Note

FEE-FISHING OPERATION EVALUATION AT NORTHWEST SÃO PAULO STATE, BRAZIL

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ABSTRACT: Fee-fishing operations developed recently in Brazilian agricultural scenery in a rather disordered manner. This study, carried out at the northwest region of São Paulo State, Brazil, focuses on the productive performance of fee-fishing system. Several visits were made monthly to nine fee-fishing establishments, for six months. A questionnaire by owners targeting 13 indicators of the operation's productive performance. Data were submitted to multivariate analysis (MANOVA), principal component analysis (PCA) and cluster analysis. MANOVA indicated significant differences between the fee-fishing operations. The PCA analyses indicated, from the higher coefficient eigenvectors, three attributes for the lakes, such as *productive system*, *fishery management* and *operational administration*. The cluster analyses classified the fishing lakes in four groups. The indicators angler frequency (AF), stocking density (SD), stocking biomass (SB), total capture (TC) and capture/lake/day (CLD), which are part of the attribute *productive system*, were the most important indicators of "fee-fishing" operations performance in this study.
Key words: fish, multivariate analyses, productive system, lakes

INDICADORES DE DESEMPENHO DE PESQUE-PAGUE NO NOROESTE DO ESTADO DE SÃO PAULO, BRASIL

RESUMO: Os lagos de pesca recreativa, pesque-pague, surgiram no Brasil em um cenário agrícola denominado como novo rural brasileiro. Este estudo conduzido no noroeste paulista teve como foco o desempenho produtivo dos lagos de pesca recreativa. Foram feitas visitas mensais a nove empreendimentos de pesca recreativa durante seis meses. A cada visita foi aplicado um questionário contendo 13 indicadores de desempenho. Os dados levantados foram submetidos à análise multivariada (MANOVA), análise de componente principal (ACP) e análise de agrupamento. A MANOVA indicou diferenças significativas entre os lagos de pesca recreativa. A ACP revelou, a partir do coeficiente dos autovalores, três atributos: sistema produtivo, gerenciamento pesqueiro e administração operacional. A análise de agrupamento classificou os lagos de pesca recreativa em quatro grupos. Freqüência de pescadores (FP), densidade de estocagem (DE), biomassa de estocagem (BE), captura total (CT) e captura lago dia (CLD), os quais fazem parte do atributo sistema produtivo, mostrando-se os indicadores mais importantes para a avaliação de desempenho dos lagos de pesca recreativa neste estudo.
Palavras-chave: peixe, análise multivariada, sistema produtivo, lagos

INTRODUCTION

The industrialization of agriculture along the last decade, especially in the center-south region, disrupted Brazilian rural environment in a rural-urban dichotomy. Recreational fishing lakes, known as fee-fishing operations, have emerged in the recent rural scene as an activity that links recreation and animal production. However, the continuous development of these fishing lakes was done disorderly, and a study of various aspects of the production system of this new activity has become mandatory.

Fishing, as practiced in the sea, rivers, canals, public lakes and fee-fishing operations, accounts for a market of more than 30 million recreational anglers in Brazil (Carvalho Filho, 1998). Private lakes for recreational fishing can be characterized as family *aquabusiness*, located on small or medium-sized properties. It is a source of complementary, but not substitutive income, generally weigh boring urban areas, and takes on the aspect of a nonagricultural rural activity (Graziano et al., 1999). Recreational fishing practiced today in fee-fishing lakes, in the State of São Paulo, Brazil, is an outlet for the partial or total production of fish farms (Chabalin, 1996).

This *aquabusiness* constitutes one of the few, if not the single, possibility of fishing around urban areas and metropolitans zones, especially in center-south as a consequence of contamination of the aquatic ecosystem, continuous degradation of the riparian vegetation, increasing demand for sport fish, and difficulties for the angler to access attractive fishing locations, (Lopes, 2000; Zakia, 1998; Montag et al., 1997). This characterizes a growing demand for recreational fishing facilities adjacent to the urban areas, and the importance of a competent operational management of the fishing lakes or urban fishing tanks, to develop a successful fishery for the sporting, non-professional angler. Fee-fishing operations represent in the urban-rural scenery dynamics a role of revitalization of the recreational fishing practice constituting an alternative for entertainment areas for various segments of the local population (Lopes et al., 2001). For Sigler & Sigler (1990), good management makes possible the utilization of fish stocks and their habitats, allowing anglers to catch an acceptable number of popular sporting species.

This study evaluates some indicators of fishery management of fee-fishing operations located in the northwest region of São Paulo State, aiming to provide a better understanding of this new production system.

MATERIAL AND METHODS

Nine fishing lakes distributed over five counties were regularly visited: Pereira Barreto (20°38' 43" S and 51°06'35" W), Palmeira D' Oeste (20°25'20" S and 50° 45'47" W), Jales (20°16'17"S and 50°32'54"W), Fernandópolis (20°16'51" S and 50°15'01" W) and Dolcinópolis (20°17'18" S and 50°30'52" W). These towns are distributed along hydrogeographical basins Baixo Tietê, Turvo-Grande and São José dos Dourados, all tributaries of the high Paraná River.

Selection of fee fishing lakes

The evaluated operations were chosen from fish farmers registration at Departamento de águas e energia elétrica (DAEE) in São Paulo State. Nine fee-fishing units were monitored monthly from December 1998 to May 1999. Only one lake was utilized for observations at each county. The selection criteria were: localization in northwest São Paulo State, and the willingness of the operators to collaborate with the study. The following abbreviations were adopted to identify each location: UIR – Uirapuru; RDD - Recanto do Didi; PRP - Pesqueiro Rola Papo; EPL - Estância Palmeira; PIF - Pesqueiro Irmãos Facão; PEF - Pesqueiro Estância Felicidade; FSL - Fazenda São Lourenço; PPD - Pesqueiro da Prefeitura de Dolcinópolis; and SBV - Sítio Bela Vista. Six lakes were situated in the hydrographic basin of São José dos Dourados River (UIR, RDD, PRP, EPL, PIF, FSL and SBV), one in the Baixo Tietê hydrographic basin (PEF); and one in the Turvo-Grande basin (PPD).

Collection of field data

Field data were recorded from the completion of a questionnaire previously compiled and tested. At each visit, either owners or managers were submitted to questions from an interview format proposed by Guilhermino & Grossi (1996), concerning production and management practices. Based on these questionnaires, 13 variables were identified, and denominated indicators (Table 1).

Table 1 - Indicators evaluated in the recreational fishing lakes.

Abbreviations	Indicators	Description of indicators
AF	Angler frequency	The number of active anglers accounted for, that is, those who actually fished.
TC	Total capture kg^{-1}	Monthly record keeping of the weight (kg) of fish removed from the stock of the lakes.
CLD	Capture lake/day	Obtained from total capture converted into per day.
SD	Storage density	Calculated by the relationship fish number and lake area corrected monthly in accordance with catch rates and fish replacement.
SB	Storage biomass	Calculated by the relationship fish weight and lake area corrected monthly in accordance with catch rates and fish replacement.
NFL	Number of fish in lake	Records based on operator declarations
TIW	Total ichtyomass weight	Obtained from the result of the average weight per fish declared by the operators and the number of fish stocked.
FR	Feeding rate	Percentage obtained considering daily ration supplied and total weight of ichtyomass.
RC	Rate of capture kg^{-1}	Percentage obtained considering total catch and total weight of ichtyomass.
NSL	Number of species in lake	Records based on operator declarations
AFW	Average fish weight	Records based on operator declarations
LD	Lake depth	Records based on operator declarations
LA	Lake area	Records based on operator declarations

Statistical Analyses

Multivariate analyses of variance (MANOVA) were carried out taking as a model nine fee-fishing operations, over a six-month period (December to May) considering the interaction of the factors as error. This model considering the 13 indicators is described by the following equation:

$$Y = X\beta + E$$

where Y is the dimension observation matrix ($n \times p$), where n is the number of fee-fishing units and p the number of indicators; b is the parameter matrix ($p \times p$); X is the incidence matrix of zeros and ones ($n \times p$); and E is the random error matrix ($n \times p$).

Principal component analysis (PCA) (Mardia et al., 1979) and cluster analysis (Johnson & Wichern, 1992) were conducted distinctly. PCA and the correlations between the indicators were obtained by the PROC PRINCOMP and PROC CORR procedures of the SAS system, version 6.12 (SAS Institute, 1996). To confirm the number of main components the methodology proposed by Krzanowski (1987) was used. The cluster analysis was carried out with the STATISTICA FOR WINDOWS 5.1 (STAT SOFT, 1993) software using the Euclidean distance as a measure of dissimilarity and the unweighted pair group with arithmetic average method (UPGMA) (Johnson & Wichern, 1992) was used for the scattering formation of the groups. The SAS program version 6.12 was used to prepare the scattering graph.

RESULTS

Differences ($P < 0.0001$) were found for all fee-fishing operations, considering the significance tests (Wilk's Lambda, Pillai's Trace, Hotelling-Lawley's Trace and Roy's greatest root) obtained from the MANOVA analysis, revealing the dissimilarity between the fee-fishing units observed in this study and prompt consideration of variability between them. The accumulated variance of the first two components in the PCA was 75.40% (Table 2). This percentage is considered fair to explain the differences between the fee-fishing operations, since it is close to the 80% value proposed by Mardia et al. (1979). This value was surpassed by the accumulative variance of the first three components (89.43%).

A coefficient with a greater absolute value corresponds to a high importance from the original variable, in the definition of principal component (Morrison, 1990). The indicators with higher indexes in the first component were angler frequency, storage density, storage biomass, total capture, and lake capture per day (Table 2), and were denominated *production system*. In the second component, the highest coefficient corresponded to number of fish in the lake followed by total fish biomass, lake area and feeding rate, named *angling management*. For the third component, the indicators of greatest relevance were, in descending order, number of the species per lake, average fish weight and lake depth, and were denominated *operational administration*.

Table 2 - Estimate of the variances (eigenvalues), accumulated variance and indicators coefficients (eigenvectors) of the first four principal components to management indicators evaluated for nine fishing lakes.

	Productive system (Factor1)	Angling management (Factor2)	Operational administration (Factor3)
Eigenvalues	5.28	4.51	1.82
Accumulated variance	40.64	75.40	89.43
Indicators[1]		Eigenvectors	
AF	0.41969	0.09470	0.11550
TC	-0.40572	0.13745	0.09325
CLD	0.40919	0.12419	0.13239
SD	0.41065	-0.13828	-0.40447
SB	0.41218	-0.06169	-0.11421
NFL	0.10415	0.42741	0.18101
TIW	0.09459	0.44461	0.05548
FR	-0.05057	-0.42430	0.08745
RC	0.27747	-0.30215	-0.17164
NSL	-0.01624	0.00946	0.64448
AFW	0.00952	0.24192	-0.54104
LD	-0.01399	0.28939	-0.36970
LA	-0.23104	0.37397	0.16618

[1]Indicators described in Table 1.

The scattering of the fishing lakes (Figure 1) was formed from the first three principal components: *productive systems* (Factor 1), *angling management* (Factor 2) and *operational administration* (Factor 3). The UIR fishing operation presents a high correlation with the productive system orthogonal axis (Factor 1) and a negative correlation for the operational administration (Factor 3) (Figure 1). Operations RDD and EPL are in an intermediate position between Factors 1 and 2. On the other hand, operations PEF, PRP and FSL present a strong correlation to Factor 2. However, PIF Lake maintains a greater correlation with the operational administration of fee-fishing enterprises (Factor 3). The fishing operation PPD is situated intermediately between the axes Factor 2 and Factor 3.

A cluster analysis classified the fishing operations into four groups: Group I (UIR), Group II (RDD, EPL, PIF and SBV), Group III (PRP, PEF and FSL) and Group IV (PPD) (Figure 2), and confirmed results obtained in the PCA (Figure 1). Group I (UIR) surpassed the other groups presenting greater angler frequency, number of fish per lake, stocking density, fish biomass and total cap-

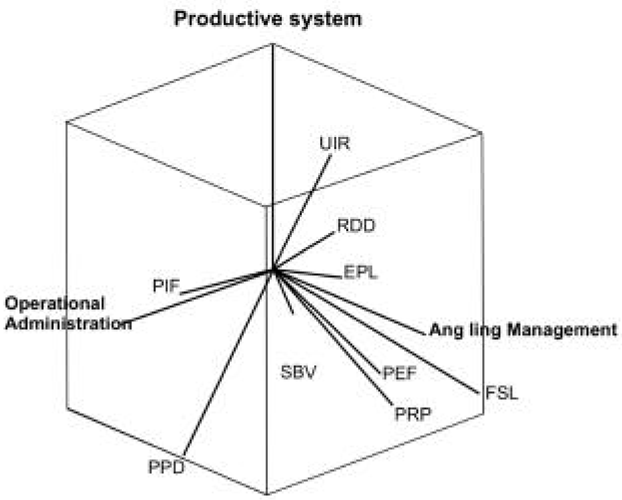

Figure 1 - Scattering graph of the recreational fishing lakes UIR, RDD, PRP, EPL, PIF, PEF, FSL, PPD and SBV and the attributes productive system, angling management and operational administration.

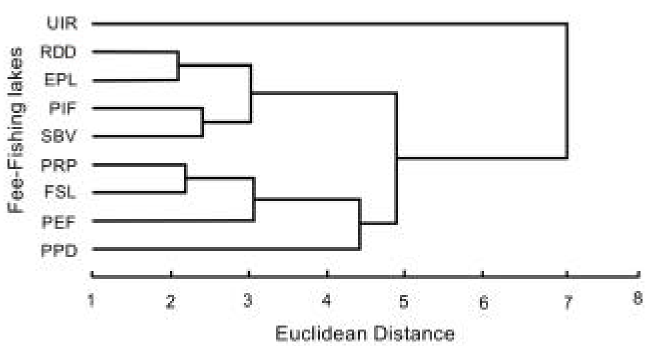

Figure 2 - Cluster analysis dendrogram obtained with 13 indicators (in the recreational fishing lakes), utilizing the Euclidean distance and UPGMA method for nine fishing lakes.

ture kg^{-1}, rate of capture kg^{-1}, lake capture per day, and a lower value for feeding rate (Table 4). Group II showed the lowest values for the number of fish per lake, lake area and total biomass. This group presented the highest feeding rate. Group III showed the highest values for average fish weight and lake depth and the lowest values for number of species per lake, also showing a low value for feeding rate. Group IV presented the higher value for number of species per lake and a high value for feeding rate. This group maintained the highest value of the diversity of available species (seven). This group registered, however, the lowest values for angler frequency, stocking density, fish biomass, average fish weight, total capture kg^{-1}, rate of capture kg^{1}, lake capture per day, and lake depth.

DISCUSSION

Only two operations designed and built especially for recreational fishing were observed (UIR and PRP), one of them equipped with a pier (PRP). The others were built primarily to attend farming requirements, and gradually adapted for fee- fishing, although possessing multiple uses. The average depth found in the fee-fishing lakes was 2 m. Masser et al. (1993) considered depths between 0.91 and 1.52 m excellent to maximize the capture. However, Kubitza (1997) claims that pond depth between 1.2 and 1.5 m maximizes fish capture by angling.

The stocking density used by the operators was on average 1.04 fish m^{-2}, equivalent to a biomass of 1.32 kg m^{-2}. These data confirm Cichra & Carpenter (1989) and Cichra et al. (1994), who reported biomass values around 1.36 kg m^{-2} in fee-fishing operations.

The grouping of enterprises (Figure 2) can be explained by differences of stocking density (SD) adopted. The average SD obtained for groups I and II are considerably higher than those for groups II and IV. Considering that the low rate of water renovation in the ponds of groups I and II, and that aerators are used, values obtained can lead to an insufficiency in the load capacity, generating effects in scale. This can result in low water quality (metabolites accumulation), animal discomfort and eventually low harvesting. Concerning animal well being, the stocking density evaluated in group I is excessively high, 90% higher than group II. High densities can cause system disequilibrium, especially regarding water quality, thus allowing, the diseases outbreaks. On the other hand, 50% of the operations had low stocking density, which makes fishing activity difficult and decrease profits. In general, operations replace their stocks weekly or every 15 days, so fish do not remain in the ponds for long time. High density stocking management demands close monitoring of water quality, not observed in the studied premises. Unsatisfactory fishery administration itself declares the deficiency of management in northwest São Paulo State.

A high positive Spearman's correlation (Table 3) was found between the number of fish in the lake (NFL) and total ichtyomass weight (TIW) (r = 0.98), which refers to the mean fish weight. The mean fish weight was 1.2 kg, highly contrasting with values reported by Cichra & Carpenter (1989) - 4.08 kg to 6.35 kg. This contrast can perhaps be explained by the socioeconomic differences, which renders prohibitive capture of big fish. Operations managers preferentially opt to make available smaller fish, also because these fish can be purchased by lower prices from the fish farmers.

Fish weight, the sportive feature (the fight of the fish against being captured) and the quality of the fish are regionally different (Kubitza, 1997). The AFW indicator shows the same number for all the four groups, presenting a mean of 1.21 kg fish^{-1}. However, the highest value was presented in group III which, the largest flooded area. Because of this characteristic, this fee-fishing establishment can maintain its stocking for a longer

Table 3 - Estimative of Spearman's correlation coefficients among the thirteen indicators[1] evaluated.

	NFL	LA	NSL	SD	SB	TIW	AFW	TC	RC	CLD	LD	FR
AF	-0.05	-0.44	0.54	0.65	0.45	-0.60	-0.66	0.81	0.43	0.80	0.29	-0.11
NFL		0.78	0.05	-0.20	-0.13	0.98	0.23	0.20	-0.55	0.31	0.40	-0.86
LA			-0.09	-0.75	-0.66	0.78	0.19	-0.23	-0.78	-0.14	0.41	-0.68
NSL				0.11	0.17	-0.00	-0.55	0.11	0.04	0.17	-0.15	0.05
SD					0.91	-0.21	-0.08	0.60	0.71	0.58	-0.18	0.20
SB						-0.16	0.03	0.78	0.80	0.76	0.11	0.11
TIW							0.33	0.21	-0.53	0.28	0.40	-0.90
AFW								0.38	0.10	0.21	0.48	-0.55
TC									0.68	0.95	0.62	-0.40
RC										0.56	0.16	0.33
CLD											0.64	-0.43
LD												-0.60

[1]Indicators described in Table 1.

time, which may not be a good strategy for business, once price is charged per kg of captured fish. Anglers may disconsider effort in trying to catch a fish, and as a consequence, reduction of the profits of the fee-fishing is observed.

The indicators of total capture and capture per lake per day abide by estimative of Spearman's correlation coefficients (95%). The total capture (kg) and the rate of capture (%) is shown to be more attractive in smaller fee-fishing operations. The high rate of capture achieved by group I results from the balance between area of lake, choice of sporting species, and combined services (facilities) offered. However, group IV is positioned in the dendrogram in clear contradiction, presenting the highest index for species diversity in the lake (NSL) and facilities appreciated by anglers. It is thus interesting to emphasize the positive correlation between capture per lake per day and lake depth (r = 0.64) (Table 3). The highest capture per lake per day average occurred in lakes 1.90 to 2.00-m deep, a clear option on the part of the fee-fishing operators for offering the fishermen shallow water species. On the other hand these depths range can underline the concern to create shelter areas for the fish, especially in the winter.

The total average capture observed during the study for all operations was 275.42 kg month^{-1}, a little more than 1/3 of the capture reported by Kitamura et al. (1999) for operations in the Piracicaba River basin, southwest São Paulo State, Brazil. There is strong tendency of anglers of northwest São Paulo State preferring to fish in the wild. The area of study is benefited by the presence of large hydroelectric reservoirs with good fishing potential. Socioeconomic differences between industrialized hydrographic basins, such as Piracicaba River Basin, and essentially rural basins, such as São José dos Dourados, Baixo Tietê and Turvo Grande, can also explain the significant difference between capture per lake per day observed in fee-fishing establishments on both regions.

The most common fish species found in the fee-fishing facilities are pelagic species such as pacu (*Piaractus mesopotamicus*), tambaqui (*Colossoma macropomum*), piau (*Leporinus copelandi*); deep-water fish such as curimbatá (*Prochilodus scrofa*); and surface fish such as piracanjuba (*Brycon orbignyanus*) and matrinxã (*Brycon cephalus*). Only native Brazilian fishes, preferred by anglers, were found in all operations.

The average rate of feeding 0.47 kg per lake per day (0.1% live weight of stock). Operations of group II, which covered less flooded area, had the highest rate of feeding 0.71 kg per lake per day (Table 4). On the other hand, the fee-fishing lakes of groups III and IV, which cover larger areas, adopted water fertilization to supply natural food to fish. The average crude protein value of fish feeds was 26%. However, the supplementary feeding is only adopted by operators to bestow greater vulnerability of fish to baits, that is, to condition fish to attack artificial baits. That can be confirmed by the negative correlations obtained between the number of fish in lake and feeding rate (FR) (r = -0.86) and total ichtyomass weight and FR (r = -0.90). However, in larger fee-fishing lakes there was a negative correlation between lake area and FR (r = -0.68), basically due to the smaller concentration of anglers in these operations and the abundance of natural feed.

The average active angler (who actually practice sport fishing), was 823.9 anglers per month, with the UIR fish out operation responsible for 81% of this total. Regarding the rate of capture kg^{-1}, the best performance of the fishing operations concerning frequency, was related to combined services, providing good localization, night fishing, playground, bar and restaurant, among others.

Table 4 - Indicator averages in the groups obtained in the cluster analysis for the recreational fishing lakes.

Group	AF[1]	NFL	LA	NSL	SD	SB	TWI	AFW	TC	RC	CLD	LD	FR
	N	nº	ha	nº	nº	kg	Kg	kg	kg	%	kg	m	%
I	2083.33	2591.60	0.10	3.00	2.59	3.16	3279.50	1.27	1367.67	41.00	45.18	2.00	0.15
II	282.62	374.45	0.03	2.00	1.34	1.58	446.37	1.18	163.32	40.40	2.63	1.90	0.71
III	112.83	1906.66	0.50	1.00	0.39	0.71	2638.00	1.41	139.50	4.63	1.04	2.50	0.19
IV	83.30	1319.67	0.50	7.00	0.25	0.23	1316.67	0.99	40.33	2.20	0.27	1.50	0.38

[1]Indicators described in Table 1.

Positive correlations occurred between angler frequency (AF) and stocking density (SD) (r = 0.65), AF and total capture kg^{-1} (r = 0.81), AF and capture per lake per day (r = 0.80), SD and rate of capture kg^{-1} (r = 0.71), stocking biomass (SB) and rate of capture kg^{-1} (r = 0.80) and SB and capture per lake per day (r = 0.76) (Table 3), which indicates a tendency of greater number of anglers to be associated with larger fish stocks, and consequently, greater total catch and greater catch per lake per day. However, AF showed negative correlation with average fish weight (r = -0.66), which can be explained by the system of charging per kg of fish caught.

Lake area was negatively correlated with SD and SB (r = -0.75 and r = -0.66, respectively), because the smaller the size of the lakes the greater the density and the stocking biomass (Table 4). This occurs because there is a greater demand by the anglers for smaller size lakes. The total ichtyomass weight indicator presented a positive correlation for lake area (r = 0.78). This correlation was found in all the larger lakes, except for the UIR lake that possesses intermediate size dimensions; this can be explained by the low catch pressure, in the larger lakes, as shown by the correlation between lake area and rate of capture kg^{-1} (r = -0.78), which will thus elicit a greater weight increase.

The RDD and EPL operations occupy an intermediate position between productive and fee-fishing system, according to the scattering graph (Figure 1). Both possess reduced fishing areas combined with high stocking density. The association of these two indicators allowed these two angling operations to prevent higher rate of capture kg^{-1} (RC) during the study period, forming "virtual fish deposits". The PIF operation presents high correlation with the operational administration attribute. Among all the studied operations, the lowest index for average fish weight and lake depth was found for this lake. Due to these two operational characteristics, associated with reduced water body extent, this lake had the third best individual performance for the RC indicator.

However, operations PEF, PRP, and FSL, distinguished themselves presenting fishing resources of larger weight and number, with reduced stocking density. In these operations, low stocking renewal was observed, indicating the presence of non-catchable fish, that is, fish that remain in the operations as residual resources and present low vulnerability to bait. This particularity tends to inhibit capture by the anglers, which can lead to greater individual fish biomass. These operations present the largest flooded areas.

The PPD lake occupied an intermediate position between the attributes angling management (Factor 2) and operational administration (Factor 3), and a negative correlation with productive system (Factor 1), the opposite to UIR recreational fishing. This lake had as main characteristic species diversity, a mixed farming system represented by the indicator number of species in lake. However, it had a fish ponds of about half an hectare with low stocking biomass, which compares to PEF, PRP and FSL operations regarding capture difficulty, so this lake registered the lowest values for total capture kg^{-1}, capture per lake per day, and rate of capture kg^{-1}.

All the tropical fee-fishing operations present both singularities and intrinsic dissimilarities. The indicators angler frequency, storage density, biomass, total catch and capture per lake per day catch, that compose the productive system attribute, were the most important, in evaluating the performance of fee-fishing operations in this study.

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