Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9283
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v35i2.10932

Reproductive strategies of fish populations from three Neotropical streams

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ABSTRACT. This study aimed to characterize the reproductive strategies of fish from first order streams. Samplings were performed every three months from June 2008 to March 2009, using electric fishing at three streams: Conceição, Scherer and Jurema, located in the municipalities of Diamante do Norte and Amaporã, Paraná State, Brazil. We obtained the total weight (g), standard or total length (cm), sex and maturation stage for each specimen. Limnological data were obtained with portable equipments. The minimum length at first maturation was established for each population, and reproduction period was determined by analyzing the distribution of maturation stages. The sex ratio was obtained and tested (X^2) for significant differences. Eight species were analyzed and they responded differently to environmental pressures, reflected in the ratio between males and females, and in different reproductive strategies adopted. The streams were used as spawning ground in September and rest and recruitment areas in December and March, due to changes in the limnological parameters that signalize favorable periods for reproduction. We conclude that the protection provided by preserved riparian vegetation encourage the uptake of food by fishes and maintain their general physical characteristics, promoting the diversification in tactics found.

Keywords: upper Paraná river basin, sex ratio, conservation unit, reproductive stages.

Estratégias reprodutivas de populações de peixes de três riachos Neotropicais

RESUMO. O presente estudo teve como objetivo caracterizar as estratégias reprodutivas de peixes de riachos de primeira ordem. Para tanto, foram realizadas amostragens trimestrais, de junho/2008 a março/2009, com uso de pesca elétrica em três riachos: Conceição, Scherer e Jurema, situados nos municípios de Diamante do Norte e Amaporã, Estado do Paraná, Brasil. Foram obtidos o peso total (g), comprimento-padrão (cm) ou total (cm), sexo e estádio de maturação gonadal de cada exemplar. Variáveis limnológicas foram obtidas com o auxílio de potenciômetros portáteis. Foi estabelecido o comprimento mínimo de primeira maturação para cada população, e o período de reprodução foi determinado por meio da análise da distribuição dos estádios de maturação gonadal. A proporção sexual foi obtida e testada (X^2) quanto a diferenças significativas. Foram analisadas oito espécies e constatou-se que as espécies respondem de forma diferenciada às pressões ambientais, refletidas na proporção entre machos e fêmeas e nas diferentes estratégias reprodutivas adotadas. Verificou-se que os riachos foram utilizados como área de desova em setembro e repouso e recrutamento em dezembro e março. Atribuiu-se, portanto, às variações dos parâmetros limnológicos a sinalização dos períodos favoráveis à reprodução. Concluiu-se que a proteção fornecida pela vegetação ripária preservada favoreça o aporte de alimento e a manutenção de suas características físicas gerais, favorecendo a diversificação nas táticas encontradas.

Palavras-chave: bacia do alto rio Paraná, proporção sexual, unidade de conservação, estádio reprodutivo.

Introduction

Due to their small size, first order streams are intensely affected by changes in the environment and in the hydrological regime (ZWEIMÜLLER, 1995). These water bodies depends on the input of organic matter from the riparian vegetation as sources of food, refuge, shelter and reproduction for several species (ARAUJO; GARUTTI, 2002; SALVERINO; NESSIMIAN, 2008), and, aditionaly, the limnological and physical features of each stream tends to influence the fisiology of fish species (BARBIERI et al., 2000). Beside, they may be responsible for the recharge of large rivers and used as nursery areas by larger sized species (SÚAREZ; LIMA-JUNIOR, 2009).

Fish inhabiting these water courses are small sized (ARAUJO; GARUTTI 2002), with reduced

ability of displacement and characterized by the high degree of endemism (CASTRO; MENEZES, 1999). In small rivers, fish present adaptations that allow the survival in environments with great spatial and temporal variations.

For this taxonomic group, the analysis of species reproductive biology is a valuable tool in the diagnosis of the environmental conditions, which are mainly influenced by changes in temperature and pluviosity. For many species, the reproductive activity is cyclic, critical and requires high energy expediture, hence, the strategies adopted by the organisms are an evidence of the high degree of human disturbance to which the waterbody is submitted and according to Flores-Lopes and Malabarba (2007) this environmental condition may reflect a reproductive disfunction of the species.

In general, the organisms exhibit reproductive strategies that are intrinsic to the species, with tactics that may vary according to the environment (VAZZOLER, 1996). The same author argues that the adopted tactics may be used as indication of the environmental conditions and the length at first maturity and the sex ratio are some of the analyzed parameters used in the determination of these tactics adopted by the population.

In this way, the present study aimed to characterize the reproduction strategys of fish species from first order streams in the upper Paraná river basin.

Material and methods

Study area

For this study, we investigated three first order streams from Conservation Units located in the Northwestern of Paraná State. The region presents sandy substrate from the Caiuá Formation (MAACK, 2002), constitute by quartz and naturally susceptible to erosion. The Stational Semidecidual Forest is the phytogeographic unit that comprises the area of Caiuá Formation and the river valleys (CAMPOS et al., 2000; SOUZA et al., 2004) (Figure 1).

The headwater from the streams Conceição (22°35'15.0"S 052°53'29.0"W) and Scherer (22°36'06.7" S 052°53'02.0" W) are located within the Caiuá Ecological Station, Diamante do Norte County, Paraná State, and flow into the Paranapanema river, downstream from the dam of Rosana Reservoir. The first stream has about 450 m, whereas the second, with 1,600 m, presents a dam in the intermediary stretch.

The Jurema Stream (23°04'53.0" S 052°47'38.3" W) rises at the Amaporã State Park, Amaporã County, Paraná State, presents approximately 3,000 m of extension, of which 1,000 m are inside the park. It flows into Lica Stream, a tributary of Ivaí river.

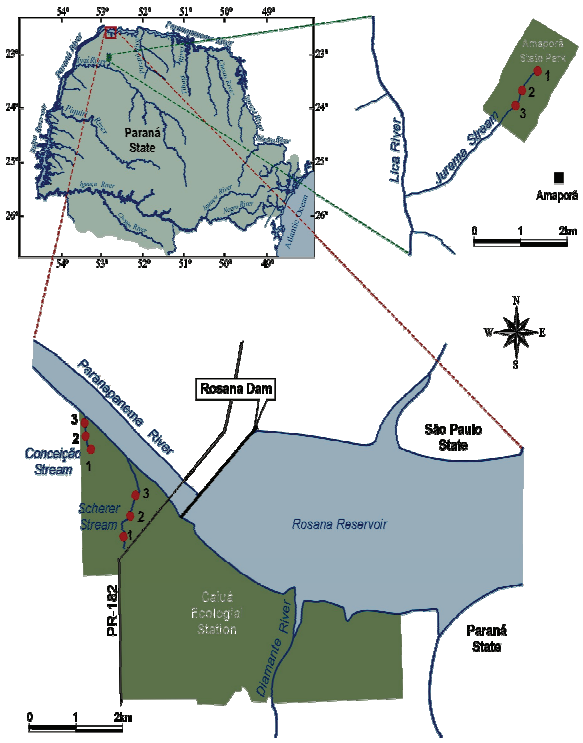

Figure1. Location of the sampling stations (1, 2 and 3) at the Caiuá Ecological Station (Conceição and Scherer streams) and Amaporã State Park (Jurema Stream).

Samplings

Samplings were carried out every three months, from June 2008 to March 2009, using electric fishing, in three stretches with 40 m of length at each one of the streams. The individuals were anesthetized with benzocaine hydrochloride solution, fixed in formaldehyde 10%, kept in plastic pots, and taken to the Laboratório de Ecologia Energética from the Núcleo de Pesquisas em Limnologia, Ictiologia e Aqüicultura (Nupélia) in the State University of Maringá, where they were identified and analyzed. The voucher specimens are settled in the Ichthyological Collection of Nupélia.

At each sampled stretch, we measured the dissolved oxygen and water temperature (oxymeter - YSI® 550A), electric conductivity (condutivimeter - Digimed®), pH (pHmeter - Digimed®) and turbidity (turbidimeter – LaMote®).

From each sampled individual, we obtained the total weight (g), standard length (cm) or total length (cm), in the absence of a defined caudal fin. The sex and the maturation stage were identified according

to the criteria established by Vazzoler (1996), and the maturation stages were classified in: immature (A), maturing (B), mature (C), semi-empty (D), empty (E) and resting (F).

At each sampled stretch, we measured the dissolved oxygen and water temperature (oxymeter - YSI® 550A), electric conductivity (condutivimeter - Digimed®), pH (pHmeter - Digimed®) and turbidity (turbidimeter – LaMote®).

Data analysis

The results were graphically analyzed using Statistica® 7.0 Software (STATSOFT, 2005). The minimum length for half (L_{50}) and the entire population (L_{100}) of a certain species that were able to reproduce was determined through frequency distribution of adults per class of standard or total length, whenever possible. These values were compared to the smaller size of the individual in reproduction for each studied species. The period and the location of reproduction were determined through the analysis of distribution of maturation stages.

The χ^2 test ($\alpha = 0.05$) was applied to the sex ratio values, which were obtained through the frequency of males and females captured during the whole sampling period, to detect significant differences from the expected proportion of 1:1. For the species with low abundance we employed the Yates' correction (ZAR, 1996).

Results

Abiotic variables

The values of the limnological parameters are presented in the table attached (Annex 1) and were tested regarding the variation over the sampling months, through an analysis of variance, ANOVA.

The abiotic variables that varied significantly along the months in Scherer stream were pH, dissolved oxygen and water temperature. For Conceição, only water conductivity, and for Jurema, pH and water temperature (Table 2).

Fish composition

We recorded 2,194 individuals belonging to six orders, nine families and 10 species (Table 1). Among them, 963 females, 803 males and 428 non identified. The latest weren't identified because they were immature, without differentiated gonads or because they were in advanced state of decomposition. Moreover, 62 specimens were preserved as voucher in the Ichthyological Collection of Nupélia; and *Callichthys callichthys* and *Synbranchus marmoratus* were not analyzed due to their low abundance. *Phalloceros harpagos* was sampled in two different streams, thus, for the present study, we considered them as two different populations.

Phalloceros harpagos was the most representative species in the Conceição Stream, while *Astyanax altiparanae* and *Astyanax* aff. *paranae* were the most abundant in the streams Scherer and Jurema, respectively (Table 1).

Table 1. List of species collected in the streams Conceição, Scherer and Jurema, registration number at the museum, the descriptors of the species and the number of sampled individuals.

Order/Family/Species	Registration number	Streams		
		1	2	3
Cyprinodontiformes				
Poeciliidae				
Phalloceros harpagos Lucinda, 2008	NUP6059	804	_	298
Rivulidae				
Melanorivulus apiamici (Costa, 2011)	NUP6060	171	_	_
Characiformes				
Characidae				
Astyanax altiparanae Garutti and Britski, 2000	NUP6068	_	256	_
Astyanax aff. *paranae* Eigenmann, 1914	NUP6067	_	_	375
Crenuchidae				
Characidium aff. *zebra* Eigenmann, 1909	NUP6071	_	17	_
Siluriformes				
Trichomycteridae				
Trichomycterus sp.	NUP6069	_	_	124
Callichthyidae				
Callichthys callichthys (Linnaeus, 1758)	NUP6122	_	_	5
Gymnotiformes				
Gymnotidae				
Gymnotus inaequilabiatus (Valenciennes, 1839)	NUP7607	1	132	2
Perciformes				
Cichlidae				
Crenicichla britskii Kullander, 1982	NUP6072	_	7	_
Synbranchiformes				
Synbranchidae				
Synbranchus marmoratus Bloch, 1795	NUP6073	2	_	_

1- Conceição; 2- Scherer; 3- Jurema.

Sex ratio

The expected proportion between males and females (1:1) was recorded for *A. altiparanae*, *Gymnotus inaequilabiatus*, *P. harpagos* (Jurema Stream) and *Melanorivulus apiamici*. However, a significant divergence was detected in this proportion for *A. paranae*, *Trichomycterus* sp., *Characidium* aff. *zebra*, *Crenicichla britskii*, and *P. harpagos* (Conceição Stream) (Table 3). For the first two, there were more males than females, whereas for the others, more females than males.

Size range of adults

The minimum size recorded for the individuals in reproductive activity was 1.2 cm for *P. harpagos*, in Conceição Stream, while, 12.7 cm for *G. inaequilabiatus*, in Scherer Stream (Table 4). The same trend of size variation was observed when comparing the L_{50} from the species. Despite the size range registered for the studied species, all are considered small sized. The largest individual captured presented 27.1 cm and corresponds to *G. inaequilabiatus*.

Table 2. Results from the ANOVA for the limnological parameters in the studied streams, between June 2008 and March 2009. (Cond. = conductivity, DO= dissolved oxygen, p= significance, F= F test).

Stream	pH		Cond. (µs cm^{-1})		DO (mg L^{-1})		Water temperature (°C)	
	F	p	F	p	F	p	F	p
Scherer	12.68	0.002*	2.76	0.111	8.43	0.007*	27.35	0.000*
Conceição	1.45	0.298	5.96	0.019*	0.10	0.959	1.93	0.203
Jurema	4.91	0.031*	0.16	0.917	1.84	0.217	33.71	0.000*

Table 3. Sex ratio from the most abundant species sampled in the streams Scherer, Conceição and Jurema. ([1]Conceição Stream; [2]Jurema Stream).

Species	Males		Females			
	N	%	N	%	M : F	χ^2
Astyanax altiparanae	77	53.1	68	46.9	1.13	0.4
Gymnotus inaequilabiatus	45	48.4	48	51.6	0.94	0.1
Characidium aff. *zebra*	5	38.5	8	61.5	0.62	5.3*
Crenicichla britskii	1	33.3	2	66.7	0.5	11.1*
Phalloceros harpagos[1]	188	26.7	516	73.3	0.36	21.7*
Melanorivulus apiamici	64	54.2	54	45.8	1.2	0.7
Astyanax aff. *paranae*	184	65.9	95	34.0	1.9	10.2*
Phalloceros harpagos[2]	59	41.3	84	58.7	0.7	3.1
Trichomycterus sp.	61	61	39	39	1.6	4.8*

*= Significant at the level of 5%.

Table 4. Minimum and maximum standard size, minimum size of adults, L_{50} and L_{100} of species collected in the streams Scherer, Conceição and Jurema.

Stream	Species	Minimum Ls	Maximum Ls	Minimum Ls from adults	L_{50}	L_{100}
Scherer	*A. altiparanae*	6.4	12.8	7.0	–	8.0
	G. inaequilabiatus	2.2	27.1	12.7	15.0	17.0
	C. zebra	5.1	6.9	5.0	–	5.0
	C. britskii	4.8	7.7	7.2	–	7.2
Conceição	*P. harpagos*	0.9	3.7	1.2	1.7	2.1
	M. apiamici	1.1	3.6	1.7	2.0	2.4
Jurema	*A.* aff. *paranae*	1.2	5.8	1.8	2.3	3.9
	Trichomycterus sp.	1.4	5.9	2.9	3.2	4.4
	P. harpagos	1.2	3.3	1.5	1.6	2

Reproduction

We found a greater frequency of immature specimens for *C. britskii, G. inaequilabiatus* and *Trichomycterus* sp., in comparison to the other maturation stages. Regarding *A. altiparanae*, specimens were captured more frequently in mature stages, while *P. harpagos* and *A.* aff. *paranae* presented greater percentage of specimens in maturation (Figures 2, 3, 4 and 5).

It was verified higher frequency of specimens in maturation in June, especially for the species inhabiting Conceição (*P. harpagos*[1] and *M. apiamici*) and Jurema streams (*A.* aff. *paranae*, *Trichomycterus* sp. and *P. harpagos*[2]). At Scherer, *A. altiparanae* presented higher frequency of semi-empty specimens, *G. inaequilabiatus* of immature, *C.* aff. *zebra* of maturation and, for last, *C. britskii* was not captured in this month (Figure 2).

In September the higher frequency of individuals were captured in mature stages. *G. inaequilabiatus* specimens were captured in higher frequency in maturation. One individual of *C. britskii* was captured immature while one semi-empty. *M. apiamici*, presented individuals in all gonadal maturation stages, as for *Trichomycterus* sp., with exception of the empty stage, while *A.* aff. *paranae* was represented by individuals in maturation and mature. *P. harpagos*[1] and *P. harpagos*[2] presented higher frequency of mature individuals (Figure 3).

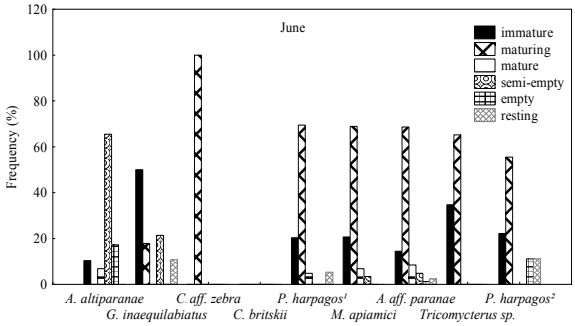

Figure 2. Relative frequency of individuals distributed over of six gonadal maturation stages in the streams Scherer, Conceição and Jurema, in June 2008.

In December, for the species of Conceição and Jurema streams, it was verified that the higher frequency of specimens were captured in immature, maturation and mature stages, representative of reproduction period. Semi-empty specimens were the most representative for *A. altiparanae*, immature for *G. inaequilabiatus*, mature for *C.* aff. *zebra* and empty for *C. britskii* (Figure 4).

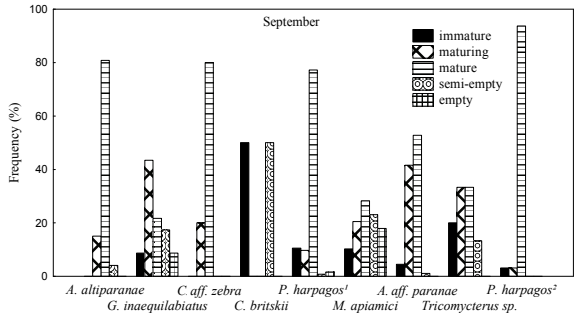

Figure 3. Relative frequency of individuals distributed over of six gonadal maturation stages in the streams Scherer, Conceição and Jurema, in September 2008.

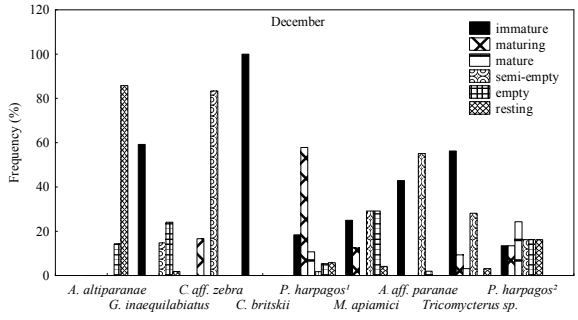

Figure 4. Relative frequency of individuals distributed over of six gonadal maturation stages in the streams Scherer, Conceição and Jurema, in December 2008.

Finally, in March, higher frequency of resting specimens of *A. altiparanae* were captured, empty of *G. inaequilabiatus*, semi-empty of C. aff. *zebra*, and immature of *C. britskii*. Concerning the species captured in Conceição stream (*P. harpagos*[1] and *M. apiamici*), higher frequency of immature and maturation specimens were captured. For Jurema stream (A. aff. *paranae*, *Trichomycterus* sp. *P. harpagos*[2]), immature, mature and semi-empty specimens were the most frequent (Figure 5).

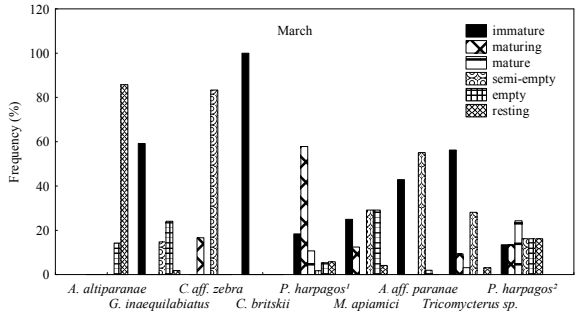

Figure 5. Relative frequency of individuals distributed over of six gonadal maturation stages in the streams Scherer, Conceição and Jurema, in March 2009.

In June we captured more individuals in maturation and in September, mature ones. For the next month, December, we recorded different stages occurring at the same time, from immature individuals to mature ones. In March, the populations presented all sort of gonadal maturation stages, suggesting that they are in constant growth.

In general, the reproduction period is long and extends for three trimesters or even for the entire study period as verified for *P. harpagos.*

For the Conceição Stream, we verified mature individuals during all sampling periods as well as for the Jurema Stream. On the other hand, in Scherer Stream, the number of mature individuals was low in relation to the other maturation stages, with exception of *A. altiparanae* with 59 individuals, in September.

Discussion

The most species-rich orders, Characiformes and Siluriformes, are the most commonly found in Neotropical aquatic environments (LOWE-MCCONNELL, 1975), nevertheless, for the present study, the Cyprinodontiformes presented higher number of specimens in comparison to Siluriformes and Characiformes. The same result was verified by Quintela et al. (2007) in studies performed in a coastal plain in the Rio Grande do Sul State.

Among the sampled species, the most abundant was *P. harpagos*, also recorded in the studies realized by Lemes and Garutti (2002) and Casatti (2004) in streams from the upper Paraná river basin. Furthermore, the species was recently described (LUCINDA, 2008), and, consequently, little is known about its ecology and biology. Previously to the description, the species was classified as *Phalloceros caudimaculatus*.

Independently from the difference of size between males and females, fish species inhabiting small streams are inherently small. In accordance to Vazzoler (1996), individuals smaller than 20 cm of total length can be classified as small sized, whereas Castro and Menezes (1999) ascribed 15 cm as the limit for this classification. For the studied streams, we adopted the category proposed by Castro and Menezes (1999). Then, only seven from the eight examined species, were classified as small, since *G. inaequilabiatus* reached up to 27.1 cm in total length, being characterized as a medium sized species. This species, even inhabiting streams, tends to present relatively larger size, partially due to the body morphology, naturally elongated.

In aquatic environments, the expected sex ratio of fish population is 1:1 (VAZZOLER, 1996). According to the same author, divergences in this proportion may be associated to mortality and

growth, which influence in different ways the individuals of each sex. Orsi et al. (2004) attributed to the same cause the pressure of abiotic factors on the distinct sex ratio found for *A. altiparanae* in four stretches from Tibagi river basin.

According to Raposo and Gurgel (2001), through the results from sex ratio of a population, we may deduce whether the growth is occurring. In consequence, higher frequency of females signifies a response from the population to favorable conditions provided by the environment. For the present analysis, in streams Scherer and Conceição we recorded more females, while in the Jurema Stream, more males. Meantime, the environmental conditions of the latter are more preserved in comparison to those observed for the other studied streams. The greater abundance of males may be related to the occurrence of females in locations distinct from those sampled as an effect of a possible natural stratification of the population (ORSI et al., 2004; RAPOSO; GURGEL, 2001).

In streams, with more drastic environmental fluctuations due to their small size, reflecting more intensively the climatic changes, strategies which favor survival and reproduction guarantee populations' maintenance. The size at first maturity from the sampled populations indicate that the individuals from these streams begin the reproductive activity with sizes below 1.5 cm. The weight and minimum size at first maturity are variables that depend on the food availability, water temperature and general environmental conditions (CREPALDI et al., 2006). Moreover, under low conditions of survival, Kusano (1982) assure that the early offspring production is more advantageous than invest in somatic growth. Females that mature too late may not survive to reproduce. However, the studied streams are protected by the preserved riparian vegetation, and despite the natural fluctuations, they present good environmental conditions. Under such circumstances, we may assume that the record of females able to reproduce at small size is more related to the environmental quality, due to the constant input of allochtonous resources and environmental complexity.

In this context, regarding the proportions of the different maturation stages, the occurrence of immature individuals is an evidence of the use of the streams as recruitment area, suitable for reproduction (ORSI et al., 2004). On the other hand, the presence of mature individuals, as well as semi-empty and empty, characterizes the environment as a spawning area. Thus, we consider that the study areas are being used for several ecological activities, from growth and feeding to reproduction, due to favorable conditions.

Indeed, comparing the distribution of gonadal maturation stages between the three streams, is possible to verify that Conceição and Jurema species present more homogeneous distribution, with all stages been registered, while Scherer species with only a few of them. These can be attributed to the less preserved conditions in Scherer stream, in comparison to Conceição and Jurema, and to the low abundance of individuals representing *C.* aff. *zebra* and *C. britskii.*

The factors that induce the spawning include since the chemical characteristics and temperature of the water, until availability of food and locations for reproduction (ALKINS-KOO, 2000). The occurrence and frequency of these factors are strongly related to the amount of rain that reaches the streams, since the discharge and channel volume increases with the rain, submerging food and shelter resources.

The water temperature signalize the best period for reproduction, since warmer waters stimulate metabolic activities (MERTEN et al., 2010), favoring decomposition processes that release nutrients that can be consumed by autotrophic organisms and, in the end, by fishes. Besides, stimulates fish metabolism, increasing foraging activities and, consequently favoring reproduction processes.

Such factors tend to stimulate the reproductive behavior of species at the beginning of rainy period, and if the conditions remain favorable, the gonad maturation occurs continuously, over the year. The period with the greater capture of mature individuals occurs from September to December, coinciding to the period with higher temperature and rainfall.

The higher availability of space and food tend to influence the spawning from the species, culminating in the increase of recruitment and, consequently, in the maintenance of populations in the streams. Vazzoler (1996) argues that factors as the availability of dissolved oxygen, food and minimizing predation risk on the offspring are important to induce the reproductive process, because they provide better survival conditions for the juvenile and for the entire population. The capture of a superior number of mature individuals from *A. altiparanae* in September indicates favorable conditions for the reproduction during this month. The species presents variations in the reproductive patterns according to the inhabited environment, and may spawn from September to December (ORSI et al., 2004; SANTOS et al., 1995) or throughout the year (GOMIERO; BRAGA, 2007). The same authors emphasize that specimens of *A. altiparanae* found in small streams tend to present an

extended reproduction period, with several peaks over the year. Furthermore, these variations are ascribed to temporal and spatial variations of each environment rather than the factors intrinsic to the species.

The low rainfall recorded during December in the region of Scherer Stream, where *A. altiparanae* was sampled may have induced the sudden decrease in the number of mature individuals due to space restrictions and the low input of allochtonous organic matter.

For *P. harpagos*, we registered reproducing individuals throughout the sampling period, as also recorded by Wolff et al. (2007) for *P. caudimaculatus*. *Phalloceros harpagos* is a viviparous species and present marked sexual dimorphism in size, with larger and more robust females (ENDLER, 1983), and morphology, with the presence of a gonopodium in males (LUCINDA, 2008), and beyond the continuous spawning, presents high fecundity, small size at first maturity and high metabolism, as intrinsic characteristics of the species.

Even for the species that reproduce throughout the year, there is a period with an abundance peak of mature individuals as a result of the positive influence from periods with higher availability of space and food to favor the recruitment rather than mortality (CASATTI, 2005). For *P. harpagos*, as well as the other species, the reproduction peak coincides with the higher values of temperature and rainfall, from September to December.

Regarding the other species, there was a record of mature individuals during specific periods, reflecting in distinct reproductive strategies. The presence of immature over the entire year, independent of the species, represents an important evidence of the favorable and available environmental conditions in the studied streams.

In general, the reproductive strategies adopted by small sized fish ranged from the production of small offspring, by favoring the parental care (VAZZOLER, 1996; LOWE-MCCONNELL, 1975), to multiple spawning by permitting the increase of fecundity . The small size of these species limits the number of oocytes produced in a given period (ALKINS-KOO, 2000), thus, both tactics favor the species maintenance in the environment.

In this way, for the investigated populations, we verified a variety of reproduction strategies. For *P. harpagos* we observed remarkable variations in these strategies, depending on the sampling environment, since it presented significant difference in the sex ratio, with relevant predominance of females in Conceição Stream, while in Jurema Stream, the proportion was not significantly different. Besides that, mature individuals occurred along the year at Conceição Stream; while in Jurema these individuals did not occur in June.

Conclusion

Fish population from first order streams present reproductive strategies adapted to natural environmental fluctuations found in these locations, and that the peculiarities from each stream are essential for establishing the range of the reproductive period from each species. The protection offered by preserved riparian vegetation in these water bodies favor the input of food and maintain their general physical characteristics, enabling the existence of different reproductive strategies.

Acknowledgements

The authors would like to thank Nupélia for the logistic support, CNPq for the financial support for the project and scholarships, to the team from the laboratory of Ecologia Energética, Jaime Pereira for making the map, and Celso, Valmir, José Ricardo, Valdir, Valdecir, Rafaela, Luciano, Vivian, Cláudio, Ciro and Leandro for the help during field samplings.

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Received on August 19, 2010.
Accepted on October 4, 2010.

Annex 1

Table. Limnological parameters from the studied areas, from june 2008 to march 2009. Cond. = water conductivity; DO = dissolved oxygen; T. = temperature.

Stream	Month	pH	Cond. (µs cm^{-1})	DO (mg L^{-1})	air T. (°C)	water T. (°C)
Scherer	Jun/08	5.7±0.14	25.7±1.74	7.9±0.13	22±0.00	21±0,26
	Sep/08	5.2±0.14	29.7±2.34	7.4±0.56	18±0.00	21.3±0.35
	Dec/08	6.3±0.48	26.6±2.34	6.4±0.21	31±1.00	24.1±0.91
	Mar/09	5.7±0.18	25.3±1.83	6.8±0.15	27.7±0.58	23.4±0.21
Conceição	Jun/08	5.55±0.42	26.8±1.25	6.2±1.59	24.0±0.00	22.5±0.26
	Sep/08	5.0±0.4	29.2±0.42	6.5±0.93	24.5±0.50	22.6±0.15
	Dec/08	5.4±0.50	29.1±0.46	6.03±1.25	26.8±1.26	22.9±0.10
	Mar/09	5.0±0.33	28.0±0.75	6.0±1.30	23.0±1.00	22.7±0.30
Jurema	Jun/08	6.0±0.08	19.1±3.41	6.8±1.38	24.0±0.00	18.3±0.45
	Sep/08	5.3±0.21	20.7±3.18	8.2±0.45	18.7±1.53	21.1±0.67
	Dec/08	5.7±0.32	20.7±3.10	7.0±0.19	24.0±1.00	21.9±0.31
	Mar/09	5.3±0.39	19.9±3.21	7.4±0.35	21.7±3.06	21.5±0.45