# Anuran diversity (Amphibia, Anura) in a Seasonal Forest fragment in southern Brazil

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***Abstract:*** The Atlantic Forest is the home to a diverse and threatened fauna of amphibians. However, knowledge on these species is still scarce to many of its ecosystems, such as the Seasonal Forest. This study was aimed at determining the diversity of anurans in Parque Estadual Fritz Plaumann (PEFP), located in the municipality of Concórdia, Santa Catarina, southern Brazil. The PEFP comprises 741 ha, and is the only Conservation Unit of Seasonal Forest in Santa Catarina state. From August 2010 to July 2011 we surveyed frogs fortnightly during four to ten days, from sunset until approximately midnight. Active, audio and visual searches were carried out at breeding sites and favorable areas to meet the species. The sampling effort of the survey was evaluated with species accumulation curve considering the field expeditions as sample units. The species composition of PEFP was compared with 16 other different vegetal formations of the Atlantic Forest biome through similarity analysis. Twenty-three species were recorded. The accumulation curve approached an asymptote, indicating that most species of the area were observed. Most species were observed in lentic habitats of open areas. The anuran species composition of PEFP was similar to other areas of Mixed Ombrophile Forest and Seasonal Forest in southern region. Although PEFP comprised a relatively small area, the occurrence of habitat specialists, endangered amphibians that dependent on the forest, indicates the importance of this area for the conservation of the regional fauna. The continuation of long-term standardized studies is needed to monitor the population dynamics of recorded species and support alternative management practices, aiming at the conservation of anurans at the Seasonal Forest.
***Keywords:*** *biodiversity, conservation, frogs, Atlantic Forest, Santa Catarina.*

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***Resumo:*** A Mata Atlântica abriga uma expressiva e ameaçada fauna de anfíbios, mas o conhecimento sobre as espécies ainda é bastante escasso para diversos de seus ecossistemas, como a Floresta Estacional. Este estudo teve como objetivo conhecer a diversidade de anuros no Parque Estadual Fritz Plaumann (PEFP), localizado no município de Concórdia, Santa Catarina, sul do Brasil. O PEFP possui 741 ha, sendo a única Unidade de Conservação de Floresta Estacional no estado de Santa Catarina. Durante os meses de agosto de 2010 a julho de 2011 realizamos amostragens quinzenais de quatro a dez dias, a partir do entardecer até aproximadamente a meia noite. Empregamos o método de busca ativa, visual e auditiva, em sítios reprodutivos e locais favoráveis ao encontro das espécies. A suficiência de amostragem foi avaliada através da curva de acumulação de espécies considerando as campanhas de campo como unidades amostrais. Utilizamos uma análise de similaridade para comparar a anurofauna do PEFP com outras 16 áreas de Mata Atlântica. Foram registradas 23 espécies. A curva de acumulação mostrou tendência à estabilização, indicando que grande parte das espécies da área foi registrada. A maioria foi observada em ambientes lênticos em área aberta. A composição da anurofauna do PEFP foi similar a áreas de Floresta Ombrófila Mista e Floresta Estacional da região sul. Apesar de o PEFP possuir uma área relativamente pequena, a ocorrência de anfíbios especialistas de hábitat e ameaçados de extinção evidencia a sua importância para a conservação da fauna regional. O prosseguimento de estudos sistematizados em longo prazo é importante para monitorar a dinâmica populacional das espécies registradas e subsidiar alternativas de manejo, visando a conservação da anurofauna de Floresta Estacional.
***Palavras-chave:*** *biodiversidade, conservação, anfíbios, Mata Atlântica, Santa Catarina.*

## Introduction

The Atlantic Forest is considered the second largest tropical rainforest of the American Continent, extending along the Brazilian coast from Piauí to Rio Grande do Sul states (Pinto et al. 2006), and to southeastern Paraguay and northeastern Argentina (Tabarelli et al. 2005). This biome originally covered approximately 1.350.000 km$^2$ of the Brazilian territory (Fundação... & Instituto... 2002), of which only 12% remain, distributed in small and isolated fragments (Ribeiro et al. 2009).

Because of its wide variations in latitude, altitude, and climatic regimes (Pinto et al. 2006, Ribeiro et al. 2009), the Atlantic Forest exhibits high species richness and endemism rates (Brasil 2000). However, this biological diversity is currently endangered by the expansion of agricultural activities, increased population density, and the presence of the largest Brazilian industrial centers (Brasil 2000, Pinto et al. 2006). The few remnants of Atlantic Forest are currently limited to steep regions, where agricultural and extractive activities were difficult or unfeasible, or to few areas of legal protection (Fundação... et al. 1998). The Atlantic Forest is currently considered one of the 34 biodiversity hotspots of the world (Myers et al. 2000, Mittermeier et al. 2004), and the richest Brazilian biome. From this ecosystem, more than 400 species of anurans have been described and approximately 85% are endemic (Cruz & Feio 2007).

Despite its high biodiversity, knowledge on the taxonomic status, biogeography and conservation status of the frogs of the Atlantic Forest is still scarce (Silvano & Segalla 2005). This is associated to the lack of intermediate and long-term studies, surveys of the fauna from different regions (Silvano & Segalla 2005), and the fast pace of human actions degrading natural habitats (Forlani et al. 2010).

Santa Catarina state was originally covered only by Atlantic Forest, distributed among the vegetation types of Dense Ombrophile Forest (DOF), Mixed Ombrophile Forest (MOF), Seasonal Forest (SF) and Grasslands (Klein 1978). The western region of the state is covered mainly by Mixed Ombrophile Forest (also called as Araucaria Forests), which in the past comprised 42% of the state, while Seasonal Forest occupied approximately 9% of the territory, and Grasslands represented 14% and generally forming spots within Araucaria Forests (Medeiros 2006). Among the vegetation types of the Atlantic Forest present in Santa Catarina, the Seasonal Forest is one of the most endangered formations and least protected as conservation units (Fundação... & Instituto... 2002). Although the biome as a whole has been impacted by colonization (Câmara 2003), Seasonal Forests have more deforested areas, as its relief promoted agricultural activities, cattle ranching, and silviculture (Araujo et al. 2009).

The anurans of Santa Catarina state represent 15% of the described species in Brazil (Lucas 2008). Despite recent taxonomic studies (Kwet 2006, Garcia et al. 2007, Toledo et al. 2007, Garcia et al. 2008), few have focused on diversity and conservation of amphibians of the area (Hartmann et al. 2008, Lucas & Fortes 2008, Lingnau 2009, Dallacorte 2010, Wachlevski & Rocha 2010, Lucas & Marocco 2011), and species from many areas are still poorly known (Lucas 2008). Knowledge on diversity of species in conservation units is also limited to few studies (Lucas & Fortes 2008, Dallacorte 2010, Wachlevski & Rocha 2010, Lucas & Marocco 2011).

Given the scarcity of information on diversity and distribution of anurans in the Atlantic Forest in southern Brazil, especially in areas of Seasonal Forest, this study was aimed at 1) determining richness and composition frog species in a conservation unit of Santa Catarina state; 2) comparing its species composition with those of other Brazilian localities, and 3) identifying potential threats to frog conservation in the area. In addition to broaden the knowledge on the species diversity of the state, the information presented in this study may support analyses on the real effectiveness of amphibian conservation in conservation units.

## Materials and Methods

### *1. Study site*

The study was conducted at the Parque Estadual Fritz Plaumann (PEFP), located in the municipality of Concórdia, western Santa Catarina state, southern Brazil (27° 17' 36" S and 52° 06' 38" W; 400 m of altitude; 741 ha, Figure 1). PEFP is located by the reservoir of the Itá Hydroelectric Power Plant (Itá HPP), in the Uruguay river basin, and the Queimados river mouth. The climate in the region is mild mesothermal (Instituto... 2002). The average annual maximum temperature is 22 °C and the average annual minimum temperature is 13 °C. The average annual rainfall is 2.000 mm (Leite & Leão 2009) without a defined dry season (Instituto... 2002). Of the 741 ha, 265 ha correspond to an island formed during the creation of the reservoir of the Itá HPP. In this study, surveys were carried out only in continental portion, comprising 476 ha.

The PEFP is a conservation unit of integral protection, created in 2003, as a measure to compensate the environmental impacts created by the Itá HPP. The vegetation of the region is characterized by Seasonal Forest as part of the Atlantic Forest biome. This vegetation occurs in low altitudes (up to 800 m) of the Uruguay river valley and its tributaries. The PEFP is the only conservation unit in Santa Catarina state that protects fragments of this forest type (Vitali & Uhlig 2010). Although it is a protected area, some invasive exotic plant species are frequently found in the area, such as *Hovenia dulcis* (Japanese raisin tree) and *Hedichyum coronarium* (white garland lily) (Instituto... 2003).

### *2. Data collection*

The data collection was carried out from August 2010 to July 2011. The fortnightly surveys, during four to ten days, a total sampling effort of approximately 350 hours/person. Sampling procedures began at sunset, with the aid of flashlights and ended approximately at midnight. The sampling method consisted of visual and audio searches in aquatic habitats used for the reproduction of species (sensu Scott Junior & Woodward 1994) and in trails inside the forest and occasional encounters.

Eight aquatic reproductive sites were regularly sampled, consisted of four lentic habitats in open areas (marsh, Porto, Brum, and Mirante ponds), three lotic habitats inside the forest (Lajeado Cruzeiro, Linha, and Canafístula creeks) and a lotic habitat in forest edge (Temporary creek; Table 1). For ponds and marsh, the entire perimeter was surveyed, and in creeks, a section of approximately 300 m was sampled. Some physical features were recorded for each habitat, such as the hidroperiod (temporary or permanent), water flow (lentic or lotic), surface area (m²), water column depth (m), type of predominant vegetation in the margins of each habitat and type of bottom (substrate with more than 50% of predominance). One or two breeding sites were sampled on each night. At the Linha and Canafístula creeks, the same 300 m of the creek was sampled, while in Lajeado Cruzeiro creek, different sections were sampled during the survey due to access conditions. During the day, the creeks, lentic habitats, and trails inside the forest were walked for the observation of diurnal species.

To identify potential threats to the conservation of amphibians at PEFP, we examined if direct or indirect human effects associated to land use were present. The most evident ones in the area, which have also been reported in other studies were characterized by the presence of exotic animals (e.g. Both et al. 2011) and plants (e.g. Martin &

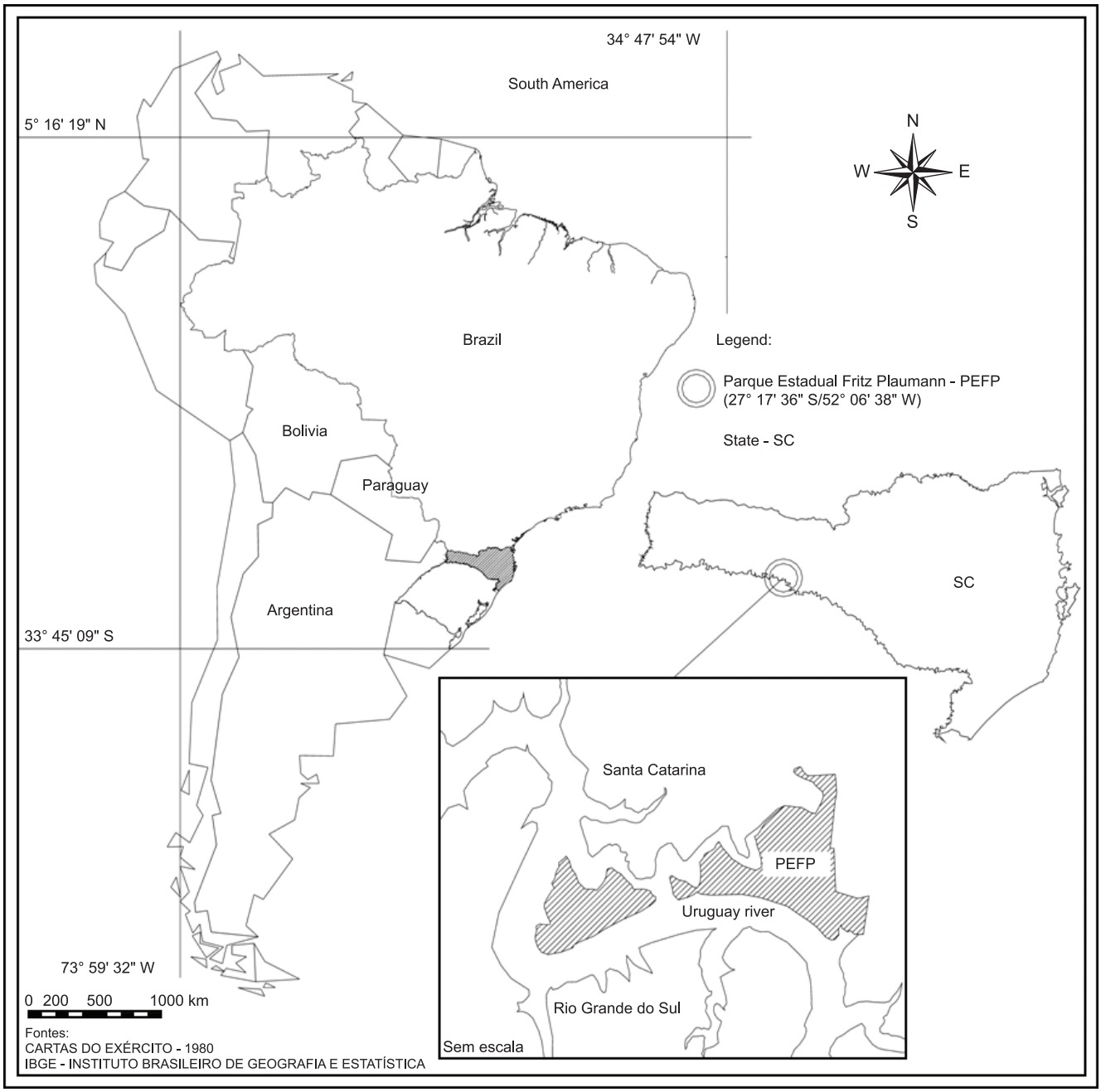


**Figure 1.** Location of the Parque Estadual Fritz Plaumann (PEFP) in Santa Catarina state, southern Brazil.

Murray 2011), presence of agricultural activities (e.g. Relyea 2005a, Kopp et al. 2007), presence or proximity of roads and/or human settlements (e.g. Hamer & McDonnell 2008).

The species identification was carried out based on the literature, consultation with specialists and comparison with specimens deposited in scientific collections. To aid the taxonomic identification, calls of the species were recorded with a digital recorder. Voucher specimens were deposited in the scientific collection of the Universidade Comunitária da Região de Chapecó (Research Permit # 04/2010/PAEFP/GERUC/DPEC and # 13/2011/GERUC/DPEC-FATMA). The nomenclature and the taxonomic classification followed Frost (2011) and Pyron & Wiens (2011).

### *3. Data analysis*

To evaluate the sampling effort of the survey conducted in the eight bodies of water at the PEFP, species richness was estimated by extrapolating the species accumulation curve (Santos 2003), calculated on 21 sampling periods in the field. One thousand random repeats were performed with the software Estimates 7.5.0 (Colwell 2005). The species composition of PEFP was compared with those of other vegetal formations of the Atlantic Forest biome (Seasonal Forest, Mixed Ombrophile Forest and Coastal Ecosystem) (Table 2). Only Seasonal Forest was considered for the vegetation type of Seasonal Deciduous Forest and Seasonal Semideciduous Forest, due to the ongoing discussion about the distinction between them

**Table 1.** Main characteristics of the eight bodies of water examined at the Parque Estadual Fritz Plaumann, Santa Catarina, southern Brazil, from August 2012 to July 2011. MAR = Marsh; PP = Porto Pond; BP = Brum Pond; LCC = Lajeado Cruzeiro Creek; CC = Canafístula Creek; LC = Linha Creek; TC = Temporary Creek; MP = Mirante Pond. TR = Trees (Aquifoliaceae, Boraginaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Meliaceae, Myrtaceae, Arecaceae, Rhamnaceae, Rutaceae); SH = Shrubs (Annonaceae, Malpighiaceae, Solanaceae, Verbenaceae, Zingiberaceae); ESV = Erect Shrubby Vegetation (Asteraceae, Cyperaceae, Malvaceae, Poaceae, Pteridophyta); TSV = Tall Shrubby Vegetation (>30 cm; Poaceae); SSV = Short Shrubby Vegetation (<30 cm; Poaceae); M = Macrophyte (*Eichhornia crassipes*, *Salvinia* sp., *Eleocharis* sp.); BG = Bare ground. The sequence of the types of vegetation in the items "Riverbed vegetation" and "Riverbank vegetation" indicates the decreasing predominance. CH = Cover by hydrophytes; M = Muddy; PR = Predominantly rocky; PM = Predominantly muddy. OA = open area; EN = edge of native forest; IN = interior of native forest.

| Local | Geographic coordinates | Altitude (m) | Duration | Area ($m^2$) | Depth (m) | Riverbed vegetation | Riverbank vegetation | Floor | Ecosystem | Habitat |
|---|---|---|---|---|---|---|---|---|---|---|
| MAR | 27° 17' 22.9" S 052° 07' 05.8" W | 403 | Temporary | ~1600 | 0.40 | M, ESV, SH | ESV, TSV, SSV, SH, TR | CH | Lentic | OA |
| PP | 27° 18' 16.6" S 052° 06' 04.8" W | 388 | Temporary | ~350 | 0.90 | M, ESV | TSV, SSV, SH, TR | CH | Lentic | OA |
| TC | 27°18'14.7" S 052° 06' 05.4" W | 397 | Temporary | ~800 | 0.30 | Absent | BG, SSV, ESV, SH, TR | PM | Lotic | EN |
| BP | 27° 18' 18.8" S 052° 06' 00.9" W | 380 | Permanent | ~400 | ~0.40 | M | ESV, TSV, SSV, SH, TR | M | Lentic | OA |
| LCC | 27°17'19.0'' S 052° 06' 50.8" W | 393 | Permanent | ~1000 | 0.60 | Absent | TR, ESV | PR | Lotic | IN |
| CC | 27° 17' 36.0" S 052° 06' 38.7" W | 415 | Permanent | ~290 | 0.50 | Absent | ESV, SH, TR | PR | Lotic | IN |
| LC | 27° 16' 47.7" S 052° 06' 24.7" W | 402 | Permanent | ~300 | 0.70 | Absent | ESV, SH, TR | PR | Lotic | IN |
| MP | 27° 17' 49.9" S 052° 06' 53.6" W | 521 | Permanent | ~120 | 0.40 | M, ESV | ESV, TSV, SH, TR | M | Lentic | OA |

**Table 2.** Richness of anuran species, sampling effort (months of study), study area, and plant formation of the localities compared with the Parque Estadual Fritz Plaumann. CE = coastal ecosystem (restinga); MOF = Mixed Ombrophile Forest; SF = Seasonal Forest.

| Formation/ Ecosystem | Size of the area (ha) | Sampling effort (N. months) | Number of species | Local | Reference |
|---|---|---|---|---|---|
| CE | - | 12 | 15 | SC, Palhoça | Wachlevski & Rocha (2010) |
| CE | Aprox. 30000 | 11 | 20 | SP, Peruíbe | Narvaes et al. (2009) |
| CE | - | 19 | 29 | RS, Torres | Colombo et al. (2008) |
| MOF | - | 13 | 21 | SC, Ipuaçu | Hartmann et al. (2008) |
| MOF | 876.7 | 15 | 32 | PR, Fazenda Rio Grande | Conte & Rossa-Feres (2007) |
| MOF | 1606 | 37 | 26 | SC, Chapecó and Guatambú | Lucas & Fortes (2008) |
| MOF | 12839 | 2 | 29 | SC, Ponte Serrada and Passos Maia | Lucas & Marocco (2011) |
| MOF | - | 13 | 23 | PR, Tijucas do Sul | Conte & Machado (2005) |
| MOF | Aprox. 4500 | 48 | 55 | RS, São Francisco de Paula | Kwet et al. (2010) |
| MOF | 747 | 26 | 32 | SC, Lebon Régis | Lingnau (2009) |
| SF | 2178.84 | 35 | 34 | SP, Gália and Alvinlândia | Brassaloti et al. (2010) |
| SF | 2069.06 | 4 | 24 | SP, Pedregulho | Araujo et al. (2009) |
| SF | 243 | 12 | 24 | SP, Rio Claro | Zina et al. (2007) |
| SF | 2222.80 | 17 | 21 | SP, Rio Claro - FEENA | Toledo et al. (2003) |
| SF | 17491 | 12 | 31 | RS, Derrubadas | Iop et al. (2011) |
| SF | - | - | 23 | RS, Quarta Colônia | Cechin et al. (2002) |
| SF | 476 | 12 | 23 | SC, Concórdia | Present study |

(Oliveira-Filho et al. 2006, Pennington et al. 2009). The similarity analysis was carried out using the Jaccard coefficient of affinity, with later clustering analysis with the weighted pair group method using arithmetic averaging (WPGMA) (Krebs 1999). To avoid the interference of taxonomic issues, we excluded from the analysis species classified as undetermined, such as: "sp." (unidentified species), "gr." (species group), "aff." (*affinis*) and "cf." (*confer*). The exotic species *Lithobates catesbeianus* was also excluded from the analysis. The consistency of the similarity analysis was determined based on cophenetic correlation coefficient (r) (Romesburg 1984), to verify the loss of information for the construction of dendrogram. This coefficient was obtained by correlating the original similarity matrix obtained from the dendrogram, with r values $\geq 0.9$ considered very good fit, $0.8 \leq r < 0.9$ good fit; $0.7 \leq r < 0.8$ poor fit, and $r < 0.7$ very poor fit (Rohlf 2000).

To examine if the geographic distance influenced the composition of anuran species and consequently the result of similarity analysis, we performed the Mantel test (Manly 2000), using the Jaccard coefficient

for the similarity matrix and the euclidean distance coefficient for the geographic distance matrix with 5.000 permutations. The geographic distance was calculated based on geographic coordinates of the areas. All analyses were performed with the software Past (Hammer et al. 2001). The significance level for all tests was set at $p < 0.05$ (Zar 1999).

## Results

We recorded 23 species of anuran amphibians, 22 native and one exotic, distributed in 15 genera and eleven families (Table 3). Hylidae was the most representative family, with eight species, followed by Leptodactylidae and Bufonidae (3), Leiuperidae (2) and Alsodidae, Brachycephalidae, Centrolenidae, Hylodidae, Microhylidae Odontophrynidae and Ranidae (1). The latter was represented by the exotic species *Lithobates catesbeianus*. The species accumulation curve approached an asymptote, indicating that most species of the area were observed during the study (Figure 2).

Richness of native species was highest in lentic habitats than in open areas (72.7%; n = 16), and lowest in lotic habitats inside or at the edge of the native forest (50%; n = 11; Table 3). The cluster analysis (Figure 3) revealed that the anuran assemblage of the Parque Estadual Fritz Plaumann was more similar to that of the Parque Estadual do Turvo (Iop et al. 2011), located in Rio Grande do Sul state, and covered by Seasonal Forest. The anuran composition of these two areas was similar to those of other two areas in Santa Catarina state, Ipuaçu (Hartmann et al. 2008), characterized by Mixed Ombrophile Forest and the Floresta Nacional de Chapecó (Lucas & Fortes 2008), characterized by the transition between MOF and SF, also geographically close. These four areas combined with two other sites mainly in MOF and SF localities in Southern Brazil comprise a group with about 50% similarity, while a second group with approximately 45% similarity consists of localities in SF of southeastern Brazil. The cophenetic correlation coefficient indicated that the similarity analysis was consistent (r = 0.92). Geographically

**Table 3.** Species of anurans and habitats examined at the Parque Estadual Fritz Plaumann, Santa Catarina, southern Brazil, between August 2010 and July 2011. IN = interior of native forest; EN = edge of native forest; OA = open area. *leaf litter, in trail inside forest.

| Family/specie | Habitat | | |
|---|---|---|---|
| | IN | EN | OA |
| Alsodidae | | | |
| *Limnomedusa macroglossa* (Duméril & Bibron, 1841) | X | | |
| Brachycephalidae | | | |
| *Ischnocnema henselii* (Peters, 1872)* | X | | |
| Bufonidae | | | |
| *Melanophryniscus* sp. | X | X | |
| *Rhinella henseli* (Lutz, 1934) | X | | X |
| *Rhinella icterica* (Spix, 1824) | X | | X |
| Centrolenidae | | | |
| *Vitreorana uranoscopa* (Müller, 1924) | X | | |
| Hylidae | | | |
| *Dendropsophus minutus* (Peters, 1872) | | | X |
| *Hypsiboas bischoffi* (Boulenger, 1887) | | | X |
| *Hypsiboas curupi* Garcia, Faivovichi & Haddad, 2007 | X | | |
| *Hypsiboas faber* (Wied-Neuwied, 1821) | X | | X |
| *Phyllomedusa tetraploidea* Pombal & Haddad, 1992 | | | X |
| *Scinax aromothyella* Faivovich, 2005 | X | | X |
| *Scinax fuscovarius* (A. Lutz, 1925) | | | X |
| *Scinax perereca* Pombal, Haddad & Kasahara, 1995 | | | X |
| Hylodidae | | | |
| *Crossodactylus schmidti* Gallardo, 1961 | X | | |
| Leiuperidae | | | |
| *Physalaemus cuvieri* Fitzinger, 1826 | | | X |
| *Physalaemus* aff. *gracilis* (Boulenger, 1883) | | | X |
| Leptodactylidae | | | |
| *Leptodactylus latrans* (Steffen, 1815) | | | X |
| *Leptodactylus mystacinus* (Burmeister, 1861) | | | X |
| *Leptodactylus plaumanni* Ahl, 1936 | | | X |
| Microhylidae | | | |
| *Elachistocleis bicolor* (Guérin-Menéville, 1838) | | | X |
| Odontophrynidae | | | |
| *Proceratophrys bigibbosa* (Peters, 1872) | X | X | |
| Ranidae | | | |
| *Lithobates catesbeianus* (Shaw, 1802) | X | | X |
| Species richness | 12 | 2 | 17 |

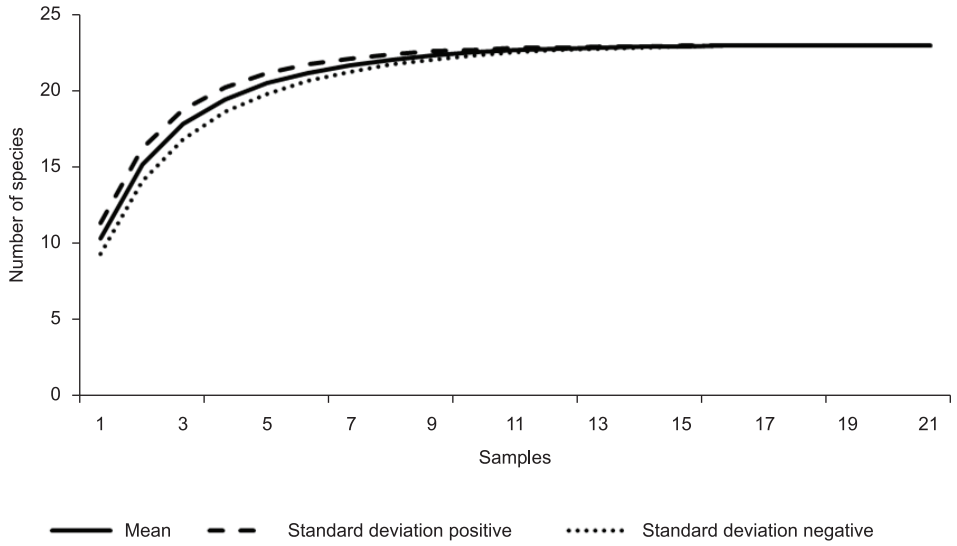


**Figure 2.** Species accumulation curves, calculated based on 21 sampling periods in the field, from August 2010 to July 2011 at the Parque Estadual Fritz Plaumann, Santa Catarina, southern Brazil, from 1.000 randomizations.

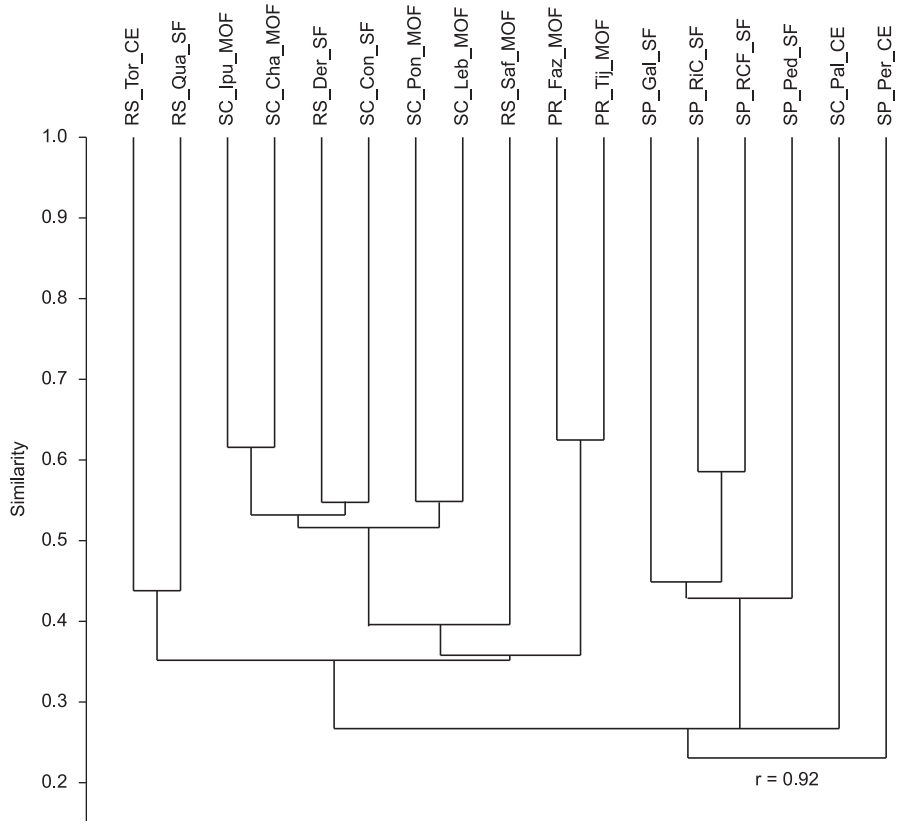


**Figure 3.** Similarity in species composition of anurans among Brazilian localities, based on the Jaccard coefficient of affinity, and later cluster analysis with WPGMA. The legend indicates the geographic location of the areas, considering state, county and type of vegetation, respectively. State: SP = São Paulo; PR = Paraná; SC = Santa Catarina; RS = Rio Grande do Sul; County: Gal = Gália and Alvilândia; RiC = Rio Claro; RCF = Rio Claro (FEENA); Ped = Pedregulho; Per = Peruíbe; Faz = Fazenda Rio Grande; Tij = Tijucas do Sul; Ipu = Ipuaçu; Cha = Chapecó and Guatambú; Con = Concórdia; Pon = Ponte Serrada and Passos Maia; Leb = Lebón Regis; Pal = Palhoça; Tor = Torres; Qua = Quarta Colônia; Der = Derrubadas; SaF = São Francisco de Paula. Formação/ecossistema: SF = Floresta Estacional; MOF = Floresta Ombrófila Mista; CE = Ecossistema Costeiro (restinga). r = cophenetic correlation coeficiente.

closer assemblages of anurans were more similar regarding species composition (r = 0.56, p = 0.00).

Five threatened or "near threatened" species were observed in the area. *Crossodactylus schmidti* and *Proceratophrys bigibbosa* are in the category "near threatened" according to the IUCN Red List of Threatened Species (International... 2011). *Crossodactylus schmidti* is in the category "critically endangered", *Limnomedusa macroglossa* and *Hypsiboas curupi* are "endangered" and *Vitreorana uranoscopa* is "vulnerable" according to the List of Species of Threatened Fauna of Santa Catarina State (Conselho... 2011).

The potential threats to the anurans observed were the presence of exotic species of animals and plants, especially inside the conservation unit, and agricultural activities in the surrounding areas, with possible use of pesticides. The exotic species *Lithobates catesbeianus* (American bullfrog) was present in five of the eight sampled habitats. *Hovenia dulcis* (Japanese raisin tree) and *Hedichyum coronarium* (white garland lily) were present in most waterbodies examined especially lotic habitats. *Hedichyum coronarium*, possibly due to its predominance in the margins of some aquatic habitats, was frequently used as calling sites and shelter by *Hypsiboas curupi* and *Scinax aromothyella*. Agricultural activities, as well as silviculture of *Pinus* and *Eucalyptus* and human settlements in the surrounding area were commonly observed. Solid waste from domestic and agricultural (e.g. plastic bags, sacks, other packaging like PET bottles and pots, tire rubber, clothing, aluminum cans) were very common, especially in Lajeado Cruzeiro creek, which crosses the conservation unit.

## Discussion

The anurans recorded at PEFP represent 16% of the amphibians occurring in Santa Catarina state (144 species) (Lucas 2008), 5.6% of the known frogs of Atlantic Forest (405 species) (Haddad & Prado 2005) and 2.4% of the fauna of amphibians currently known in Brazil (913 species) (Sociedade... 2012). The species accumulation curve indicates that the study recorded most of the richness of the area, despite the occurrence of at least 15 additional species in other areas of Seasonal Forest and Mixed Ombrophile Forest in southern Brazil (e.g. Lucas 2008, Iop et al. 2011, Marocco et al. 2011). However, the anuran richness found is similar to the reported in other fragments of Mixed Ombrophile Forest in western Santa Catarina state (Hartmann et al. 2008, Lucas & Fortes 2008, Lingnau 2009, Lucas & Marocco 2011).

The anuran community in the study area is characteristic of interior formations of Atlantic Forest with 40.9% of species with distribution restricted to southern Brazil (*Ischnocnema henselii*, *Rhinella henseli*, *Limnomedusa macroglossa*, *Proceratophrys bigibbosa*, *Hypsiboas curupi*, *Scinax aromothyella*, *Crossodactylus schmidti*, *Leptodactylus plaumanni* and *Elachistocleis bicolor*) or to others southern countries of South America (Frost 2011). The similarity analysis regarding the composition of anuran species revealed the importance of geographic distance and plant cover in the structure of anuran assemblages of the study area and of other localities of Atlantic Forest in southeastern and southern Brazil included in the comparison. The importance of biogeographic factors in community structure has been demonstrated (Ricklefs & Schluter 1993) and reported in other studies on amphibians of Atlantic Forest (e.g. Zina et al. 2007, Lucas & Fortes 2008, Rocha et al. 2008).

The highest species richness were found in lentic ecosystems of open areas, with several species exclusively from these habitats, such as *Dendropsophus minutus*, *Scinax fuscovarius*, *Physalaemus cuvieri*, *Leptodactylus mystacinus* and *Leptodactylus latrans* (Haddad & Prado 2005, Brassaloti et al. 2010). Several studies on anuran assemblages in South America (e.g. Conte & Machado 2005, Vasconcelos & Rossa-Feres 2005, Araujo et al. 2009, Lucas & Marocco 2011) have shown this pattern, in which most species is typical of open areas and reproduce in lentic habitats (Haddad & Prado 2005), and comparatively few species are restricted to forest habitats and have a reproductive mode exclusively associated with lotic habitats. This pattern in habitat use is possibly associated with phylogenetic constraints of the species (Zimmerman & Simberlof 1996), resulted from a combination of factors, such as predation, competition, and habitat variables. In addition, the predominance of generalist species associated with open areas in assemblages from regions originally covered by Atlantic Forest might be due to the intense destruction and reduction of the biome (Ribeiro et al. 2009). Many species typical of wet habitats in the forest might have been eliminated due to deforestation, resulting in an impoverishment of the specialized fauna in detriment of the permanence of generalist species or those resistant to environmental disturbances (Haddad & Prado 2005, Conte & Rossa-Feres 2007).

In PEFP, the species associated with well-preserved habitats (*Vitreorana uranoscopa*, *Proceratophrys bigibbosa*, *Crossodactylus schmidti*, and *Hypsiboas curupi*) and whose reproductive modes are exclusively dependent of lotic habitats in or at the edge of the forest (Kwet & Faivovich 2001, Brassaloti et al. 2010, Gallardo 1961, Garcia et al. 2007) are the most vulnerable to local extinction. This type of habitat has become gradually more scarce in the study region, mainly due to the deforestation of gallery forests along creeks for the expansion of agricultural and cattle ranching activities, and the conversion of lotic into lentic habitats with the construction of dams and pollution of waters with chemicals from agricultural activities (Bonai et al. 2009, Ternus et al. 2011). On a large-scale, changes in lotic habitats inside forest may have an negative impact on the amphibian populations that use these habitats along their distributions (Becker et al. 2010, Toledo et al. 2010).

Some species associated to forest habitats in PEFP are considered endangered in lists of species threatened with extinction. The occurrence these species indicates the need of conservation plans based on intermediate and long-term studies, supporting the suggestions of the National Action Plan for the Conservation of Endangered Reptiles and Amphibians of Southern Brazil (Directive 25, of 17th February 2012) (Brasil 2012). Lucas & Garcia (2011) recently reported *C. schmidti* in westernmost Santa Catarina, and the population observed during the present study is the second record for the state and the first for the species in a conservation unit in the state (Bastiani et al. 2012). In addition, one of the two populations of *H. curupi* known to occur in conservation units was found in the study area (Lucas & Garcia 2011, Lucas & Marocco 2011).

The conservation implications associated with the occurrence of exotic animal and plant species, and human settlements around the park need to be examined in detail, as environmental changes may cause extinctions and population declines (Bishop et al. 2012). *Lithobates catesbeianus* is known for its potential as an invasive species (Both et al. 2011), competing with native species (Alves et al. 2008) and harboring pathogens (see Cunha & Delariva 2009). The exotic plants *Hedychium coronarium* (white garland lily) and *Hovenia dulcis* (Japanese raisin tree) interfere in the structure of the vegetation at the margin of water bodies, and can affect species that use the vegetation as a reproductive site or shelter. Although *Hedychium coronarium* is used by some anurans (see also Colombo et al. 2008), it dominates the margins of aquatic habitats, making them homogeneous, while *Hovenia dulcis* can have an allelopathic effect (Wandscheer et al. 2011), in addition to still unknown implications caused by the large size of its leaves and fruits in creeks and ponds. The evaluation of the impact of exotic fauna and flora on native species focused on management strategies is especially important as this is a conservation unit, whose main goal is to protect biodiversity.

In addition to threats inside the PEFP, in the surrounding area, agricultural activities, silviculture of *Pinus* and *Eucalyptus*, and human settlements are commonly observed. They cause changes in water quality, and loss and degradation of natural habitats (Peltzer et al. 2003, Machado et al. 2012) due to the presence of human residues (Hamer & McDonnell 2008) in aquatic habitats in the park, and the contamination by chemical products used in crops. The occurrence of exotic plant species, such as *Pinus* and *Eucalyptus*, has a negative influence on anuran assemblages, reducing anuran richness and abundance, and changing anuran composition (Machado et al. 2012). The contamination by pesticides from agricultural activities may result in death or abnormalities, mainly in anuran larva (e.g. Gurushankara et al. 2007, Krishnamurthy et al. 2008) and induce cellular and genetic alterations (Lajmanovich et al. 1998), malformations and sex-reversing in adults (Hayes et al. 2002, 2010). The exposure and effects of amphibians to pesticides also

needs to be further investigated, as it can reveal contamination in many compartments of the ecosystem (Lajmanovich et al. 2005, Schneider et al. 2009), as well as changes in ecological interactions that can possibly cause environmental imbalance (Lajmanovich et al. 2003, Mann et al. 2003, Relyea 2005b).

Although the area of PEFP is relatively small with vegetation in different successional stages, the occurrence of endangered habitat specialists that depend on forests show the importance of the area for the conservation of the regional fauna, as forest fragments are scarce in the plateau region of Santa Catarina (Ribeiro et al. 2009). This forest fragment plays an important role in the connection with other conservation units (Floresta Nacional de Chapecó, Parque Nacional das Araucárias, and Parque Estadual do Turvo), through the implementation of proposals of ecological corridors, such as the Timbó Corridor (State Decree 2.956, of 20th of January 2010) (Santa Catarina 2010a) and the Chapecó Corridor (State Decree 2.957, of 20th of January 2010) (Santa Catarina 2010b). The continuation of long-term standardized studies is needed in this conservation unit in order to monitor the population dynamics of species, especially threatened ones, and seek alternatives to manage exotic species, better understand potential threats to preserve the fauna of PEFP and the Seasonal Forest, one of the most threatened vegetation types of the Atlantic Forest.

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