic distribution in South America (Reis et al., 2003). It is especially abundant in the Paranapanema River (Dias & Garavello et al., 1998; Hoffmann et al., 2005; Britto & Carvalho, 2006; Brandão et al., 2009; Oliva-Paterna et al., 2009), and well adjusted to environments of artificial reservoir.

Artificial reservoir are structured along a continuum beginning in the region of the influx of the river to the reservoir, with three distinct zones – the lotic, transition and lentic zones (Fernando & Holčík, 1985). These zones differ with regard to the physical, chemical and biological properties of the water (Pagioro et al., 2005) as well as the structuring of different groups of aquatic organisms (Fearnside, 2008; Naik et al., 2011).

Fish populations are subject to the operational conditions of the reservoir, which can lead to changes in the structure of the habitat and availability of resources for the ichthyofauna. Among the resident fish in artificial reservoirs, the species considered sedentary (able to complete all stages of their life cycle in the same environment), are generally, the most pre-adapted to survive in this type of environment, as observed in reservoir of Paranapanema River (Agostinho et al., 2007). Probably, this strategy is adopted by the species *S. insculpta*.

This small species is considered to have no commercial value and is only used as bait in professional and amateur fishing activities (Ratton et al., 2003; Bialetzki & Nakatani, 2004). However, small species, such as *S. insculpta*, are ecologically important as a food source for higher trophic levels, especially piscivorous fish (Bennemann & Shibatta, 2002). Thus, the presence of these species can ensure the survival of other species of larger size maintaining a relatively balanced ecosystem.

The aim of the present study was to evaluate the biological attributes (abundance, sex ratio, distribution in size classes and condition factor) of populations of S. insculpta and compare sites of the Salto Grande and Chavantes reservoirs, at middle Paranapanema River, Brazil.

MATERIAL AND METHODS

The Salto Grande (SG - 22° 50’ 23” S and 49° 50’ 50” W) and Chavantes (CH - 23° 07’ 50.5” S and 49° 42’ 04.8” W) reservoirs are located along the middle Paranapanema River at the border of the states of São Paulo and Paraná, Brazil (Figure 1). The two reservoir present great differences regarding size, structure and operation. The Chavantes Reservoir is 480 m above sea level, with maximal depth of 70 to 90 m, total volume of 9,410 x 106 m^3 and an area of 400 km^2 and high residence time of water (418 days) (Duke Energy, 2002, Nogueira et al., 2006). The Salto Grande Reservoir exhibits little variation in water level, regardless of the flow, and there is no expansion of the aquatic environment, even during the rainy season. This reservoir has a maximal depth of 13 m, total volume of 42.2 x 106 m^3 and an area of 12.2 km^2 and residence time of water of 1,5 days (Junior et al., 2005).

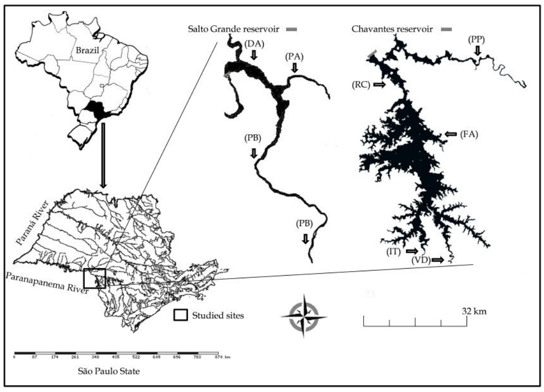

Figure 1. Location of Salto Grande and Chavantes reservoirs along middle Paranapanema River, states of São Paulo and Paraná, Brazil; sampling sites indicated by arrows (Source: GoogleEarth – DigitalGlobe).

In the Salto Grande Reservoir, samples were collected bimonthly from Nov 2005 to Set 2006 at four distinct sites representing lotic, transition and lentic environmental compartments. In the Chavantes Reservoir, samples were collected every three months from Oct 2005 to Jul 2006 at five sites representing the lotic, transition and lentic environmental compartments (Table 1). Gillnets with different mesh sizes were used to sample the fish (3 to 14 cm between opposing knots and height from 1.44 to 2.20 m). Nets were set at 17:00 PM and removed at 6:00 AM (exposure time of 14 hours). In the laboratory, the fixed (using formol 10%) specimens were weighed on a precision scale (0.001 g) and measured (standard length in centimeters). The biologic material was collected with permanent license for zoological material (Ibama Register: 2629349).

Table 1. Surroundings of the sampling areas of in the reservoirs of the Salto Grande and Chavantes.

Sites/Code	Reservoir	Geographical coordinates	Areas
Dam (DA)	Salto Grande	S 22º54'13.2" W 49º59'00.3"	Lentic
Pedra Branca (PB)	Salto Grande	S 22º 57' 08.4" W 49º 58' 22.0"	Transition
Pardo (PA)	Salto Grande	S 22º 54' 14.0" W 49º 57' 01.1"	Lotic
Diacui (DI)	Salto Grande	S 23º 01' 59.2" W 49º 54' 52.9"	Lotic
Ribeirão Claro (RC)	Chavantes	S 23º 14' 28.9" W 49º 39' 45.5"	Lentic
Fartura (FA)	Chavantes	S 23°24' 57.7" W 49° 33' 54.1"	Lentic
Paranapanema (PP)	Chavantes	S 23°08' 03.3" W 49° 26' 14.6"	Transition
Verde (VE)	Chavantes	S 23°33' 38.9" W 49° 32' 10,9"	Lotic
Itararé (IT)	Chavantes	S 23°35' 11,2" W 49° 36' 22.9"	Lotic

Species abundance was transformed into catch per unit of effort in number of individuals (CPUEn) in order to standardize catch efforts for 1,000 m^2 of nets among all sites of the river: CPUEn=numberx1000/area of nets (Carvalho & Silva, 1999). Analysis of the variation in standard length (L_s) and total weight (W_t) in the population was performed to compare sites in both reservoirs. After checking assumptions of normality (Lilliefors test), with the aid of the BioEstat 5.0 (Ayres et al., 2007), the statistical differences were tested using the nonparametric Kruskal-Wallis ($p < 0.05$) test, followed by Dunn's test for comparing differences.

The sex of the specimens was determined in laboratory by macroscopic analysis of the gonads and the sex ratio for each site and for the reservoirs was determined using the chi-square test ($\chi 2$, $p < 0.05$), employing the following equation: $\chi 2 = 2 * x(OxE)\ 2$. E, in which O is the frequency of females and males and E is the expected proportion (Ayres et al., 2007).

The length-weight relationship was calculated for males, females and total individuals, based on Le Cren (1851) and Santos (1978), as follows: $Wt = \phi \times L_s^{\theta}$, in which Wt is the total weight of the individual (g), ϕ is the parameter indicating the welfare of the fish (physiological state of the individual), L_s is the standard length (cm) and θ is the parameter defining the type of growth of the species.

The condition factor ($K = W_t/L_s^{\theta}$) (Vazzoler, 1996), derived from the calculation of the length-weight relationship, was based on Le Cren (1851) and Santos (1978). The K factor was calculated to populations considering the sampling areas grouped of each reservoir and each environmental compartment separately, irrespective of sex. The nonparametric Kruskal-Wallis ($p < 0.05$) test was performed for analysis among sites and Mann-Whitney U test was used for analysis among reservoirs. The analysis was performed in BioEstat 5.0 and STATISTICA 7 (ZAR, 1984; Ayres et al., 2007) program.

The distribution of the specimens in size classes was performed considering the sampling areas grouped of each reservoir and each environmental compartment separately, based on Sturges (1926), using the following equation: W = K x R, in which W is the width of each size class, K is the number of classes (1 + (3.222. log N) (N= number of individuals) and R is the full amplitude of the data (greatest L_s – smallest L_s). Classes were determined from the data of the total sample in the two reservoirs separately. The relative frequency of each size class for males and females was confirmed using the Kolmogorov-Smirnov test ($p < 0.05$). The analysis was performed in BioEstat 5.0 (Ayres et al., 2007).

For all statistical analyzes in this study, the differences between variables were considered significant when $p <0.05$. Voucher specimens were deposited at the Laboratório de Biologia e Genética de Peixes (LBP), Instituto de Biociências, UNESP Botucatu, Brazil.

RESULTS

A total of 336 individuals of *S. insculpta* (Voucher LBP 4823) were caught in the Salto Grande Reservoir and 525 were caught in the Chavantes Reservoir, totaling 861 specimens. The absolute abundance of fish in each site is presented at Table 2. Females were predominant at all sites, except the Itararé site (IT), where males were dominant.

The largest CPUEn in the Salto Grande Reservoir was recorded in the Pardo and the smallest catch was recorded at the Dam site. In the Chavantes Reservoir, the largest catch occurred at the Fartura site and the smallest was recorded at the Ribeirão Claro site (Figure 2).

Table 2. Total absolute abundance (n), the sex ratio (SR) and Chi-square ($\chi 2$) test applied to female to male for *S. insculpta* in all sites of Salto Grande and Chavantes reservoirs (bold), Middle Paranapanema River. *Chi-square ($\chi 2$) statistically different values ($\chi 2 > 3.84$).

Site	n	SR	χ^2
Salto Grande (SG)	336	03:1	24.36*
Dam (DA)	63	04:1	36.79*
Pedra Branca (PB)	78	3.5:1	31.64*
Pardo (PA)	125	2.9:1	23.78*
Diacuí (DI)	67	02:1	11.78*
Chavantes (CH)	525	1.5:1	4.0*
Ribeirão Claro (RC)	72	2.2:1	14.8*
Fartura (FA)	147	1.5:1	4.5*
Paranapanema (PP)	101	2.5:1	18.6*
Verde (VE)	84	2.2:1	14.6*
Itararé (IT)	121	1:1.4	3.9*

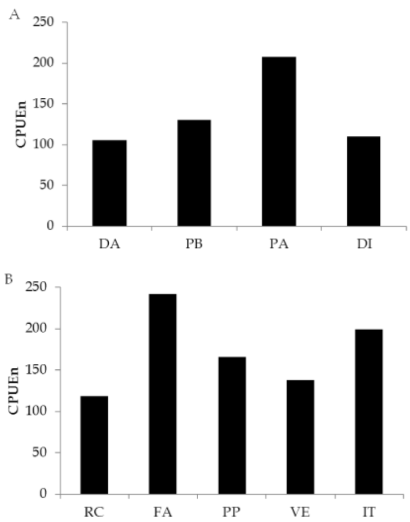

Figure 2. Catch per unit of effort (CPUEn) of *S. insculpta* populations considering sampling sites in (A) Salto Grande and (B) Chavantes reservoirs.

We observed differences in size and weight of fishes among sites. In the Salto Grande Reservoir, the longest standard lengths were observed in the lotic Pardo (PA), transition Pedra Branca (PB) and lentic Dam (DA) zones (Figure 3-A), whereas total weight presented higher values at the Pardo site (Figure 3-A and C). In the Chavantes Reservoir, the longest standard length and greatest total weight were recorded in the lentic Ribeirão Claro (RC) and transition Paranapanema (PP) zones (Figure 3-B and D).

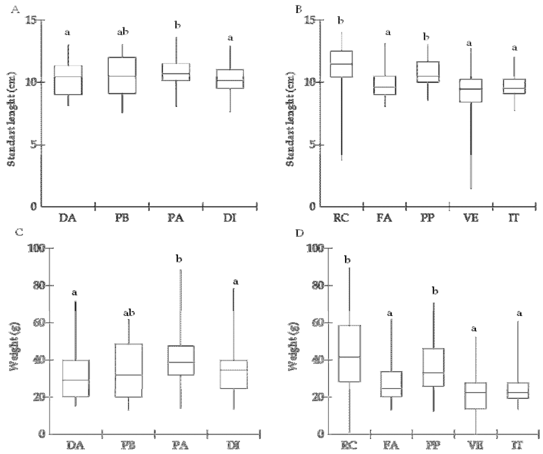

Figure 3. Variation in standard length and weight of *S. insculpta* in Salto Grande (A and C) and Chavantes (B and D) reservoirs; Vertical lines: maximum and minimum values; box: first and third quartiles; horizontal lines: medians; Different letters indicate significant differences (Kruskal-Wallis test; $p < 0.05$).

The analyses of length-weight relationship showed that the populations of *S. insculpta* of Salto Grande and Chavantes reservoirs presented positive allometric growth (Table 3). In the sites Pedra Branca (PB) and Dam (DA), the growth type was more close to 3.0, being considered isometric.

The condition factors revealed variation between environmental compartments. Considering the total population of each reservoir separately (independently of the distribution of the populations within the environmental compartments of each reservoir), significant differences was observed among reservoirs (Figure 4A). In the Salto Grande Reservoir, statistically significant differences were found between the transition Pedra Branca (PB) and lentic Dam (DA) and lotic zones (Pardo - PA and Diacuí, DI) (Figure 4B). In the Chavantes Reservoir, the highest values were recorded in the Ribeirão Claro (lentic zone), Fartura (FA) and Paranapanema (PP) sites (transitions zones), with statistically significant differences between the lotic and all other sites (Figure 4C).

Table 3. Length-weight relationship of *S. insculpta* in the sites of Salto Grande and Chavantes reservoirs (bold), Middle Paranapanema River, Brazil. N: number of analyzed specimens, (a) = condition factor, (b) = growth type, (r^2) = determination coefficient.

Sites	n	a	b	r²
Salto Grande Reservoir (SG)	336	0.0157	3.26	0.93
Dam (DA)	63	0.0023	3.07	0.96
Pedra Branca (PB)	78	0.0023	3.07	0.96
Pardo (PA)	125	0.01	3.44	0.90
Diacuí (DI)	67	0.011	3.41	0.94
Chavantes Reservoir (CH)	525	0.0164	3.21	0.98
Ribeirão Claro (RC)	72	0.0142	3.28	0.98
Fartura (FA)	147	0.0205	3.12	0.94
Paranapanema (PP)	101	0.0122	3.34	0.87
Verde (VE)	84	0.0173	3.17	0.99
Itararé (IT)	121	0.0206	3.10	0.91

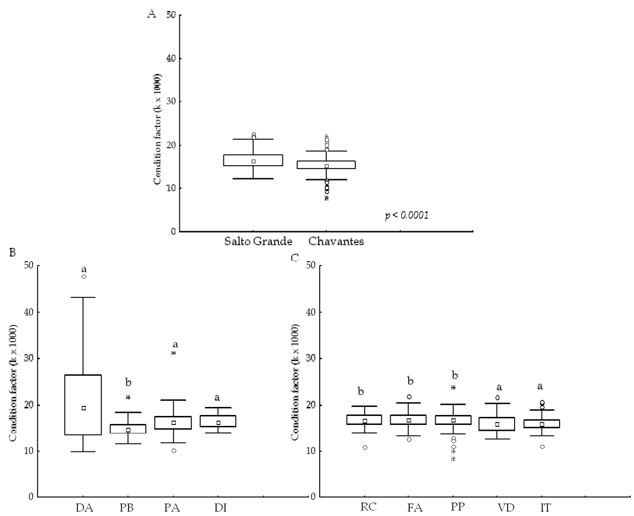

Figure 4. Variation in allometric condition factor of *S. insculpta* between Salto Grande and Chavantes reservoirs (A); significant differences based on Mann-Whitney U test (p<0.0001); sampling sites considering each dam separately: (B)Salto Grande and (C)Chavantes. Bars: standard deviation; box: first and third quartiles; square:medians; circle:outliers; *:extreme values. Different letters indicate signifycant differences (Kruskal-Wallis test; p < 0.05).

Regarding the structure of the size classes, for all sites, females and males present differences in size classes distribution (Kolmogorov-Smirnov test, p < 0.05). Most individuals at all sites in both the Salto Grande and Chavantes reservoirs were in the 9.1 to 10.5 cm class (Figures 5-A and 6-A). In the Salto Grande Reservoir, except for the Diacuí (DI) site, a greater number of females in the 10.6 to 12.0 cm class were caught, whereas the most frequent class for males was 9.1 to 10.5 cm (Figures 5 B, C, D and E).

In the Chavantes Reservoir, a greater number of males in the 9.1 to 10.5 cm class were caught at the Itararé (IT), Paranapanema (PP) and Fartura (FA) sites, whereas the predominant class was 7.6 to 9.0 cm at the Verde (VE), Fartura (FA) and Ribeirão Claro (RC) sites and 12.1 to 13.5 cm at the Ribeirão Claro (RC) site. Regarding the frequency of females caught, the predominant class was 9.1 to 10.5 cm at the Itararé (IT), Verde (VE), Fartura (FA) and Ribeirão Claro (RC) sites and 10.6 to 12.0 cm at the Paranapanema site (Figures 6 B, C, D, E and F).

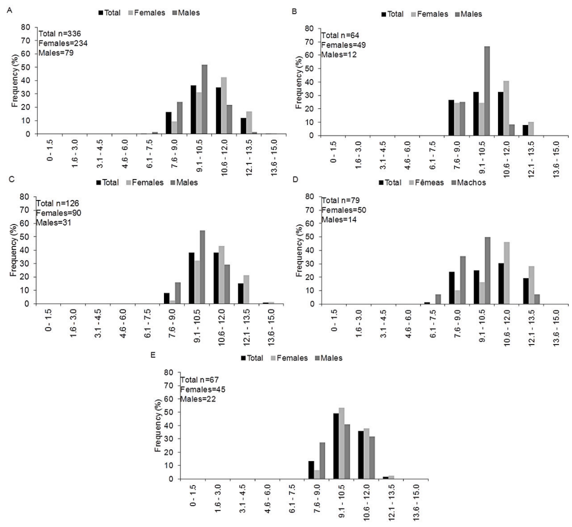

Figure 5. Frequency (%) of standard length of *S. insculpta* by size class in Salto Grande Reservoir (A) and in the different sites: Dam (B), Pardo (C), Pedra Branca (D) and Diacui (E) sites.

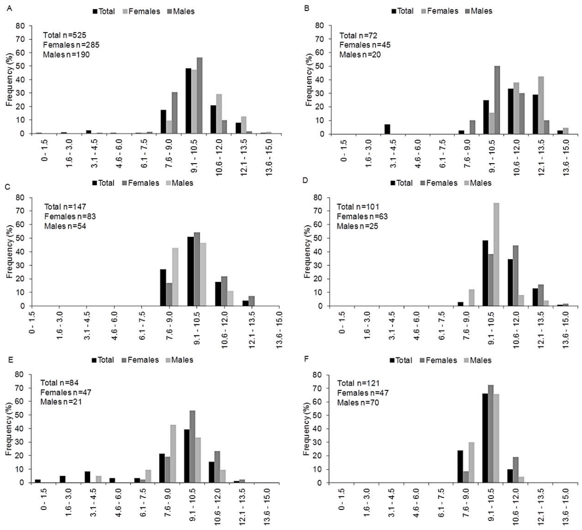

Figure 6. Frequency (%) of standard length of *S. insculpta* by size class in Chavantes Reservoir (A) and in the different sites: Ribeirão Claro (B), Fartura (C), Paranapanema (D), Verde (E) and Itararé (F) sites.

DISCUSSION

The species of fish *S. insculpta* is between the most abundant species in the two reservoirs studied (Brandão et al., 2009; Vidotto-Magnoni, 2009) and is between the dominant species of fish in the Paraná River Basin (Agostinho et al., 2007). This detritivorous species plays an important role in the trophic structure of reservoirs, since the feeding of detritus by fish species is a fundamental feeding tactic, increasing the energy efficiency and productivity of the community (Araújo-Lima et al., 1995; Lowe-McConnell 1999; Alvim & Peret 2004).

In the Salto Grande reservoir, *S. insculpta* presented greatest abundance in the Pardo site, possibly due to the considerable contribution of the input of suspended material and detritus from the surrounding municipalities, which favors detritivorous species (Bennemann et al., 2000; Teixeira & Bennemann, 2007). The high abundance of detritivorous fish is expected in river stretches of reservoirs, using the detritus of the non-consolidated bottom as food resources (Hahn et al. 1998). In addition, this can also be associated with the presence of macrophytes in the littoral zone, providing organic matter and substrate for attachment of algae and periphyton (Smith et al. 2,003; Winemiller & Jepson, 1998).

In the Chavantes reservoir, the greatest abundance was recorded in the site Fartura, which may be related to the types of compartments created in the littoral zone in lentic environments. Similarly to Pardo site, this area presents high amounts of aquatic macrophytes. These areas are favorable to the development of different organisms, performing important functions, such as structural protection of the habitat, areas for breeding and the provision of food resources (Casatti et al., 2003; Pelicice & Agostinho, 2006), such as organic matter which can be used by detritivorous fish species as S. insculpta.

The analysis of the length pattern revealed small differences in the distribution pattern of the *S. insculpta* populations in the different areas in each Reservoir, indicating that the populations respond similarly to pressure from the environment in terms of growth. Regarding the population structure based on the length pattern, smaller differences in class sizes among females and males was found in the total population in the Salto Grande Reservoir in comparison to that in the Chavantes Reservoir, which had individuals with more diversified lengths. Moreover, all females in both reservoirs were larger than the males, demonstrating sexual dimorphism. Such differences in length pattern among individuals and the distribution of length classes in the populations in different environmental compartments can be a reflection of the environmental heterogeneity among the study sites.

The sex ratio differed from 1:1, with a greater number of females in both reservoirs. However, the sex ratio pattern was not observed, only the predominance of females. The characterization of the sex ratio and size structure are basic data for assessing the reproductive potential and estimated stock size (Vicentini & Araújo, 2004). It is likely that the predominance of females constitutes a strategy reproductive (Winemiller, 1989; Vismara et al., 2004), that are directly related to the behavior of species.

The population growth pattern in both reservoirs was positive allometric, corroborating the findings reported by Orsi et al. (2002) for the Tibagi River, which is an important tributary of the Paranapanema River. This indicates that this species displays good adjustment to different environments, since the ecosystem is constantly changing, leading populations to develop appropriate strategies for the maintenance and continuity of their life cycles.

Higher condition factor values were observed in the Salto Grande Reservoir, which may be associated with some particular feature of this environment, for example, more diversity of habitat compared with the reservoir Chavantes, allowing for the populations more alternatives to find resources (food, area for breeding and spawning) for its development. The analysis in condition factor in the populations of the longitudinal axis of this reservoir was more homogeneous. However, in the Chavantes Reservoir, major differences were observed among the sites. Differences in condition factor values can be interpreted as a variation in the amount of body fat, changes in the environment related to gonad maturation and feeding intensity (Wooton, 1990; Ribeiro et al., 2007). This variation in both the Salto Grande and Chavantes reservoirs may be due to limnological characteristics (the structuring of the habitats), reflecting the amount of available food, refuge and reproductive sites for the species.

In this study we observed that the biological attributes of populations of *S. insculpta* are modified along the areas of the two reservoirs, reflecting the ability to adjust in dammed aquatic ecosystems. It is important to emphasize that the two reservoirs differ substantially in relation to size, structure and operation. Chavantes Reservoir works as accumulation basin for the other reservoirs downstream, while Salto Grande Reservoir works almost like a natural river (retention time of water is no longer 2 days). These features probably are important in distribution and structure of all biological attributes of *S. insculpta* populations.

The natural environmental variations and operating procedures of artificial reservoir can influence the spatial distribution of fish species and their biological attributes. Unpredictable differences are associated with local events, depending on the operational procedures of the reservoir and the multiple uses of the adjacent areas.

CONCLUSION

This study demonstrates that *S. insculpta* has a noticeable capacity to adjust to different environments, such as the lotic, transition and lentic limnological compartments of the Salto Grande and Chavantes reservoirs.

ACKNOWLEDGMENTS

The authors thank the Duke Energy - Generation Paranapanema for financial support; the Brazilian fostering agency CNPq for the scholarship awarded to the first author; and the Universidade Estadual Paulista (UNESP) for the infrastructure offered to carry out the study.

REFERENCES

AGOSTINHO, A.A.; GOMES, L.C.; PELICICE, F.M. **Ecologia e Manejo de Recursos Pesqueiros em Reservatórios do Brasil**. Maringa: EDUEM, 2007. 501p.

ALVIM, M.C.C.; PERET, A.C. Food resources sustaining the fish fauna in a section of the upper São Francisco river in Três Marias, MG, Brazil. **Brazilian Journal of Biology**, São Carlos, v.64, n.2, p.195-202, 2004.

ARAÚJO-LIMA, C.A.R.M.; AGOSTINHO, A.A.; FABRE, N.N. Trophic aspects of fish communities in Brazilian rivers and reservoirs. In: TUNDISI, J.G.; BICUDO, C.E.M.; MATSUMURA-TUNDISI, T. **Limnology in Brazil**. São Paulo: Brazilian Academy of Sciences/Brazilian Limnological Society. 1995, p.105-136.

AYRES, M.; AYRES JR., M.; AYRES, D.L.; SANTOS, A.A.S. BioEstat, versão 5.0, **Aplicações estatísticas nas áreas biomédicas**. Sociedade Civil Mamirauá, MCT – CNPq, Belém, Pará, Brasil. 2007. 380p.

BENNEMANN, S.T.; SHIBATTA, O.A. Dinâmica de uma assembléia de peixes do rio Tibagi. In: MEDRI, M.E.; BIANCHINI, E.; SHIBATTA, O.A., PIMENTA, J.A (Eds.). **A bacia do rio Tibagi**. Londrina, PR. p.433-442, 2002.

BENNEMANN, S.T.; SHIBATTA, O.A.; GARAVELLO, J. **Peixes do Rio Tibagi: Uma Abordagem Ecológica**. Londrina: Editora UEL, 2000. 62p.

BIALETZKI, M.S.A.; NAKATANI, K. Mudanças ontogênicas no trato digestório e dieta de *Apareiodon affinis* (Steindachner, 1879) (Osteichthyes, Parodontidae). **Acta Scientiarum. Biological Sciences**, Maringá, v.26, p.291-298, 2004.

BRANDÃO, H.; VIDOTTO-MAGNONI, A.P.; RAMOS, I.P.; CARVALHO, E.D. Assessment of the ichthyofauna in sites under the influence of Salto Grande Reservoir (Middle Paranapanema River, SP/PR, Brazil). **Acta Limnologica Brasiliensia**, Rio Claro, v.21, n.4, p.451-463, 2009.

BRITTO, S.G.C.; CARVALHO, E.D. Ecological attributes of fish fauna in the Taquaruçu Reservoir, Paranapanema River (Upper Parana, Brazil): composition and spatial distribution. **Acta Limnologica Brasiliensia**, Rio Claro, v.18, n.4, p.377-388, 2006.

CARVALHO, E.D.; SILVA, V.F.B. Aspectos ecológicos da ictiofauna e da produção pesqueira do reservatório de Jurumirim (Alto do rio Paranapanema, São Paulo). In: HENRY, R (Eds.). **Ecologia de reservatórios: estrutura, funções e aspectos sociais**. São Paulo, FAPESP: 1999, p.771-799

CASATTI, L.; MENDES, H.F.; FERREIRA, K.M. Aquatic macrophytes as feeding site for small fishes in the Rosana Reservoir, Paranapanema River, Southeastern Brazil. **Brazilian Journal of Biology**, Rio Claro, v.63, n.2, p.213-222, 2003.

DIAS, J.H.P.; GARAVELLO, J.C. Ecological studies on the fish community of Salto Grande Reservoir, Paranapanema River Basion, São Paulo, Brazil. **Verhandlungen International Verein Limnology**, Stuttgart, v.26, p.2228-2231, 1998.

DUKE ENERGY. **Relatório para licenciamento ambiental da usina hidrelétrica de Chavantes**, v.1, 2002, 119p.

FEARNSIDE, P.M. Hidrelétricas como "Fábricas de metano": O papel dos reservatórios em áreas de floresta tropical na emissão de gases de efeito estufa. **Oecologia Brasiliensis**, Rio de Janeiro, v.12, n.1, p.100-115, 2008.

FERNANDO, C.H.; HOLČÍK, J. The nature of fish communities, an important factor influencing fishery potential and yields of lakes and reservoirs: A short summary of the concept and its application. **Verhandlungen International Verein Limnology**, Stuttgart, v.22, p.2498-2501, 1985.

HAHN, N.S.; AGOSTINHO, A.A.; GOMES, L.C.; BINI, L.M. Estrutura trófica da ictiofauna do reservatório de Itaipu (Paraná-Brasil) nos primeiros anos de sua formação. **Interciencia**, Caracas, v.23, n.5, p.299-305,1998.

HOFFMANN, A.C.; ORSI, M.L.; SHIBATTA, O.A. Diversidade de peixes do reservatório da UHE Escola Mackenzie (Capivara), rio Paranapanema. **Iheringia Serie Zoologia**, Porto Alegre, v.95, n.3, p.319-325, 2005.

JUNIOR, J.H.F.; THOMAZ, S.M.; AGOSTINHO, A.A.; LATINI, J.D. Distribuição e caracterização dos reservatórios (Eds.). In: RODRIGUEZ, L.; THOMAZ, S.M.; AGOSTINHO, A.A.; GOMES, L.C. **Biocenoses em reservatórios: padrões espaciais e temporais**. São Carlos: Rima. 2005, p.1-16.

LE CREN, E.D. The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis*). **The Journal of Animal Ecology**, Londres, v.20, n.2, p.201-219, 1851.

LOWE-MCCONNELL, R.H. **Estudos ecológicos de comunidades de peixes tropicais**. São Paulo: EDUSP, 1999, 535p.

NAIK, D.R.; BOSUKONDA, S.; MRUTYUNJA-YAREDDY, K. Reservoir Impact Assessment on Land Use/Land Cover and Infrastructure - A Case Study on Polavaram Project. **Journal of the Indian Society of Remote Sensing**, Dehradun v.39, n.2, p.271:278, 2011.

NOGUEIRA, M.G.; JORCIN, A.; VIANNA, N.C.; BRITTO, Y.C. Reservatórios em cascata e os efeitos na limnologia e organização das comunidades bióticas (fitoplâncton, zooplâncton e zoobentos), um estudo de caso no rio Paranapanema (SP/PR) (Eds.). In: NOGUEIRA, M.G.; HENRY, R.; JORCIN, A. **Ecologia de reservatórios: Impactos potenciais, ações de manejo e sistemas em cascata**.2ed.São Carlos:Rima.2006,p.435-459.

OLIVA-PATERNA, F.J.; TORRALVA, M.; CARVALHO, E.D. Length–weight relationships for 20 species collected in the Jurumirim Reservoir (Paranapanema Basin, Brazil). **Journal of Applied Ichthyology**, Chichester, v.25, n.3, p.360-361, 2009.

ORSI, M.L.; SHIBATTA, A.O.; SILVA-SOUZA, A.T. Caracterização biológica de populações de peixes do rio Tibagi, localidade de Sertanópolis. In: MEDRI, M.E.; SHIBATTA, O.A.; BIANCHINI, E.; PIMENTA, J.A. **A Bacia do Rio Tibagi**. Londrina. 2002, p. 425-432.

PAGIORO, T.A.; ROBERTO, M.C.; THOMAZ, S.M.; PIERINI, S.A.; TAKA, M. Zonação longitudinal das variáveis limnológicas abióticas em reservatórios. In: RODRIGUES, L.; THOMAZ, S.M.; AGOSTINHO, A.A.; GOMES L.C. **Biocenoses em reservatórios. Padrões espaciais e temporais**. São Carlos, Rima. 2005, 333p.

PELICICE, F.M.; AGOSTINHO A.A. Feeding ecology of fishes associated with *Egeria* spp. patches in a tropical reservoir, Brazil. **Ecology of Freshwater Fish**,Madrid, v.15, p.10-19, 2006.

RATTON, T.F.; BAZZOLI, N.; SANTOS, G.B. Reproductive biology of *Apareiodon affinis* (Pisces: Parodontidae) in the Furnas Reservoir, Minas Gerais, Brazil. **Journal of Applied Ichthyology**, Chichester, v.19, p.387-390, 2003.

REIS, R.E.; KULLANDER, S.O.; FERRARIS Jr., CJ. **Check list of the freshwater fishes of South and Central America**. Porto Alegre: Edipucrs. 2003, 742p.

RIBEIRO, V.M.A.; SANTOS, G.B.; BAZZOLI, N. Reproductive biology of *Steindachnerina insculpta* (Fernandez-Yépez) (Teleostei, Curimatidae) in Furnas reservoir, Minas Gerais, Brazil. **Revista Brasileira de Zoologia**, Curitiba, v.24, n.1, p.71-76, 2007.

SANTOS, E.P. **Dinâmica de populações aplicada à pesca e piscicultura**. São Paulo: Edusp. 1978. 129 p.

SMITH, W.S.; PEREIRA, C.C.G.F.; ESPINDOLA, E.L.G.; ROCHA, O. A importância da zona litoral para a disponibilidade de recursos alimentares a comunidade de peixes em reservatórios. In: HENRY, R. (Org.) **Ecótonos nas interfaces dos ecossistemas aquáticos**. Sao Carlos, RIMA. 2003, p. 233-248.

STURGES, H.A. The Choice of a Class Interval. **Journal of the American Statistical Association**, Philadelphia, v.21, n.153, p.65-66, 1926.

TEIXEIRA, I.; BENNEMANN, S.T. Ecomorfologia refletindo a dieta dos peixes em um reservatório no sul do Brasil. **Biota Neotropica**, Campinas, v.7, n.2, p.67-76, 2007.

VAZZOLER, A.E. **Biologia da reprodução de peixes teleósteos: teoria e prática**. Maringá: EDUEM. 1996. 169p.

VICENTINI, R.N.; ARAÚJO, F.G. Sex ratio and size structure of *Micropogonias furnieri* (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba bay, Rio de Janeiro, Brazil. **Acta Scientiarum Biological Sciences**, Maringá, v.26, n.2, p.175-179, 2004.

VIDOTTO-MAGNONI, A.P. **Ecologia trófica das assembléias de peixes do reservatório de Chavantes (médio rio Paranapanema, SP/PR)**. 115p. 2009. Dissertação (Dissertação de Mestrado em Ciências Biológicas). Universidade Estadual Paulista – UNESP, Botucatu).

VISMARA, M.R.; BENEDITO-CECILIO, E.; FARIA, A.C.E.A. Efeito da maturação gonadal sobre o conteúdo calórico e condição geral de peixes da planície de inundação do alto rio Paraná. **Acta Scientiarum Biological Sciences**, Maringá, v.26, n.2, p.189-199, 2004.

WINEMILLER, K.O.; JEPSEN, D.B. Effects of seasonality and fish movement on tropical river food webs. **Journal of Fish Biology**, Chichester, v. 53, p. 267-296, 1998.

WINEMILLER, K.O. Patterns of variation in life history among South American fishes in seasonal environmentals. **Oecologia**, Heidelberg, v.81, p.225-241, 1989.

WOOTON, R.J. **Ecology of Teleost fishes**. New York, Chapman & Hall. 1990. 404p.

ZAR, J.H. **Biostatistical analysis**. Prentince-Hall Editions, New Jersey, 1984.

★★★★★