UNIVERSIDADE FEDERAL DE LAVRAS

RUANNY CASARIM

BRAZILIAN SAVANNA STRICTLY PROTECTED AREAS: LINKING PHYSICAL HABITAT AND SOCIAL SCIENCE TO PROTECT STREAM FISH FAUNA

LAVRAS – MG

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Prof. Dr. Paulo dos Santos Pompeu
Orientador

Prof. Dr. Luke Parry
Co-orientador

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Ficha catalográfica elaborada pelo Sistema de Geração de Ficha Catalográfica da Biblioteca Universitária da UFLA, com dados informados pelo(a) próprio(a) autor(a).

Casarim, Ruanny.
Brazilian savanna strictly protected areas: linking physical habitat and social science to protect stream fish fauna / Ruanny Casarim. - 2018.
98 p. : il.

Orientador(a): Paulo dos Santos Pompeu.
Coorientador(a): Luke Parry.
Tese (doutorado) - Universidade Federal de Lavras, 2018.
Bibliografia.

1. Ecologia. 2. Psicologia da conservação. 3. Ictiofauna. I. Pompeu, Paulo dos Santos. II. Parry, Luke. III. Título.

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APROVADA em 30 de novembro de 2018
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AGRADECIMENTOS

Eita, se abanquem porque lá vem estória. A catrumana aqui contará um pouco de como foi toda essa travessia de quase 5 anos. Com poesia gostaria de me explanar, mas aprendi que 'a verdadeira mejestosidade é escrever com sinceridade.'

Em uma noite de uns anos atrás com quem a vida se ajeitou de me presentear eis que surge a ideia de me doutorar. Ao Ivo tenho que causar ao dizer que sem ele esse projeto não teria lugar. Comigo idealizou, encorajou e suportou todo o caminho pra chegar onde eu queria estar. Com o seu amor todos os medos eu pude enfrentar.

Eu quase que nada sabia desse novo caminhar, mas tinha a certeza de que com o Paulo Pompeu eu queria me apoiar. O mais bonito era em acreditar que depois de me graduar e me mestrar passaria mais tempo com ele para me doutorar e assim 10 anos completar. E de repente o mestre que ensinava passou a aprender que com os Parques poderia trabalhar. Mas a verdade maior era que o mais bonito e importante foi o seu cuidar nos meus enlouquecer. E a felicidade era que como Pai eu poderia contar.

Pra toda essa loucura eu precisava financiar e no campo a Fundação Grupo Boticário de Proteção à Natureza quis me auxiliar. A forte alegria era ao imaginar que com esse apoio os Parques eu poderia desbravar. Preciso aproveitar para aqui clarear que sem a Fundação de Desenvolvimento Científico e Cultural (FUNDECC) era impossível me organizar. Mara, Elizabeth, Thaisa, Laisa, Taize e Vera tenho que me desculpar por muito causar. E de nada adiantava sonhar se não pudesse uma universidade cursar e uma bolsa de estudo da CAPES desfrutar (*O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Código de Financiamento 001*). Assim, ao começar a pesquisar com a Ellen Carvalho, Lucas Faria, Flávia Coelho, Júlio Louzada, Carla Ribas e Marcelo Passamani eu pude me apoiar e meu doutorado aperfeiçoar na UFLA, lugar onde há anos eu tinha orgulho de estar.

Mas de repente, em uma horinha chegou nesse especial lugar um outro que o SerTão também só sabe amar. E com o garoto Yuri pude me acalmar e ter um descanso na loucura por sempre no eu acredito o projeto reinventar. Mas perigosamente tudo diverso se diferenciou e a travessia ficou dificultuosa com tantos saberes. Mas o bonito é que aos poucos fomos nos 'afinando e desafinando' para juntos aprender a caminhar. E assim após a teimosia domar, a beleza de tudo passado conseguimos desfrutar. Obrigada por tanto me ensinar, brow.

E antes mesmo do inicio do campo se concretizar me disseram que eu precisava me internacionalizar. Ali eu me vi surtar, mas pude me encontrar ao descobrir que o ser humano eu podia estudar. Ao Luke Parry tenho que gratificar porque caminhos diferentes teve a paciência e cuidado de me ensinar. Ao me coorientar pude me desafiar sobre como devo pesquisar, dali aprendi que posso confiar que sempre a vitória vou alcançar. Na terra da rainha ao chegar um pint tive que experimentar e com a gringada aprender outra língua a falar. Nesse outro rio literalmente mergulhei e encontrei muito amor pelas bandas de lá. Vivian, Carla, Jos, Gina, Iain, Susan, Mel, Natalie, Kasia and Rachel obrigada por me amparar e Danny por lindamente me endoidar. A Grazyna um especial verso nesse conto quero dar, pois com ela tive a certeza de uma outra mãe ganhar. Aos brasileiros, Mari, Vitito, Lisi, Ciça, Felipe França, Júlia, André e Paty Torres, que Lancaster pôde carinhosamente me amparar tenho que falar que sem vocês por lá eu não teria lugar.

Querendo buscar o que meu doutorado elegeu investigar a travessia tinha que continuar. Ao meu país voltar, a viagem de campo eu e o Yuri começamos organizar. Êta eita! Pra peixes pescar e pessoas entrevistar precisávamos de Pupilos laçar. E assim catrumanas e catrumanos se viram no mato embrenhar e por dias ficar. Nessas águas que não paravam de encantar, cachoeiras tivemos que escalar, barracas armar, Lady poderosa desatolar, medos encarar, banho no rio tomar e comida preparar, mas tudo não foi só um caso de se ajudar e sim de se encontrar. Com o Pedro, Aline, Débora, Igor, Antônio, Marcos, Patricia, Lídia, Júlia, Fernanda, Andressa, Leticia, Dani e Marina Rufino todos os desafios conseguimos encarar, além dos nossos dias eles nos entusiasmar. Um especial salve tenho que dar a

Débora, Aline e Pedro por muitos dias ao meu lado enfrentar. Mas nada aconteceria se com os gestores não pudéssemos contar. Os chefes Ernane, Laura, Rogério, Celso, Marco Lucca e ao peixólogo Luiz Sérgio nos guiaram para os Parques desbravar, mas foi com o Albergues e o Pedrão que aprendemos o SerTão amar. Depois do Cerrado se dedicar devagarinho os peixes fomos triar, e mais uma vez os Pupilos vieram com um café e uma prosa de muito conhecimento nos agregar e ao João Pedro, Rafael, Raquel, Lorenna, Sarah, Alexandre, Ludimilla, Fábio, Francisco, Míriam, Marina Rodrigues, Marina Bueno e Silvia quero um salve dar. Para que toda a lista de espécies pudesse se acertar alguns exóticos pesquisadores vieram nos confirmar que os peixes que havíamos de pescar estava longe de tilapar. Thiago Casarim, Gilberto Nepomuceno, Sérgio Santos e Kiko Langeani obrigada por identificar e catalogar. Catrumano Yoshi, que a vida continue a nos mudar. No meio da travessia tive a chance ainda de desorientando conseguir orientar. Com as minhas filhas Júlia, Patrícia e Lídia, e as adotivas Fernanda e Andressa aprendi que quem sempre aprende um dia pode ensinar.

Ao SerTão tivemos a oportunidade de voltar e ali explanar o que tanto trabalhamos para pesquisar. No retorno conseguimos conhecimento levar e buscar, além de ter a certeza que o meu saber pode junto do saber do outro caminhar. Ao aprender escutar descobri que o SerTão do Cerrado era mais do que respeitar. Era um rasgar-se e remendar-se e assim continuar a viver. Aos que muito me ouviram falar, tenho que confessar: 'Oi sou a Ruanny por todos vocês "remexida e mudada"'.

Com o SerTão dentro de mim pude na tese focar e tentar assim causar. Amigos de longas datas, de datas curtas ou apenas de passagem e em todas as situações eu pude contar. No coração das amigas de 'Séthi': Nathália, Lívia, Mariana, Ana Luiza, Débora, Daniele e Larissa eu consegui desde pequena me abrigar e assim me reequilibrar. A Grazi minha oração eu aprendi a dedicar, e na vida sempre me jogar. Na Eco-UFLA em especial com Ernesto, Aline, Rafa Maciel, Polyanne, Ananza, Wallace, Graziele, Lizi, Vitinho, Laís, Felipe França, pude me encontrar, e o que não faltou foi oportunidade de juntos endoidar. E ao lembrar que o coração muito pode suportar, aos atleticanos Yuri, Rodrigo, Antônio, Lucas, Paulo e Aline, quero agradecer pelas noites de sufoco me acompanhar e assim extravasar. Na Rafa Bastos pude me espelhar e juntas mais uma etapa superar. Rafa, Gui, João e Bella obrigada por há 10 anos comigo lindamente caminhar e a biologar. A Thais e a pequena Aninha em dias de chuva ou de sol, com elas sempre consegui me alegrar e a minha energia recarregar. E não podia faltar um obrigada as Gatas Débora, Aline e Rafa onde várias vezes meu porto seguro fui encontrar. Meu amado amigo Vitinho tenho que mais uma vez citar, pois com ele consegui meu internacionalizar e aprendi que na vida temos pontos a se priorizar.

Eu quase que nada sei, mas na vida eu confio que no amor da minha família eu posso contar. Ao meu pai Ruy e minha mãe Alessandra com educação eles me viram se transformar, obrigada por ensinar a não me calar e por me apoiar pro que eu quiser vir a virar. Com a Nathália e Carlos pude me tranquilizar por minha família eles se juntar. Com meu irmão Henrique aprendi que é preciso sempre se reequilibrar e no silêncio é possível se encontrar. Aos meus avós Neide, Hugo e Rosa obrigada por todo orar e por aprender a ouvir da bióloga sobre o mundo se criar. Rodrigo, Renata, Deise, Willian, Bruno, Camila, Alexandre e Marina com vocês, meus primos, aprendi que podemos tudo e todos revolucionar. À Tati, minhas muitas horas de trabalho tenho que dedicar, obrigada por sempre se virar para me nortear. Com a minha família Gavião Prado, Rosemeire, Everton, Luan, Clara, Mateus e Moisés, eu pude desde o meu graduar com o amor deles me apoiar e me refugiar. Obrigada família por todo cuidar.

E quando tudo estava pra finalizar, não é que a vida inventou? E no meio de todo aquele terminar, o doutorado eu resolvi parar para assim me dedicar a quem eu só saberia por toda a vida amar. Com a minha filha Iara aprendi que por ela tudo vale esperar. Assim, quando doutora eu virar, prometo que vou lutar para que em sala de aula eu possa cada dia me reinventar.

E assim, depois de muitos sentimentos explorar, vamos o Doutorado alcançar. Obrigada Paulo Pompeu, Luke Parry, Cecília Leal, Patrícia Torres, Diego Castro e Marco Aurélio Leite por minha banca representar. FIM.

DEDICATÓRIA

Minha pequena IARA não subestime a sua força e coragem de transformar, inventar, revolucionar e sonhar.

João Guimarães Rosa no livro Grande Sertão Veredas:

“Sabe o Senhor: uma coisa é pôr ideias arranjadas, outra é lidar com país de pessoas. A vida inventa”.

RESUMO

As áreas protegidas tais como os Parques Nacionais são componentes essenciais dos programas de conservação da biodiversidade. Entretanto, a criação de áreas protegidas restringe-se, muitas vezes, a proteção da fauna e flora terrestres. Os ecossistemas aquáticos comumente são protegidos apenas incidentalmente, como consequência de sua inclusão dentro de reservas terrestres. Dados insuficientes e carência de estudos das espécies de peixes e do ecossistema aquático criam dificuldades ao delineamento de estratégias efetivas de conservação da ictiofauna. Assim, inventariar a ictiofauna, quantificar a diversidade de espécies e conhecer a intenção de conservação do homem em relação ao meio ambiente são efetivas ferramentas no planejamento da proteção local, especialmente em áreas de hotspot da biodiversidade como o Cerrado. Nesse contexto, o principal objetivo da presente tese foi compreender o papel dos Parques Nacionais na proteção da fauna de peixes da bacia do rio São Francisco e desenvolver estratégias de conservação e manejo de riachos baseadas em dados físicos e sociais. Dessa maneira, nós amostramos o habitat físico e a ictiofauna de 60 riachos dentro e fora dos Parques Nacionais inseridos na bacia do rio São Francisco no estado brasileiro de Minas Gerais. Nós amostramos 255 métricas de habitat físico para cada riacho e um total de 17.053 peixes de 64 espécies foi registrado. Questionários foram aplicados aos domicílios em torno de cada área protegida onde caracterizamos os aspectos socioeconômicas e demográficas e as medidas de exposição a iniciativas de conservação dos participantes associados ao Parque Nacional local. Os resultados indicaram que a criação ou a ampliação dos Parques Nacionais são excelentes estratégias para proteger a biodiversidade de peixes (Manuscrito 1). Entretanto, ao considerar a ampliação das áreas protegidas uma ferramenta que pode substituir os impactos sociais na população do entorno é investir em educação, onde o conhecimento é traduzido em atitudes favoráveis aos Parques Nacionais e ao ambiente, especialmente o aquático (Manuscrito 2). Assim, com a coexistência entre preservação ambiental e o homem é crucial entender quais características físicas do habitat estruturam a comunidade de peixes e que são influenciadas pelo conhecimento e atitude do homem (Manuscrito 3) para assim buscar o manejo eficiente para conservação dos riachos e da fauna de peixes.

Palavras-chave**.** Unidades de Conservação. Habitat físico. Psicologia da conservação. Ictiofauna de córrego. Bacia do São Francisco. Gestão de água doce.

ABSTRACT

Protected areas such as National Parks are essential tools for biodiversity conservation programs. However, the creation of protected areas is often restricted to the protection of terrestrial fauna and flora. Freshwater habitats are rarely considered and are usually only protected as consequence of their inclusion within terrestrial areas. The lack of data on the aquatic ecosystems, especially for fish, impose difficulties in implementing effective strategies for ichthyofauna conservation. Therefore, describing the composition and distribution of fish, quantifying the species diversity and understanding the humans and nature relationship are effective tools in protection planning, especially in biodiversity hotspots such as the Brazilian Savanna. In this context, the main objective of this study was to understand the role of National Parks in the protection of the fish fauna and to propose strategies for the conservation and management of streams based on biological, physical and social data. We sampled 255 physical habitat metrics in 60 streams inside and outside of National Parks in the São Francisco river basin, in the Brazilian state of Minas Gerais. We captured 17.053 fish from 64 species. We administered questionnaires to households around each protected area where we evaluated the socio-economic and demographic characteristics and the measures of exposure to conservation initiatives of the participants. Fish physical habitats and population interviews data allow the understanding that the creation or enlargement of National Parks are excellent strategies for fish biodiversity protection (Manuscript 1). However, when considering the enlargement of National Parks, it is necessary to avoid unacceptable levels of social impact, and a feasible alternative is to improve the education, where knowledge is converted into more favorable environmental attitudes to National Parks and the environment, especially the freshwater system (Manuscript 2). Thus, with conceptual coexistence between 'human/social' and 'nature/natural', it is crucial to understand that physical habitat metric will vary according to the neighbor's environmental knowledge and environmental attitude (Manuscript 3) in order to seek efficient management for the conservation streams and icthyofauna.

Key words. Conservation Units. Physical habitat. Conservation psychology. Stream ichthyofauna. São Francisco Basin. Management of freshwater.

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1 INTRODUÇÃO GERAL

A crescente busca pelo desenvolvimento econômico é a grande responsável pelo aumento da pressão das atividades antrópicas sobre os recursos naturais. Cada vez se intensifica mais a influência do homem direta e/ou indiretamente sobre um determinado ecossistema. Desmatamento, poluição, introdução de espécies exóticas, construção de barragens sobre os corpos d'água e a superexploração dos recursos naturais são só alguns impactos que podem resultar na diminuição da diversidade de hábitats e perda da biodiversidade. Várias iniciativas têm sido tomadas em nível nacional e internacional para diminuir os impactos sobre a biodiversidade (EZEBILO, 2012). Uma dessas iniciativas é o estabelecimento de áreas legalmente protegidas (PRIMACK; RODRIGUES, 2001). A criação das áreas protegidas é aplicada em todo o mundo para proteger e gerenciar valiosas paisagens culturais e a biodiversidade (PRIMACK; RODRIGUES, 2001; OHNESORGE et al., 2013).

No Brasil, as áreas protegidas, denominadas de Unidades de Conservação (UC's), foram definidas pela Lei 9.985 em 18 de julho de 2000, que instituiu o Sistema Nacional de Unidades de Conservação (SNUC), como sendo: "*espaço territorial e seus recursos ambientais, incluindo as águas jurisdicionais, com características naturais relevantes, legalmente instituído pelo poder público, com objetivos de conservação e limites definidos, sob regime especial de administração, ao qual se aplicam garantias adequadas de proteção*" (SNUC, 2000). O SNUC divide as UC´s em duas categorias: unidades de proteção integral e unidades de uso sustentável. As UC´s de proteção integral objetivam "*preservar a natureza, sendo admitido apenas o uso indireto de seus recursos naturais*" (art.7°, SNUC), ou seja, "*aquele que não envolve consumo, coleta, dano ou destruição dos recursos naturais*" (art. 2°, IX SNUC). Por outro lado, as UC´s de uso sustentável objetivam "*compatibilizar a conservação da natureza com o uso sustentável de parcela dos seus recursos*" (art. 7°, SNUC), ou seja, "*através do uso direto, comercial ou não, dos recursos naturais, garantindo a perenidade dos mesmos e dos processos ecológicos, de modo socialmente justo e economicamente viável*" (art 2°, XI SNUC).

Os Parques Nacionais são a mais popular e antiga categoria de área protegida no Brasil. Segundo a legislação brasileira, esta categoria de proteção integral deve "*preservar ecossistemas de grande relevância ecológica e beleza cênica, possibilitando a realização de pesquisas científicas, realização de atividades educacionais e de interpretação ambiental, recreação e turismo ecológico, por meio do contato com a natureza*", mas fica proibida a ocupação humana dentro dessa área, havendo desapropriações dessas comunidades (Art. 11 SNUC, 2000). Entretanto, muitas áreas protegidas são implementadas em meio a uma matriz urbanizada diminuindo assim a eficácia de proteção da biodiversidade (NEWMARK et al., 1996;

WOODROFFE; GINSBERG, 1998). Além de muitas vezes as UC´s serem mal protegidas (MILLER et al., 2001), dentro dos limites definidos para proteção apenas uma parte do ecossistema ou dos processos ecológicos são preservados (POWELL et al., 2000; RODRIGUES et al.; 2004; SAUNDERS et al., 2002).

Alguns estudos sobre essas áreas protegidas restringem-se, muitas vezes, a fauna e flora terrestres. Os ecossistemas aquáticos protegidos raramente são comumente protegidos apenas incidentalmente, como consequência de sua inclusão dentro das reservas terrestres (LAKE, 1980; SKELTON et al., 1995). Os peixes de água doce estão entre as espécies mais ameaçadas devido à perda e degradação do habitat (ABELL et al., 2009). Dados insuficientes e carência de conhecimento das espécies das áreas protegidas criam dificuldades a definição de estratégias efetivas de conservação (RODRÍGUEZ-OLARTE, 2011). A avaliação do número de espécies preservadas, incluindo as ameaçadas, raras e endêmicas, bem como a estrutura da comunidade de peixes (diversidade e presença de espécies exóticas) nas unidades de conservação pode ser uma ferramenta eficaz no embasamento do manejo efetivo da proteção da diversidade aquática.

A destruição de habitat é a principal causa de extinção de peixes de água doce atualmente. Os ecossistemas aquáticos, me geral, estão sujeitos à degradação física, perturbação da mata ciliar, poluição da água, invasão de espécies exóticas e alteração de regimes hidrológicos (MOYLE; RANDALL, 1998; PIRANI et al., 2003; OLIVA; MAGRO, 2004; DEFRIES et al., 2005; MADEIRA, 2009; LAPOINTE et al., 2012). Estudos ecológicos sobre as modificações ambientais antrópicas são uma maneira eficiente em diagnosticar, prever e remediar alterações em habitat naturais (FLORES-LOPES et al., 2010). A compreensão da magnitude de uma perturbação depende diretamente do conhecimento das condições ambientais originais do local afetado ou das condições factuais ou extrapoladas de um ecossistema similar prístino ou minimamente alterado (COLLIER et al., 2013). Uma vez determinadas as condições naturais do habitat, os locais de interesse serão considerados impactados à medida que suas características ambientais diferirem das condições de referência. Dessa forma, para o manejo, a recuperação e a restauração do habitat aquático, o conhecimento da estrutura e condição natural preservada é de extrema importância em estudos comparativos de reconhecimento e avaliação do nível dos impactos.

Outro esforço considerável para evitar a perda de espécies e garantir a efetividade das UC´s é a conciliação entre a presença humana e a conservação da biodiversidade. A conservação não deve ser limitada ao interior das áreas protegidas, uma vez em que essas estão inseridas numa paisagem alterada que exerce grande influência. Portanto, uma nova perspectiva para melhorar a conservação do habitat é entender a relação entre a natureza e o ser humano. Essa visão é especialmente relevante para o ambiente aquático devido à complexa conectividade entre as ações humanas e as áreas desprotegidas, bem como áreas protegidas adjacentes nas quais os diferentes usos da terra determinam a integridade do ecossistema (PERFECTO; VANDERMEER, 1997; MCNEELY; SCHERR, 2003) e podem alterar a estrutura da comunidade aquática, inclusive em (ANGERMEIER; KARR, 1994; SILVA et al., 2007; BELTRÃO et al., 2009; DE CARVAHO et al., 2010). Práticas de degradação que ocorrem fora dos limites das unidades de conservação podem ter consequências negativas para os ecossistemas de água doce dentro das mesmas (SAUNDERS et al., 2002). Logo, a percepção do homem sobre o meio ambiente, as oportunidades, os múltiplos serviços e os benefícios das áreas protegidas é fundamental na formação dessa rede de proteção. Portanto, a preocupação com visões e ambições humanas é crucial para reduzir confrontos presentes e futuros entre expansões humanas e habitats naturais (WILKIE et al., 2008).

Assim, inventariar a ictiofauna, quantificar a diversidade, determinar as condições naturais do habitat e conhecer o pensamento e as atitudes de conservação do homem em relação ao meio ambiente são efetivas ferramentas no planejamento da proteção local, especialmente em áreas de hotspot da biodiversidade como o Cerrado. Dessa forma, a presente tese é parte do projeto intitulado "*O papel dos parques nacionais na conservação de peixes de riachos da bacia do São Francisco em Minas Gerais: definindo estratégias para conservação da ictiofauna*" que contou com financiamento da Fundação Grupo Boticário de Proteção à Natureza.

Com esse projeto além da tese, duas monografias e uma dissertação foram produzidos como manuscritos científicos. Através das monografias, onde o foco foi na Ecologia básica, foi possível (1) Avaliar espécies de peixes que possuem potenciais de bioindicação auxiliando na avaliação da qualidade e no grau de perturbação dos ambientes aquáticos (Júlia Ribeiro/ *Potencial bioindicador de duas espécies de peixes no Parque Nacional da Serra do Cipó-MG*); (2) Estudar a dieta de uma espécie de peixe como ferramenta para auxiliar na caracterização ambiental do estado de preservação dos cursos d 'água (Patrícia Fráguas/ *A influência do habitat físico na alimentação de uma espécie de peixe generalista em riachos neotropicais*); (3) Compreender os fatores do habitat físico que são responsáveis por determinar a comunidade em riachos não protegidos (Lídia Wouters/ em execução).

Já através da dissertação foi possível avaliar a variação natural do habitat físico de riachos protegidos, determinando as características físicas naturais do habitat que permitem a identificação de áreas com necessidade de recuperação ou com potencial para preservação. Além de entender a relação entre a variação natural do habitat físico e a composição das assembleias de peixe entre riachos protegidos (Yuri Caldeira/ *Riachos em condição de referência em uma bacia* *neotropical: variação natural do habitat físico e sua influência sobre a estruturação da Ictiofauna*).

Nesse contexto, o principal objetivo da presente tese foi compreender o papel dos Parques Nacionais na proteção da fauna de peixes da bacia do São Francisco e desenvolver estratégias de conservação e manejo de riachos da savana brasileira baseadas em dados físicos e sociais. Os resultados indicaram que a criação ou a ampliação dos Parques Nacionais são excelentes estratégias para proteger a biodiversidade de peixes (Manuscrito 1). Entretanto, ao considerar a ampliação das áreas protegidas é preciso evitar impactos sociais na população do entorno, e uma ferramenta é investir em educação, já que o conhecimento é traduzido em atitudes favoráveis aos Parques Nacionais e ao ambiente, especialmente o aquático (Manuscrito 2). Assim, com a coexistência entre preservação ambiental e o homem é crucial entender quais características físicas dos riachos estruturam a comunidade de peixes e são influenciadas pelo conhecimento e atitude do homem (Manuscrito 3) para assim buscar o o manejo eficiente para conservação dos riachos do entorno e das áreas protegidas.

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SECOND PART- MANUSCRIPTS

MANUSCRIPT 1

CREATION OR ENLARGEMENT OF NATIONAL PARKS? THE BEST STRATEGY FOR NEOTROPICAL ICHTHYOFAUNA PROTECTION

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Submitted to *Perspectives in Ecology and Conservation*

(normas do periódico - versão preliminar)

ABSTRACT

Evaluating the stream fish fauna within protected areas is an important information for neotropical ichthyofauna protection. The role of National Parks in preserving biodiversity is a gap of study when considering aquatic environments, given their inadequate coverage in protecting the freshwater biodiversity. Understanding the best strategy to protect freshwater ecosystems is essential to the maintenance of fish biodiversity, especially at hotspot biomes. Our study addresses the discussion on the enlargement of existing National Parks or the creation of new ones. We focused on freshwater streams of a Neotropical Savanna river basin. Our objective was to assess the list of stream ichthyofauna species and to discuss if the enlargement of the existing parks or the establishment of new ones would potentially preserve additional species based on fish diversity patterns. We selected 31 streams within park boundaries and 29 within Buffer Zones. Our study found that at least 24% of the total species richness of the basin occur inside National Parks and that number increased to 32% when the Buffer Zones is included. Our findings highlight that the creation or enlargement of National Parks are both good strategies for Neotropical Ichthyofauna protection, although the last one would protect more additional species.

Keywords: Protected areas; Freshwater streams; Neotropical Savanna river basin; Buffer Zone; Fish diversity

Short Title: Strategies for Ichthyofauna protection

1. INTRODUCTION

The establishment and expansion of protected areas are important tools for biodiversity conservation (Adams et al., 2015; Liu et al., 2010; Margules et al., 2002; Primack and Rodrigues, 2001). In Brazil, among the various types of protected areas, National Parks have been highlighted as an important and popular category of preservation because of their strategy of integrating ecologic tourism and total protection (SNUC, 2000). The aim of National Parks includes preserving biological diversity focusing on maintaining native and intact habitats. However, despite their importance for conservation and for being considered the best-preserved natural areas in Brazil, some National Parks are mosaics of habitats, fragmented, isolated, or poorly protected (Miller et al., 2001; Rodrigues et al., 2018). Moreover, some National Parks fail to adequately represent the intended ecosystems (Powell et al., 2000; Rodrigues et al., 2004) and also exclude relevant species due to the lack of complete biogeographic records (Rodríguez-Olarte et al., 2011).

The lack of information on the role of protected areas in preserving biodiversity is more evident when considering aquatic environments. Freshwater habitats are usually incidentally protected within terrestrial reserves, rather than the focus of protection (Lake, 1980; Skelton et al., 1995; Suski and Cooke, 2007; Thieme et al., 2016). Studies have shown that many protected areas do not provide adequate coverage to conserve aquatic ecosystems or guarantee the maintenance of freshwater biodiversity (Barletta et al., 2010; Herbert et al., 2010; Hermoso et al., 2016; Pompeu et al., 2009) because their limits include only fragments of watersheds (Azevedo Santos et al., *in press;* Rodríguez-Olarte et al., 2011;). In addition, many protected areas in South America often include only headwater streams, which are characterized by low species diversity, and high endemism due to high environmental variability (de Aquino and Colli, 2016; Jackson et al., 2001; Lima et al., 2005; Pompeu, 2012; Schlosser, 1990).

Since impacts on the surrounding areas can influence protected lands (Adams et al., 2015; Saunders et al., 2002), some National Parks include around their limits a buffer zone. However, even designating zones of different protection levels and intensity of land use is far from protecting National Parks effectively. Fluvial networks are strongly dependent on connectivity to their ecological integrity (McCluney et al., 2014). Local disturbances may propagate along the watercourses, including water pollution, species invasion and alteration of hydrological regimes (Abell et al., 2009; Madeira, 2009; Moyle and Randall, 1998; Pirani et al., 2003). Therefore, the effectiveness of protected areas depends on the management of the area surrounding the National Park (Ezebilo, 2012), which has been suggested as a key tool for protecting the local biodiversity (Hansen and DeFries, 2007; Moyle and Yoshiyama, 1994).

Although fishes are among the most endangered group as a result of habitat loss and degradation (Abell et al., 2009), few terrestrial protected areas have been created specifically for ichthyofauna conservation or have enough coverage to protect freshwater watersheds (Adams et al., 2015; Barletta et al., 2010; Saunders et al., 2002). Brazil has the richest freshwater ichthyofauna in the world (Nogueira et al., 2010), but its conservation status is not satisfactory, especially in hotspot biomes where a large diversity of freshwater fishes occurs. The quantification and identification of fish diversity within conservation unit limits is important and necessary to determine the representativeness of protected areas for freshwater biodiversity (Rodríguez-Olarte et al., 2011), but even the basic data of species occurrence remain unknown for most drainage systems (Casarim et al., 2012).

Since evaluating the stream fish fauna within protected areas is an important information for neotropical ichthyofauna protection, our study addresses such research gap by assessing five National Parks and their buffer zones in a tropical biodiversity hotspot (Brazilian savanna). We use our findings to discuss whether the enlargement of existing parks or the establishment of new ones would potentially preserve more additional species based on the evaluation of fish diversity patterns.

2. MATERIAL AND METHODS

2.1 Study areas

We developed our study in five National Parks (NPs) in central Brazil, along the São Francisco River basin, in Minas Gerais state, and their Buffer Zones (Figure 1). In Brazil, protected areas are classified into two groups: integral protection and sustainable use (SNUC, 2000). Within the Integral protection group, ‘National Park’ (NP) is legally one of the strongest categories, because resource extraction and human habitation is prohibited within park boundaries, although tourism and research activities are allowed (Category II- IUCN, 1994). The São Francisco River basin is the third largest drainage in Brazil (Godinho and Godinho, 2003), and includes five National Parks in Minas Gerais state, which were sampled in this study: Serra da Canastra, Serra do Cipó, Sempre-Vivas, Grande Sertão Veredas and Cavernas do Peruaçu (Figure. 1).

The predominant biome in the studied parks is the Brazilian savanna (*cerrado* and *caatinga* domains). The biome covers a surface area of approximately 34% of the Brazilian territory (Franca-Rocha et al., 2007; Sano et al., 2008). Current conservation status and trends in the Brazilian c*aatinga* and *cerrado* ecosystems are extremely concerning. The domain *caatinga* is present only in the Cavernas do Peruaçu NP and is a mosaic of thorny scrub and seasonally dry forest where numerous species are endemic (Castelletti et al., 2003; Leal et al., 2005). However, in recent decades, rapid agricultural expansion threatens these vegetations (Castelletti et al., 2003; Strassburg et al., 2017), and only 3% of the *cerrado* and 0.8% of the *caatinga* are legally preserved in strictly protected areas (Françoso et al., 2015; Myers et al., 2000). The Brazilian savanna is a global biodiversity hotspot, and is ranked among the 25 most important terrestrial habitats due to its high number of endemic species, many of which are highly threatened through human activities (Myers et al., 2000; Silva and Bates, 2002). The São Francisco River basin has its drainage in both vegetation domains and supports more than 200 described fish species (Alves et al., 2011). The *cerrado* has a mean annual rainfall of 1500 mm (EMBRAPA, 2012), while the mean rainfall in the *caatinga* is usually less than 700 mm/year (Silva et al., 2017). At higher elevations of *cerrado* and *caatinga*, *campos rupestres* are one of the physiognomies found (Nunes et al., 2012; Vasconcelos, 2011). *Campos rupestres* are fragile environments with low or no resilience after disturbances (Le Stradic et al., 2014a; Le Stradic et al., 2014b), and are found in Serra da Canastra, Serra do Cipó and Sempre Vivas National Parks. Furthermore, another typical vegetation, locally known as *veredas*, often surrounds the small rivers and streams (Silva and Bates, 2002) in some regions of *cerrado*, covering a large area of the Grande Sertão Veredas NP. Among the studied parks, three of them included the protection of aquatic environments as one of the main arguments for their creation (ICMBIO, 2018). The Serra da Canastra NP was created to protect the historic spring waters of the São Francisco River, the Grande Sertão Veredas NP to conserve an important area of *veredas*, and the Serra do Cipó NP to protect the headwaters of the Cipó River (ICMBIO, 2018). Among the parks studied, only the Serra da Canastra and Serra do Cipó have Buffer Zones under land use regulation, with strict rules aiming to reduce and mitigate human impacts (MMA/IBAMA 2005, MMA/ICMBio 2009).

2.2 Data Sampling

We evaluated areas within and outside of each five National Parks (NP) covering the São Francisco River basin. On ArcGIS software (version 10.1), we defined a Buffer Zone (BZ) as a 10-km-wide circle drawn around each National Park boundary (Figure 1). The identification of possible sampling stream was obtained from census-tract data from the 2010 Brazilian national demographic census (IBGE 2010) and Google Earth. A maximum of 10 streams per NP and per BZ were sampled with a hypothetical maximum sample of 20 sampling per region (10NP + 10BZ). We selected second or third order streams (Strahler, 1957) with headwaters within NP's boundaries (N = 31) and within BZ's (N = 29). Fish sampling took place during the dry season, which is considered the best period for stream characterization (Kaufmann et al., 1999). However, the number of streams was reduced because of the severe droughts that took place in 2014 and 2015. Therefore, we further selected streams based on the presence of water and our capacity to access them. The dry season in this region is from April to October, with lowest rainfall in August. From September to October 2014, we sampled seven streams both inside and outside of the Serra do Cipó NP, and nine streams both inside and outside of the Serra da Canastra NP. In April 2015, we sampled eight streams inside and seven outside of the Grande Sertão Veredas NP; and six and seven streams within and outside Buffer Zone of the Sempre-Vivas NP, respectively. We sampled one stream in the Cavernas do Peruaçu NP. However, one point in Peruaçu river was also assessed within protected area because of the scarcity of streams. The elevation of the samples streams was variable between the BZ and NP (Table 1).

To sample fish communities, a 150 m long section of each stream was delimited in each study site. Sections were then subdivided into 10 cross-sections of 15 m. Fish collections were performed in a downstream-upstream direction with hand nets (80 cm in diameter, 1 mm stretched mesh size). Two hand nets were used for sampling, and time of collection was standardized (12 minutes per cross-section, 120 minutes for each stream). We only used hand nets because they are efficient in lower-order streams. The sampling effort was the same on all streams. We sacrificed all sampled fishes in anesthetic Eugenol solution and fixed them in 10% formalin. In the laboratory, we transferred fishes to 70% ethanol, identified them to the species level, and counted, to assess the fish assemblages of streams. Voucher specimens for each protected area were deposited at UFLA (Universidade Federal de Lavras) and PUC-MG (Pontifícia Universidade Católica de Minas Gerais) fish collections in Brazil.

2.3 Data analysis

A Venn diagram analysis was used to represent the number of shared and exclusive species among NP’s. The ordination was prepared in RStudio Desktop version 1.0.136 (RStudio Team, 2016) using the VennDiagram package and the figure using the layout from http://venndiagram.res.oicr.on.ca/. The Cavernas do Peruaçu NP had only one stream sampled therefore, this NP was considered only in Venn analysis.

We created species accumulation curves to assess the representativeness of our sampling design. The sample-based curves illustrated each region separately and all regions together.

We assessed species diversity through different spatial scales. We calculated the partition multiplicative of diversity per National Park and their Buffer Zone. In addition, we evaluated fish diversity considering only National Parks and considering the Buffer Zones as well (National

Park + Buffer Zone, herein ‘region’). For both the National Park and the respective Buffer Zone we used alpha (α) diversity as local richness, and the gamma diversity (γ) as total number of species. When considering all four National Parks or the four regions together, we used alpha (α) as local richness, gamma (γ) as total number of species per National Park or per region, and gamma2 (γ2) as the total number of species in all four National Parks or in all four regions. We calculated beta diversity ($\beta = \gamma/\alpha$) as as a measure of heterogeneity in species composition among streams of each National Park or Buffer Zone (β), and among all National Parks or among all regions (β2) (Chao et al., 2012; Jost, 2007; Legendre and Cáceres, 2013).

Differences in mean and total species richness between parks and regions were used to estimate the potential additional species preserved if National Parks had their limits expanded. Moreover, the extrapolation of the accumulation curves (rarefaction) of species richness considering each park as sampling unit, and considering the respective Buffer Zones as well, were performed to evaluate the potential impact of the creation of a new park. The simulations were performed using the EstimateS software (Colwell, 2004).

3. RESULTS

A total of 17.053 fish specimens were collected belonging to 64 species and 15 families (Table 1). Inside the National Parks (NPs), 4.459 fish specimens were collected belonging to 49 species, and in the Buffer Zones 12.594 individuals of 49 species were sampled. Grande Sertão Veredas was the richest region with 42 species, 35 species within and 25 outside the park, respectively (Table 1). No endangered species were registered, and the guppy (*Poecilia reticulata*) was the only exotic species found in this study. This species was captured in the Buffer Zones of Serra da Canastra NP and Sempre Vivas NP, and inside the Cavernas do Peruaçu NP.

The region (NP +BZ) of the Serra da Canastra, Serra do Cipó, Cavernas do Peruaçu, Grande Sertão Veredas and Sempre Vivas presented 8, 6, 1, 15 and 1 exclusive species, respectively (Figure 2A). When considering only the streams located inside parks, Serra da Canastra NP, Serra do Cipó NP, Cavernas do Peruaçu NP, Grande Sertão Veredas NP and Sempre Vivas NP showed 3, 5, 3, 22 and 1 exclusive species, respectively (Figure 2B). Four species were shared among all the regions: *Hypostomus lima, Astyanax rivularis, Rhamdia* aff *quelen* and *Trichomycterus brasiliensis* (Figure 2A, Table 1). *Astyanax rivularis* was the only species captured inside of all parks (Figure 2B, Table 1).

Although 60 streams had been sampled, the collector’s curve did not stabilize, when either considering all samples together or each park separately (Figure 3). Accumulation curves indicated that, with exception of the Grande Sertão Veredas NP, more species are expected to be found in the Buffer Zones than inside the parks.

When considering only streams located within NP, it is possible to observe that most of the diversity is related to differences among species composition of National Parks. When the BZ are taken into account, the mean species richness found per stream (α= 5,7), the beta diversity among streams (β= 5,1), and mean species richness found per region (γ=28,7) were higher, while the beta diversity among regions (β_2= 2,2) was reduced when compared to among National Parks (β_2= 3,3) (Figure 4).

The creation of another National Park in the basin would potentially protect 9.1 additional species (Figure 5). Considering also the respective Buffer Zone, 6.2 more species are expected to be protected (Figure 5). However, if the limits of the studied parks were expanded to encompass their Buffer Zones instead of creating a new park, on average 13.7 additional species would be protected inside each park, and 15 species would be added to the protected pool (Figure 4A).

4. DISCUSSION

Richness and distribution of freshwater fishes are important metrics to evaluate the effectiveness of areas with special interest for the conservation of biodiversity (Rodríguez-Olarte et al., 2011). Although many of the National Parks studied are located in regions of the mountain range, and their drainage may be protected only incidentally as part of their inclusion within terrestrial areas, we found that at least 24% of the total species of the São Francisco River basin may be found inside their limits. When the Buffer Zones were taken into account, 32% of the fish fauna is protected, considering the total ichthyofauna of the São Francisco basin, which includes species from rivers, floodplains and streams (Alves et al., 2011). Thus, our study highlights the importance of National Parks for the protection of stream fish fauna in the São Francisco basin.

In this study, the richness and beta diversity of streams located outside the National Parks were often higher than streams inside. The areas surrounding the reserves may contain distinct and heterogeneous habitats not included in protected areas (Hansen and Defries, 2007). Protected areas are often characterized by headwater streams which are located at high elevations, and present steep slopes, low temperature and rocky bottoms (Casatti and Castro 2006; Pressey et al., 1996; Scott et al., 2001). The larger species diversity of streams is often located at lower elevations, which in this study comprised the regions in the Buffer Zones of the National Parks and within Grande Sertao Veredas NP, where the habitat variability (both in volume and complexity), and relative stability of environmental variables are higher than in higher elevations (Pompeu et al., 2009; Schlosser, 1990; Scott et al., 2001). Therefore, conservation efforts should also focus on the Buffer Zones in order to protect greater habitat diversity and conserve more species. Additionally, negative effects may exceed the boundaries of reserves where the land uses of surrounding areas are not restricted (Hansen and Defries, 2007; Jones et al., 2009; Saunders et al., 2002).

The high level of connectivity and the easy propagation of impacts from Buffer Zones to National Parks make freshwater a complex system for effective conservation using protected areas (Adams et al., 2015), because they are susceptible to indirect degradation effects in surrounding regions (Ferreira et al., 2014). The exotic species *Poecilia reticulata* was reported within one park and in the Buffer Zone of another two, and its presence is an important indicator of habitat degradation (de Carvalho et al., 2017). However, the efficiency of National Parks in preserving a representative portion of fauna is not related only to the level of conservation in the surrounding areas, but also to the regional relevance of the locations of the reserves, and their irreplaceability (Le Saout et al., 2013). The diversification in species composition among National Parks was higher when compared to among Buffer Zones. The diversity could be considered a proxy of such spatial variation, and shows the importance of the biogeography as a tool to select areas for biodiversity conservation (Bridgewater et al., 2004; Whittaker et al., 2005). Regional aspects like geology, geomorphology and climate are important factors driving the fish species distribution (Heino et al., 2015). The geomorphological variation of Brazilian savanna along with its different physiognomies and habitat structures are probably related to the distribution of species and the uniqueness of each National Park studied (Silva and Bates, 2002), since complex spatial patterns of species distributions have been described for the *cerrado* (Caldeira, 2016; Cole 1986, Diniz-Filho, 2009).

Our study indicates that the enlargement of a National Park would result in a greater increase on the number of potential protected species, considering either the new park alone or together with its Buffer Zone. Although the enlargement of National Parks improves the number of fish species protected locally, such strategy has been considered a more challenging legal option. A total of 28 National Parks have been established in Brazil since 2000, compared to only four enlargements (ICMBIO, 2017). Brazil was responsible for 74% of the reserves created on the planet between 2003 and 2008, and it is also signatory of an agreement to increase in 17% the areas conserved for each biome by 2020 (Jenkins and Joppa, 2009; MMA, 2013). Unfortunately, several laws have been proposed and implemented in the opposite direction of expansion (Ferreira et al., 2014; Scarano, 2012). In addition, changing the boundaries of an established National Park is potentially more challenging because of the need to remove local residents and end resource extraction activities (Allendorf et al., 2007; Ezebilo, 2012; Ite, 1996; Mackenzie et al., 2014).

The creation or enlargement of National Parks are both good strategies for Neotropical Ichthyofauna protection, although the last one would protect more additional species. Buffer Zones presented a greater diversity of fish that complement the pool of protected species. Their proper management itself would represent a cheaper strategy to increase protection on the tropical savanna fish biodiversity, especially in developing countries such as Brazil, with scarce financial resource available for management, monitoring and enforcement of protected areas. Such strategy would avoid land expropriation and strict use restrictions, that could cause unacceptable levels of social impact (Azevedo-Santos *et.al., in press*), but requires cooperation with people who live around National Parks as part of the conservation effort.

5. ACKNOWLEDGEMENTS

We thank the Fundação Grupo Boticário de Proteção à Natureza for financial support. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001. Thanks also to the team of Laboratory of Fish Ecology (UFLA); guides Pedrão and Albergues and the managers of ICMBio and Funatura: Carla Polaz, Simone Nunes, Márcio Lucca, Laura V. França, Luiz Sérgio F. Martins, Ernane Faria, Celso L. Paiva, Rogério O. Souza, Fernando A. T. Tiziane and Rafael Pereira for providing logistical support. We also thank Francisco Langeani, Thiago C. Pessali, Gilberto Salvador and Sérgio Lima for helping to identify the species.

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Table 1 Fish species and number of individuals sampled in National Parks (NP) and Buffer Zones (BZ) on São Francisco River basin in Minas Gerais state, Brazil. (*exotic species). The elevation of streams located at the BZ ranged from 567 to 655 m (Sempre Vivas), 703 to 806 m (Sertão Veredas), 745 to 1100 m (Serra do Cipó), 753 to 949 m (Serra da Canastra). However, within the park limits, the streams were located in mountainous regions with elevations ranging from 665 to 1244 m (Sempre Vivas NP), 787 to 815 m (Serra do Cipó NP), 970 to 1364 m (Serra da Canastra NP), except for Sertão Veredas NP, in which the variation was from 729 to 788 m.

TÁXON	LOCATION									
	Serra do Cipó		Serra da Canastra		Sempre Vivas		Grande Sertão Veredas		Cavernas do Peruaçu
	NP	BZ	NP	BZ	NP	BZ	NP	BZ	
CHARACIFORMES									
Anostomidae									
Leporinus piau Fowler, 1941							1		
Characidae									
Astyanax cf. *bockmanni* Vari & Castro, 2007		5				2	4		
Astyanax fasciatus (Cuvier, 1819)	6		2	10			4	3	75
Astyanax lacustris (Lütken, 1875)		1		11		25	7	8	
Astyanax rivularis (Lütken, 1875)	693	885	1550	398	675	676	67	1046	204
Astyanax sp.	26	5		1					
Bryconops sp.							15		
Bryconamericus stramineus (Eigenmann, 1908)		26						18	
Hasemania nana (Lütken, 1875)								23	
Hemigrammus marginatus Ellis, 1911							7	63	
Knodus moenkhausii (Eigenmann & Kennedy, 1903)	4					115			
Lepidocharax burnsi Ferreira, Menezes & Quagio-Grassiotto, 2011		16				11	1		
Moenkhausia sanctaefilomenae (Steindachner, 1907)						1	9		
Hysteronotus megalostomus Eigenmann, 1911									16
Piabina argentea Reinhardt, 1867	2	5		4			15	24	1
Phenacogaster franciscoensis Eigenmann, 1911							33		
Serrapinnus heterodon (Eigenmann, 1915)						4	19	151	
Serrapinnus piaba (Lütken, 1875)							14		
Crenuchidae									
Characidium fasciatum Reinhardt, 1866					5		4	18	1
Characidium sp.	1								
Characidium cf. *zebra* Eigenmann, 1909				2	1	7	41	39	
Erythrinidae									
Hoplias intermedius (Günther, 1864)					3	10		3	
Hoplias malabaricus (Bloch, 1794)				5					
Parodontidae									
Parodon hilarii Reinhardt, 1866		1				4			1
CYPRINODONTIFORMES									
Poeciliidae									
Phalloceros uai Lucinda, 2008	275	753		7549					
Poecilia reticulate * Peters, 1859				2		6			3
GYMNOTIFORMES									
Gymnotidae									
Gymnotus carapo Linnaeus, 1758						3	4	1	
Sternopygidae									
Eigenmannia gr. *trilineata* *(Reinhardt, 1852)*		5				16	16	12	
Sternopygus macrurus (Bloch & Schneider, 1801)						2	3		
PERCIFORMES									
Cichlidae									
Geophagus brasiliensis (Quoy & Gaimard, 1824)		19		8			1		
Crenicichla lepidota Heckel, 1840		3							

Cichlasoma sanctifranciscense Kullander, 1983							1		
SILURIFORMES									
Auchenipteridae									
Centromochlus bockmanni (Sarmento-Soares & Buckup, 2005)							2		
Callichthyidae									
Corydoras garbei Ihering, 1911							2		
Callichthys callichthys (Linnaeus, 1758)		1							
Corydoras multimaculatus Steindachner, 1907				2					
Heptapteridae									
Cetopsorhamdia iheringi Schubart & Gomes, 1959	3	17		2			10	5	1
Imparfinis borodini Mees and Cala, 1989		2							
Imparfinis minutus (Lütken, 1874)		22					3	34	10
Phenacorhamdia tenebrosa (Schubart, 1964)							4		1
Pimelodella lateristriga Lichtenstein, 1823							3	4	
Rhamdia aff. *quelen* (Quoy & Gaimard, 1824)		6		11		8	7	8	22
Rhamdiopsis cf. *microcephala* (Lütken, 1874)				4					
Loricariidae									
Hypostomus francisci (Lütken, 1874)						2	3		2
Hypostomus lima (Lütken, 1874)		10		10	8	12	21	5	29
Hypostomus cf. *garmani* (Regan, 1904)				2					
Hypostomus cf. *macrops* (Eigenmann & Eigenmann, 1888)							1		
Hypostomus cf. *paulinus* (Ihering, 1905)				1				1	
Hypostomus sp.							5		
Harttia sp.				2					
Harttia leiopleura Oyakawa, 1993								1	
Harttia longipinna Langeani, Oyakawa & Montoya-Burgos, 2001	4								
Harttia torrenticola Oyakawa, 1993	1		44	11					
Neoplecostomus sp.n Langeani, 1990			11			1			
Hisonotus sp.		2	12	39			176	2	4
Rineloricaria sp.		2					2		
Pareiorhina cepta Bockmann & Ribeiro, 2003			7	1				3	
Pareiorhina rosai Silva, Roxo & Oyaka, 2016			1						
Parotocinclus robustus Lehmann A.& Reis, 2012						1			
Trichomycteridae									
***Trichomycterus brasiliensis* Lütken, 1874**	***1***	***61***	***192***	***186***	***2***	17		1	22
***Trichomycterus variegatus* Costa, 1992**		***40***	***29***	***44***			1	2	
SYNBRANCHIFORMES									
Synbranchidae									
Synbranchus marmoratus Bloch, 1795							3	1	
TOTAL 17053	1016	1890	1848	8305	694	922	509	1477	392

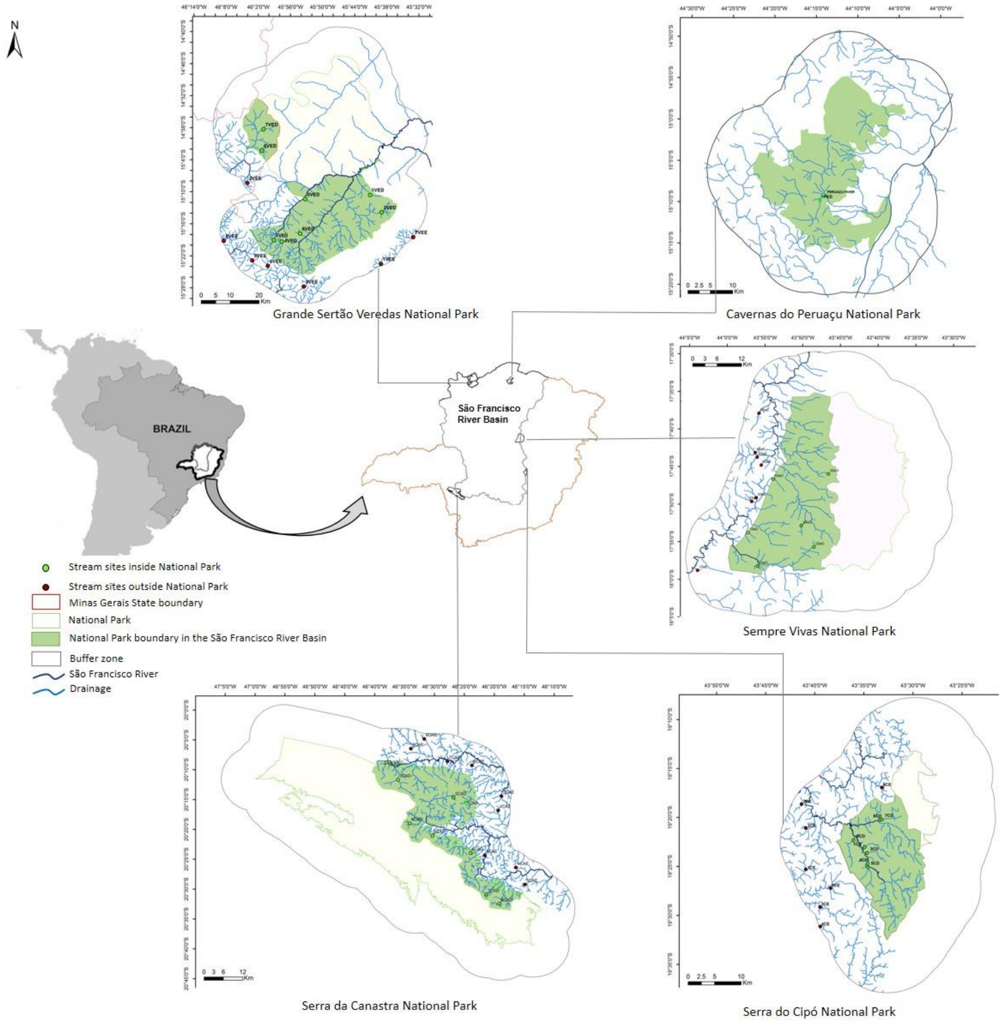

Figure 1 Study area in Neotropical savanna river basin in Minas Gerais state, Brazil. Sample stream sites are located inside National Parks and within the Buffer Zone of each National Park

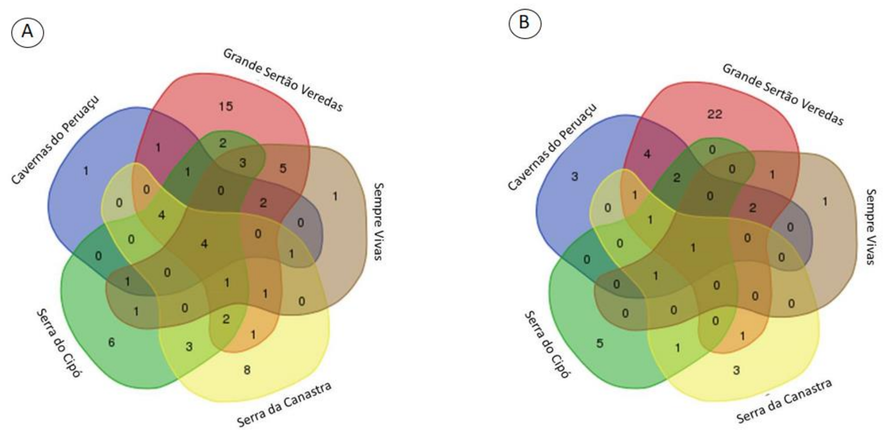

Figure 2 Number of shared and exclusive species by studied region (A), number of species shared and exclusive in each National Park boundary and their Buffer Zones (B).

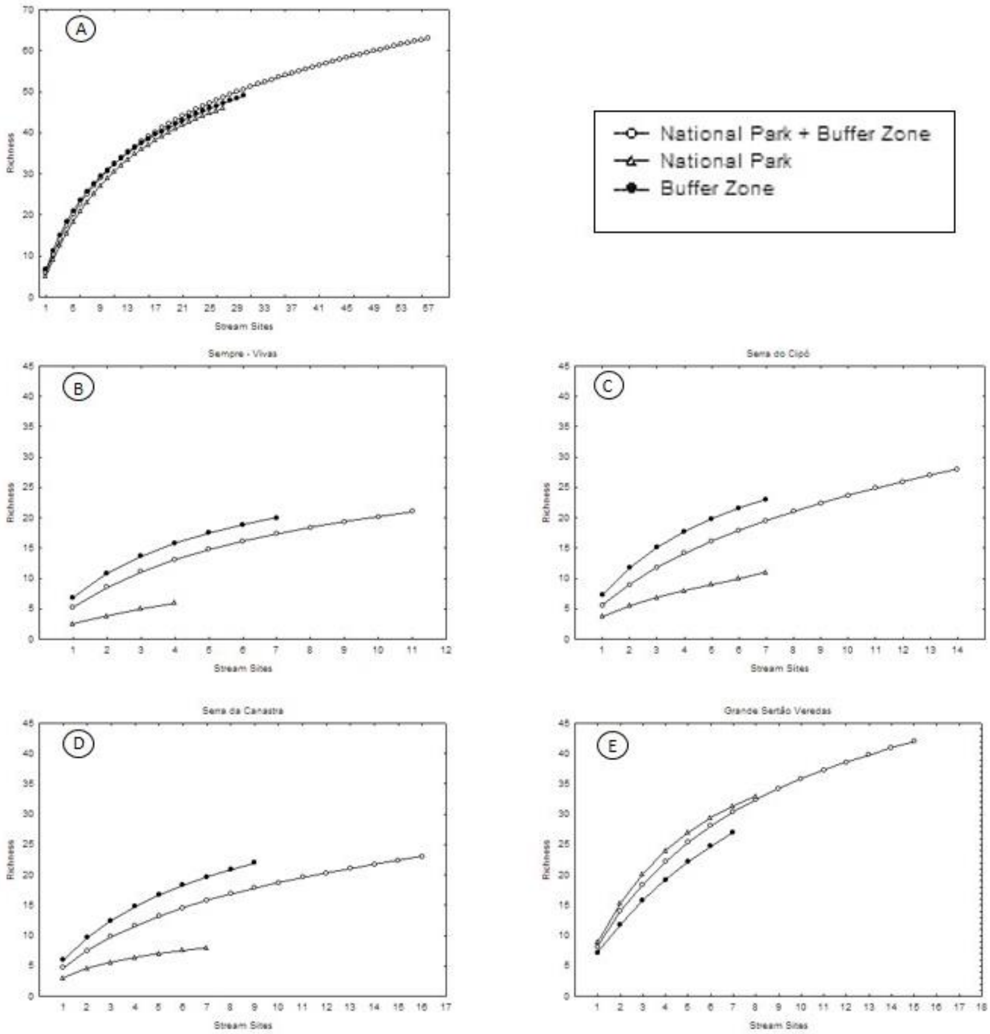

Figure 3 Fish species accumulation curves estimated from samples streams. The curves represent extrapolation to National Park plus Buffer Zone, only National Park and only Buffer Zone in all studied area (A), and in Sempre Vivas (B), Serra do Cipó (C), Serra da Canastra (D) and Grande Sertão Veredas (E).

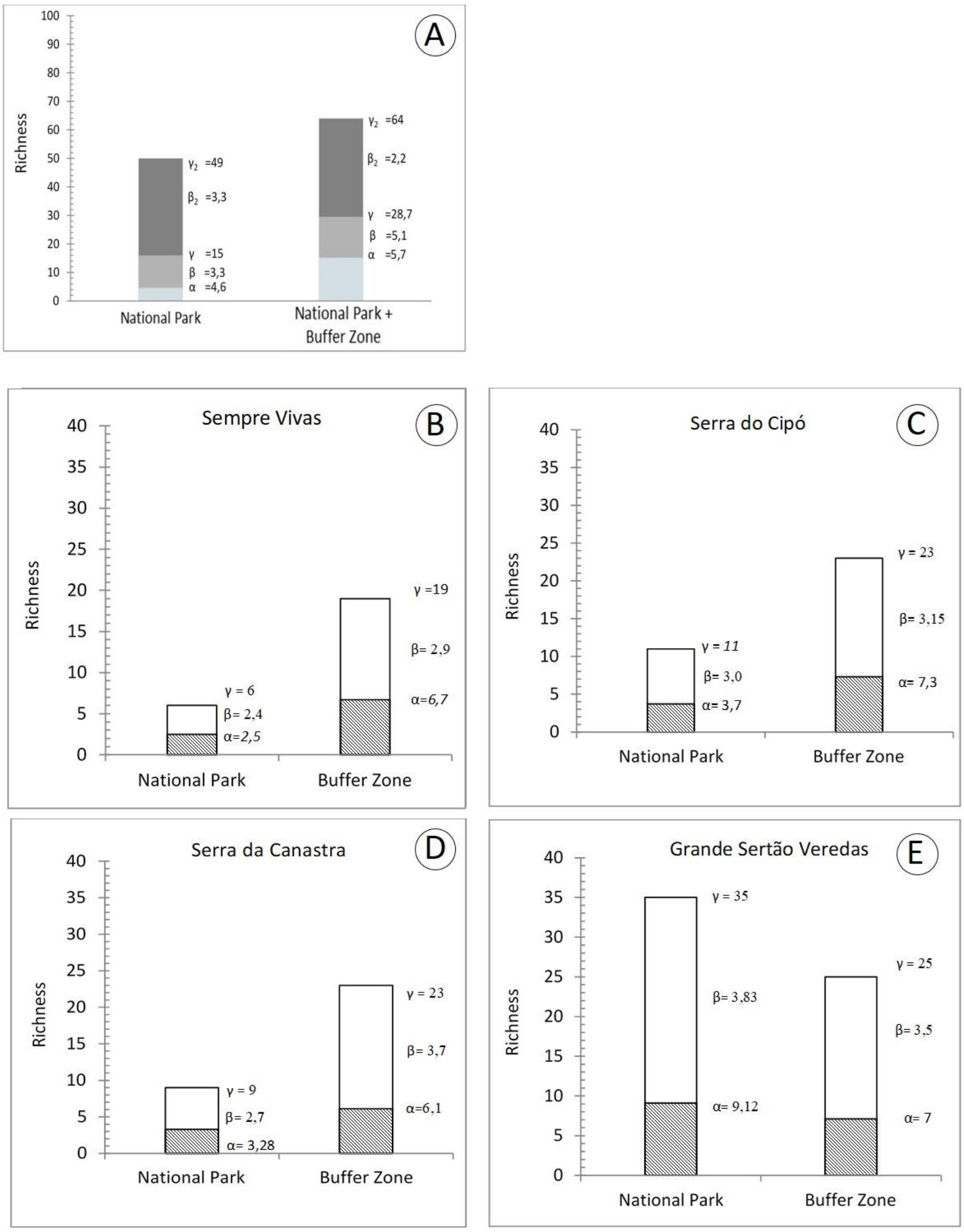

Figure 4 Multiplicative diversity partitioning showing the following components: α (mean stream richness), γ (total richness per National Park or region) and differentiation of species composition among streams from each National Park or Buffer Zone (β), and among all National Parks or among all regions (β2). National Parks and regions (National Park + Buffer Zone) together (A), Sempre Vivas (B), Serra do Cipó (C), Serra da Canastra (D) and Grande Sertão Veredas (E).

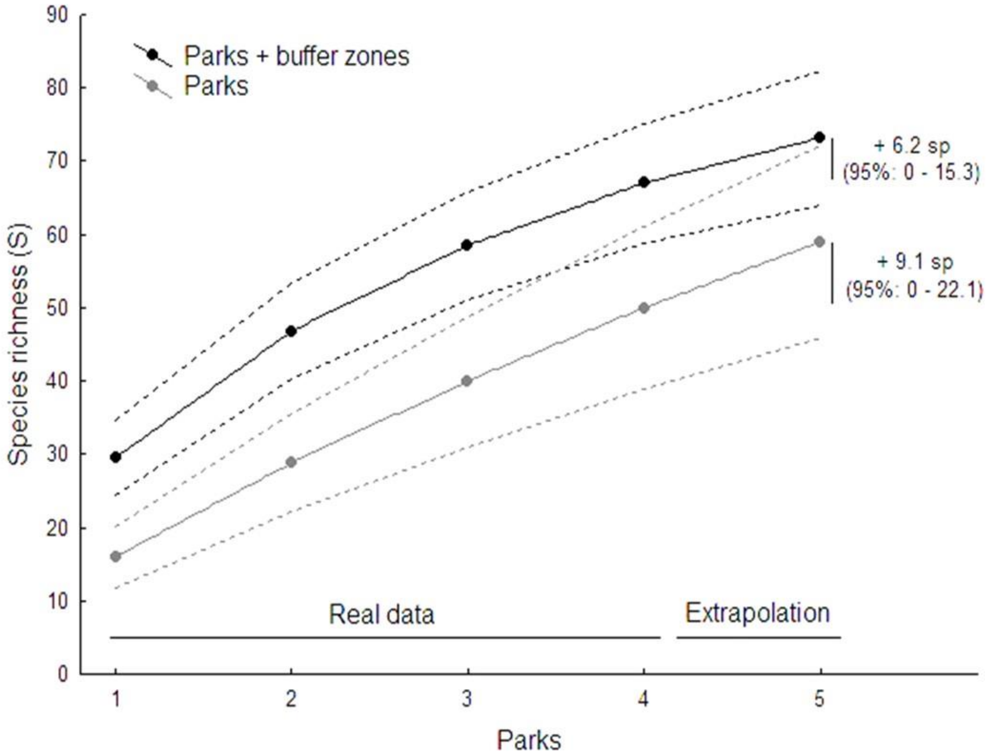

Figure 5 Extrapolation of the accumulation curves of species richness considering only the National Parks and considering the National Parks with their buffer zones.

MANUSCRIPT 2

POSITIVE ATTITUDES TOWARDS STRICTLY PROTECTED AREAS IN THE BRAZILIAN SAVANNA ARE LINKED TO ENVIRONMENTAL KNOWLEDGE

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Submitted to *Ecology and Society*

(normas do periódico - versão preliminar)

ABSTRACT

Reconciling biodiversity conservation with the well-being, perspectives and freedoms of people is a major challenge and receives increasing attention from conservation scientists, political ecologists and conservation practitioners. Our study seeks to improve understanding of the relationship between humans and nature beyond the fences of protected areas in the Global South, and contribute to building the knowledge base for effective and socially just conservation. We focused on the milieu (social environment) surrounding four National Parks in Brazil, dominated by biodiversity-rich cerrado savanna and freshwater ecosystems. We explored the role of social factors in shaping environmental knowledge and conservation attitudes among people living around the Parks using quantitative methods from conservation psychology. We then scrutinized the linkage between knowledge and attitudes, the latter being a foundation for pro-environmental behavior. Overall, levels of environmental knowledge were relatively high and environmental attitudes were mostly favorable to state conservation interventions around the Parks. Moreover, analyses showed that greater environmental knowledge and more favorable attitudes were associated with male respondents, people with more formal education and those born outside of the immediate vicinity. Finally, we found that greater environmental knowledge is translated into more favorable environmental attitudes. We therefore conclude that fostering community participation in conservation initiatives has the potential to facilitate the co-existence of rural livelihoods and healthy freshwater ecosystems surrounding protected areas. Finally, our findings demonstrate that plurality is needed by conservation practitioners interested in resolving tensions and sharing benefits and costs fairly, instead of homogenizing assumptions about working with the 'local community'.

Keywords: Conservation psychology; Pro-environmental attitude; Pro-environmental thought; São Francisco basin; Watershed management.

1. INTRODUCTION

The cumulative impact of billions of people has negatively affected global biodiversity (Newbold et al. 2014), as well as all systems and biophysical cycles (Groom et al. 2005, Oliveira et al. 2017). For instance, tropical deforestation for crops, pasture, and other land uses has been a major driver of global environmental change and species decline (Brooks et al. 2002, Barlow et al. 2016). Conservation scientists have spent decades investigating how species, communities and ecosystems are disturbed by human activities (Mace 2014, Redpath et al. 2015), which have often been compared with natural environmental conditions in areas with little or, supposedly, no human presence (Miller and Hobbs 2002, Kareiva and Marvier 2012). A long-standing intervention in the conservationists' toolkit is lobbying for the creation of protected areas, which have been partially successful in collectively reducing global rates of habitat and biodiversity loss (Primack and Rodrigues 2001, Liu et al. 2010). For reasons of interest (conservation importance) and convenience (lower opportunity costs), protected areas are more prevalent in the least disturbed areas where more 'natural' ecosystems persist (Kareiva and Marvier 2012). Nonetheless, conservation efforts cannot be limited to protected areas because, of course, biodiversity is also found on lands outside of protected areas (Redford and Grippo 2008, Pompeu et al. 2009, Di Minin et al. 2016).

The conceptual division between 'human/social' and 'nature/natural' reflects the on-going debates around reconciling human presence with biodiversity conservation (Bradshaw and Bekoff 2001, Adams and Hutton 2007, Lowe et al. 2009, Kareiva and Marvier 2012, Bennett and Roth 2015, Bennett et al. 2017). A pathway forward may be accepting the basic principle that conservation efforts should address not only organisms living in 'natural' conditions, but also the vast majority of contexts where nature and humans co- habit (Groom et al. 2005, Begon et al. 2007, Liu et al. 2007, Lowe et al. 2009, Kareiva and Marvier 2012). Insights into what people know and think about the environment and conservation issues serve an important and instrumental role in facilitating communication, understanding human interests and reducing conflicts between human activity and natural ecosystems (Lowe et al. 2009, Welch-Devine and Campbell 2010, Bennett and Dearden 2014). Moreover, important contributions from social sciences have supported conservation policy and decision making (Mascia et al. 2003, Decker et al. 2012, Bennett and Roth 2015). Institutions developing conservation interventions often assume that public opinion around a given policy is homogeneous. Yet, we also know that the success of biodiversity conservation is built on a broad understanding of the factors which shape local support (Gelcich and O'Keeffe 2016). Finally, examining the diversity of on-the-ground perspectives and experiences of conservation is key to understanding inequities in the distribution of 'goods' and 'bads' and moving towards a conversation paradigm that is pro-poor and socially just (Adams and Hutton 2007; Martin et al. 2013).

Developing the theory, applied research, and institutionalized practices necessary for improving human-nature relations comprise the mission of environmental psychology (Gifford 2014). A better understanding of how people interact and think about nature has been used as support for policy and intervention to promoting environmental sustainability, natural resource management and species conservation (Clayton and Myers 2009, Bennett et al. 2017). For example, models from environmental psychology have been used to understand decision-making by people in Sumatra around hunting endangered species (St. John et al. 2018). Alternatively, Bruskotter and Wilson (2014) reviewed psychological theory in order to assess whether human tolerance appears to promote or inhibit large carnivore conservation. Nonetheless, despite rapid growth in this field (Nilsson et al. 2016), few studies have drawn on psychological research methods to understand human-environment relations around protected areas. This is an important shortcoming because protected areas are strongly connected to their surrounding areas (Coimbra 2006) where agricultural and others kinds of human activities can affect biodiversity and ecosystem functioning within the park boundaries (Oliva and Magro 2004). Moreover, there are spillover effects from protected areas on people living and working around them, ranging from often positive effects on faunal abundance (e.g. fisheries around marine protected areas; Di Lorenzo et al. 2016) to legal restrictions on the kinds of development activities, land-uses or livelihoods which are permissible in buffer areas around parks (Nayak et al. 2014, Miranda et al. 2016).

Our study addresses this research gap by examining the environmental knowledge and environmental attitudes of people living around four National Parks in the Brazilian savanna (*cerrado*). The meaning of environmental knowledge (herein 'knowledge') is contested (Mascia et al. 2003, Schultz et al. 2005) but we refer to it as what people understand about the natural states of ecosystems (Fryxell and Lo 2003, Frick et al. 2004, Bennett and Roth 2015). Furthermore, this knowledge reflects a person's ability to understand the ecology and complex interactions between organisms and the environment as well as grasp the essence of environmental problems and possible solutions (Maloney and Ward 1973, Zsóka et al. 2013). We define environmental attitudes (herein, 'attitudes') as rational evaluation by an individual of their perceived positive and negative consequences of performing a particular environmental behavior (Bamberg and Möser 2007, Wiernik et al. 2013). We focus on the relationships of people living around parks with freshwater ecosystems because of the complex connectivity between human interference and aquatic ecosystems (Angermeier and Karr 1994, Silva et al. 2007, Beltrão et al.

2009, de Carvalho et al. 2017). In Brazil, the creation of protected areas has been planned in large-scale (74% of reserves created on the planet between 2003 and 2008; MMA, 2011) and is central to biodiversity conservation, yet to achieve effectiveness and fairness it is critical to understand local perspectives on these territories and their rules (Coimbra 2006, Andrade and Rhodes 2012). Myriad social factors such as gender, education, monetary income, cultural or geographical origins or age are likely to shape pro-environmental attitudes, as the pre-cursor to behavior. Hence, the aims of our study were to; (a) explore the role of social factors in shaping environmental knowledge and conservation attitudes among people living around the Parks; (b) assess the linkages between knowledge and attitudes, the latter being a foundation for pro-environmental behavior.

2. METHODS

2.1 Study Area

We developed our study in areas surrounding four National Parks (NPs) in central Brazil, along the São Francisco River basin, in Minas Gerais state (Figure 1). This basin is the third largest basin in South America (Godinho and Godinho 2003), and flows entirely in Brazil with 37% of its length within Minas Gerais (Igam, 2017). Across the basin in this State, there are five NPs where the largest amount of freshwater system is represented by streams. We surveyed rural people living around the stream networks surrounding four NPs. The Serra Canastra NP (46°26' W, 20°14' S), Serra do Cipó NP (43°34' W, 19°23' S), Sempre-Vivas NP (43°48' W, 17°55' S) and Grande Sertão Veredas NP (45°53' W, 15°11' S) are dominated by *cerrado*. The *cerrado* biome is a tropical biodiversity hotspot (Myers et al. 2000, Klink and Machado 2005) which has been drastically affected by the expansion of mechanized agriculture and cattle-ranching in recent decades (Klink and Machado 2005, Diniz-Filho et al. 2009, Kaschuk et al. 2011).

National Parks in Brazil are categorized as strictly protected areas, which means there are restrictions on land-use, resource extraction and human habitation is prohibited after creation. Tourism and research are allowed and the principal objective is ensuring the conservation of biodiversity (Category II, IUCN 1994, SNUC 2000). The governmental institution ICMBio (Instituto Chico Mendes de Conservação da Biodiversidade) is responsible for administering NPs, enforcing rules and developing NP-specific management plans. Among the Parks studied, only the Serra da Canastra and Serra do Cipó have borders (buffer zones) under land use regulation, with strict rules important to reduce and mitigate human impacts (MMA/IBAMA 2005, MMA/ICMBio 2009).

2.2 Survey design

To define our target study population, we first created a 10-km-wide buffer around each NP boundary using ArcGIS software (version 10.1). Each buffer was subdivided in 10 cross-sectional polygons and within each quadrant we randomly chose one stream and selected households with a maximum 2-km radial distance from the watercourse. The selection of each stream and house were obtained from census-tract data from the 2010 Brazilian national demographic census (IBGE 2010) and Google Earth. A maximum of five houses per quadrant were sampled with a hypothetical maximum sample of 50 questionnaires per park (10 quadrants with 5 houses in each). A team of two researchers – both native to Minas Gerais - conducted all interviews. Prior to data collection, the questionnaire was pre-tested in the field during a pilot phase (March 2015) when we identified and modified or removed questions which were ambiguous to interviewees or led to unclear answers. Questionnaires were administered to households between April and November 2015 and in March 2016. In the first part of the questionnaire we characterized the socio-economic and demographic characteristics of participants and their households and measures of exposure to conservation initiatives associated with their local NP. The second section was designed to quantify attitudes and knowledge based on a Likert- type scale (Likert 1932) (Figure 2). We conducted interviews only with the household head (≥ 18 years). A total of 93 households from Serra da Canastra (n=29), Serra do Cipó (n=22), Sempre Vivas (n=25) and Grande Sertão Veredas (n= 17) were sampled.

2.3 Data analysis

<u>Socioeconomic and exposure characteristics, knowledge and attitudes</u>

We assessed the socioeconomic characteristics of study participants through questions about age, formal education, monetary income, livelihood and birth-place (Figure 1). Gender was dummy coded (1= female; 2= male). We categorized the education level as no formal education (= 0); primary education only (at least some elementary school) (= 1); high school education (at least some high school education = 2); and higher education (university started or completed) (= 3). The wealth variable was a binary based on monthly monetary income and households (the national minimum salary was R$880 per month in 2016) were classified as either non-wealthy (less than two minimum salaries per household) (= 0) and wealthier (more than two salaries per household) (= 1). Livelihoods were classified into a binary of dependent on land (= 1) and not-dependent on the land (= 2). Finally, place of birth was classified as either native (born in a municipality immediately surrounding the national park to which they were neighbor (= 1) or non-native (= 2). Exposure to conservation initiatives was measured using two variables: (a) Park as a fixed factor indicating the local which interviewees lived around: CA= Serra da Canastra NP, CI= Serra do Cipó NP, SV= Sempre-Vivas NP, GSV= Grande Sertão Veredas NP. (b) Contact is an index which represents the sum of three measures of exposure: (i) awareness about the Park's existence (1= yes; 2= no) ii) whether the interviewee had previously visited the Park (1= yes; 2= no); (iii) whether they had attended a public talk or lecture offered by the Park (1= yes; 2=no) (Figure 1).

We investigated variation in attitude and knowledge using questions with a Likert-type format: "agree", "agree in part", "neutral/or indifferent", "disagree in part", and "disagree". For each statement, we attributed points from 0 to 4. Four represented the maximum level of knowledge or attitude towards the environment, whereas 0 represents "neutral/or indifferent", and 1 indicates the extreme of unfavorable 'knowledge' and 'attitude' towards the environment. Among the 21 statements in the questionnaire, 14 related to 'knowledge' and 7 statements to 'attitudes'. We categorized each assertion as 'knowledge' or an 'attitude' by drawing on relevant literature: (Fryxell and Lo 2003, Wiernik et al. 2013, Zsóka et al. 2013). For each interviewee and each set of questions about 'knowledge' and 'attitude', we summed the points assigned to all statements. Hence, higher scores (hypothetical maximum of 56 points) reflect greater 'knowledge' and more favorable 'attitudes' toward the local environment.

Statistical analyses

We first checked the distribution of the continuous social predictors using a residual test and histogram and QQ plot to check assumptions of normality. There was no strong deviation from the straight line, and by applying Shapiro test we confirmed that our residuals had a normal distribution. We used a model selection approach based on choosing the "best" model (defined as that which can explain the greatest level of variance in the outcome variable) and a ranking of the plausible models in a pre-defined set (Burnham and Anderson 2002). This approach allows the inference to be based on multiple models, leading to more robust data-analysis. We used a generalized linear model (GLM) to investigate the additive and the linear relationship between one or more social factors (gender, age, education level, wealth, livelihood dependence, birth, park and contact) with each response variables, 'knowledge' and 'attitudes'. We ran the GLM with a Gaussian distribution and all factors were included in the modelling process. We ran models using the *MuMIn* package (version 1.15.6, Bartoń 2013) and *dredge* function for a hierarchical distribution of possible models. We selected models based on the Akaike's Information Criterion (ΔAICc). All models with value of ΔAICc ≤ 2 in relation to the first-ranked model were chosen. We created a table of importance showing for each factor selected in the models the value of influence in 'knowledge' and 'attitude' variation. Model results were visualized by creating plots of model coefficients using the *coefplot* function in the package *arm*. This produces a scatter plot of the estimates for each effect in the model, with lines indicating the width of standard errors for the parameters. Social factors whose intervals intersect the line at 0 are not significant. A Pearson's correlation was used to test the relationship between 'knowledge' and 'attitude' and then with social factors. All statistical analyses were implemented using the statistical platform R 3.1.0 (Zuur et al. 2009).

3. RESULTS

The 'knowledge' and 'attitudes' values were generally favorable, indicating that most heads of households living around National Parks in the Brazilian savanna have relatively pro-environmental thoughts and desires for park conservation activities. The summed 'knowledge' and 'attitude' scores had means of 38.3 /56 (SD = 7.7) and 39.0 / 56 (SD = 5.3), respectively. The minimum score was 13 points for 'knowledge' and 14 for 'attitudes', whereas the maximum score was 56 for both. Respondents were mostly (58%) male (N = 54). Levels of formal education were generally low; most household heads had only primary education (58%) or no formal education (23%). The majority of women were retired or worked at home (total 80%), whereas three-quarters (76%) of men worked outside the family home. Most respondents (83%) were native to the local area, and 64% of households were classified as not-wealthy. Most interviewees (60%) relied on the land as their source of income. A majority (60%) of interviewees had contact with their local Park at some point in time.

The greatest variance in 'knowledge' – i.e. the highest-ranked model (ΔAICc= 0) – included education and gender (Table 1). However, when analyzing the data using multi-model inference, eight plausible models were selected. Hence, education, gender, age, birth-place and park contact were important social factors linked to 'knowledge'. Education and gender were included in all 'knowledge' models, birth-place in 46%, age in 44%, and contact in 41% of models (Table 2). Age, however, was included in eight plausible models but its effect was not clear (interval intercepted the line at 0), unlike other factors where the coefficient plot shows the significance for the variation in 'knowledge' (Table 2; Figure 3A).

The highest-ranked model (ΔAICc = 0) of 'attitudes' included: contact, education, gender and park (fixed factor) (Table 3). However, age and birth-place were also important predictors of 'attitude' according to other plausible models. Park contact and education-level were included in all plausible models, whereas other predictors were relatively less important: gender (57% of models), park (56%), age (56%), and birth (48%) (Table 2). Respondent age was included in 8 models of 15 plausible models (Table 3) but its influence as a social predictor indicated a lack of relationship with environmental knowledge and environmental attitudes (Figure 3B). Neither livelihood-dependence or wealth were included in any plausible models.

In summary, people who were non-native to the local area and had contact with their local NP were more likely to have pro-conservation thoughts and desire for positive actions (Figure 4A, C and E). In addition, male respondents and those with more formal education tended to have a greater level of 'knowledge' (Figure 4B) and more positive 'attitudes' (Figure 4D). However, our results also show that 'attitudes' were influenced by the park-level fixed effect (Figure 4F). In other words, we found that environmental attitudes tend to vary by geographic context. Our results show a significant positive correlation between 'knowledge' and 'attitudes' ($r = 0.61$, $p<0.001$) (Figure 5). The correlations between social factors and 'knowledge' were relatively weak: birth ($r=0.25$, $p<0.05$), contact ($r=0.25$, $p<0.05$), whereas the correlation with education level was relatively high ($r=0.36$, $p<0.001$). Attitudes were significantly and positively correlated with park contact ($r=0.35$, $p< 0.001$) and education level ($r=0.30$, $p< 0.01$), but only weakly with birth-place ($r=0.24$, $p< 0.05$) (Figure 5).

4. DISCUSSION

Our results provide novel insights into understanding how some indicators of social difference are associated with heterogeneity in environmental knowledge and environmental attitudes among people living and working in the proximity of protected areas. These findings strongly demonstrate that plurality is needed by conservation practitioners interested in resolving tensions and sharing benefits and costs fairly, instead of homogenizing assumptions about working with the 'local community'. Understanding the diversity of public opinion is key to the success of any environmental conservation measure, for example in Chile where attitudes to management differ depending on fishers' experiences (Gelcich et al. 2005, Gelcich and O'Keeffe 2016). We have shown that within the social environment around savanna National Parks in Brazil, being male or having more formal education are linked to greater environmental knowledge and more favorable attitudes to the local environment. This suggests there are untapped opportunities for broader engagement by conservationists with women and more marginalized households in these contexts and may resonate with research showing that the chronically-poor bear a higher burden of the costs of protected areas (Nayak et al. 2014). Another key finding was that positive environmental attitudes appear to be promoted by contact with a strictly protected area and its institutions. Perhaps surprisingly, people who had moved to the park from elsewhere were apparently more favorable to conservation initiatives. In addition, our results also show that environmental knowledge is translated into more favorable environmental attitudes, in which case educational or participatory activities promoted by governments or others could improve the performance and social acceptability of strictly protected areas.

Very little conservation psychology research has been conducted in the Global South with no studies, to our knowledge, using this approach to understand human-environment relations in or around protected areas. Nonetheless, the results of this study are consistent with evidence that individuals provided with more information, through education, tend to express greater knowledge about the environment and have more positive environmental attitude (Brody and Dietz 1997, McClanahan et al. 2005, Kideghesho et al. 2007, M. Wiernik et al. 2013, Gifford and Nilsson 2014, Kaltenborn et al. 2017). A body of research has found that people with more years of formal education tend to know more about the environment and are more likely to engage in conservation initiatives (Hines et al. 1987, Ostman and Parker 1987, Gifford and Nilsson 2014, Cheng and Wu 2015). In addition, most conservation attitudes are influenced by the involvement of people with nature imparted of knowledge received by environmental and traditional education (Zsóka et al. 2013, Frantz and Mayer 2014).

That women appear to be, in general, less knowledgeable or interested in potential conservation efforts is consistent with the literature (Chandler 1972, Arcury 1990, Gendall et al. 1995, Tikka et al. 2000). The relatively weaker environmental orientation of women is perhaps related to fewer opportunities to participate in environmental decision-making within the household or community (Agarwal 2009, Veleta et al. 2017). In the cultural context of this study, rural Minas Gerais state, men dominate livelihood activities outside the home. Futhermore, greater environmental knowledge may result from better access information, in contexts where men are socialized to be more involved in the ‘‘public sphere’’ of society (Tindall et al. 2003). Enhancing women’s access to information can be a strategy to improve public policies in the environmental field and participating in buffer zone management.

Our results also show that, at least in the Brazilian savanna, incomers tend to have a different, more positive perspective towards environmental conservation than those born locally. This may be a product of Park histories - associations between people and protected areas can involve contents over resource use and protected areas that exclude local communities frequently have conflicts and problems with local people (Ite 1996, Mutanga et al. 2015). In our study, park neighbors’ attitudes towards the potential benefits of conservation were directly related with awareness and exposure to Park institutions. Indeed, the variation across the four NPs shows the importance of reserve location in being affected by either regional differences in environmentalist perspectives, and/or the role of park-specific institutional histories in shaping attitudes among park neighbors. Conservation failures often follow the exclusion of local people from ecosystem management plans, stemming from a lack of participatory management (Ghimire and Pimbert 1997, Berkes 2004, Funder et al. 2013). Conservation planning is considerably more difficult (and more likely to be unjust) when local peoples are not aligned with or motivated to achieve conservation goals (Berkes 2004). In the Brazilian savanna, perceptions of Park neighbors about its existence or, indeed, understanding about nature conservation were associated with more positive environmental attitudes. A variety of initiatives, including actions to protect native species, participation of local people in scientific research and involvement in the establishment and management of protected areas can lead to measurable, positive environmental changes (Ite 1996, Törn et al. 2007, Andrade and Rhodes 2012). Following Berkes (2004), we reiterate that building knowledge and ecological relationships are the main pathways for putting humans back into ecosystems.

A direct relationship between environmental knowledge and attitude found in our study and the positive correlation of education with environmental knowledge and attitudes does suggest that knowledge can support the development of pro-environmental attitudes (Haron et al. 2005, Zsóka et al. 2013). Consequently, the powerful role of education indicates that environmental education and outreach to local people is a promising strategy for reducing negative social-ecological outcomes from, and on, strictly protected areas. Major financial investment in the social or beyond-fences aspects of protected area management are, unfortunately, relatively unrealistic at this point in Brazil's political-economic history. Hopefully, future interventions and the return of 'conservation optimism' could lead to improved, and socially-just conservation outcomes in areas adjacent to parks by fostering state-citizen dialogue, and nurturing environmental knowledge and attitude and behavioral change.

5. CONCLUSION

Our study shows the variation in environmental knowledge and attitude across people living around National Parks in Brazil's threatened savanna (*cerrado*) biome. These results reiterate the importance of accounting for the diversity of local opinions and environmental attitude or behavior and demonstrate the complex linkages of these characteristics with social difference. Importantly, ensuring the effectiveness of biodiversity conservation initiatives requires a deep and accurate understanding of where to intervene, and how. Therefore, the evaluation and understanding of public opinion is a first step towards improving communication and engagment around conservation policies (Wallner-Hahn and de la Torre-Castro 2017). Thus, our findings lead us to recommend investments in initiatives which will increase awareness of Park activities beyond their boundaries, fostered through environmental outreach and education (whether formal or informal) for local people. We also recommend that there should be a particular emphasis on engaging with women. Moreover, projects should be implemented that lead to increased understanding of local ecosystems, the characteristics of the biome and also promote experiential interaction with organisms. In addition, community awareness of the importance of National Parks for biodiversity conservation, its rules and its initiatives may be effective for promoting participation in conservation activities among park neighbors. These actions would be especially important in the case of neighbors living near watercourses, where the permeability with protected area is greater. Thus, because environmental knowledge and pro-environmental attitude are highly interconnected, our study suggests that the best strategy is to consider the human presence around protected areas through participatory community initiatives, increasing the chance of conservation success.

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Table 1 Model selection results for social determinants of 'knowledge' among people living around National Parks. Only selected models with weight ΔAICc≤ 2 are shown. AICc: Akaike value, ΔAICc: difference in AICc value compared to the first-ranked model, ωi: Akaike weight.

Model description	**df**	**logLik**	**AIC_c**	**ΔAIC_c**	**ω_i**
Education +Gender	4	-311.528	631.5	0.00	0.053
Education +Gender+ Age	5	-310.569	631.8	0.32	0.045
Education +Gender+ Birth	5	-310.575	631.8	0.33	0.045
Education +Gender+ Contact	5	-310.693	632.1	0.56	0.040
Education +Gender+ Age +Birth	6	-309.636	632.2	0.74	0.036
Education +Gender+ Birth + Contact	6	-309.693	632.4	0.85	0.034
Education +Gender+ Age +Contact	6	-309.891	632.8	1.25	0.028
Education +Gender+ Age +Birth + Contact	7	-308.914	633.1	1.63	0.023

Table 2 Relative importance of predictors of environmental knowledge and environmental attitudes based on multi-model inference and selection of plausible models using AICc.

	Education	Gender	Birth	Age	Contact	Park
Environmental knowledge						
Relative importance (0 to 1)	1.00	1.00	0.46	0.44	0.41	-
Included in N models	8	8	4	4	4	-
Estimate	4.38	3.44	2.70	0.07	0.88	-
Std. Error	1.19	1.6	2.02	0.05	0.73	-
Environmental attitude						
Relative importance (0 to 1)	1.00	0.57	0.48	0.56	1.00	0.56
Included in N models	15	8	8	8	15	8
Estimate	2.64	3.52	3.82	0.12	2.64	1.52
Std. Error	1.00	2.23	2.79	0.07	1.00	0.96

Table 3 Model selection results for social predictors of environmental attitudes. Only selected models with weight ΔAICc≤ 2 are shown. AICc: Akaike value, ΔAICc: difference in AICc value compared to the first-ranked model, ωi: Akaike weight.

Model description	df	logLik	AIC_c	ΔAIC_c	ωi
Contact+ Education +Gender +Park	6	-338.257	689.5	0.00	0.051
Contact+ Education +Gender +Park + Age	7	-337.292	689.9	0.41	0.041
Contact+ Education +Age +Birth	6	-338.552	690.1	0.59	0.038
Contact+ Education +Park +Age	6	-338.665	690.3	0.81	0.034
Contact+ Education +Gender +Park + Birth	7	-337.545	690.4	0.92	0.032
Contact+ Education +Gender +Age	6	-338.725	690.4	0.94	0.032
Contact+ Education +Age	5	-339.898	690.5	0.99	0.031
Contact+ Education +Park +Age + Birth	7	-337.630	690.6	1.09	0.029
Contact+ Education +Gender+ Age + Birth	7	-337.679	690.7	1.19	0.028
Contact+ Education +Gender	5	-340.030	690.7	1.26	0.027
Contact+ Education +Gender +Park +Age +Birth	8	-336.564	690.8	1.35	0.026
Contact+ Education +Gender +Birth	6	-338.961	690.9	1.41	0.025
Contact+ Education +Park	5	-340.131	691.0	1.46	0.024
Contact+ Education +Park + Birth	6	-339,053	691.1	1.59	0.023
Contact+ Education + Birth	5	-340,261	691.2	1.72	0.021

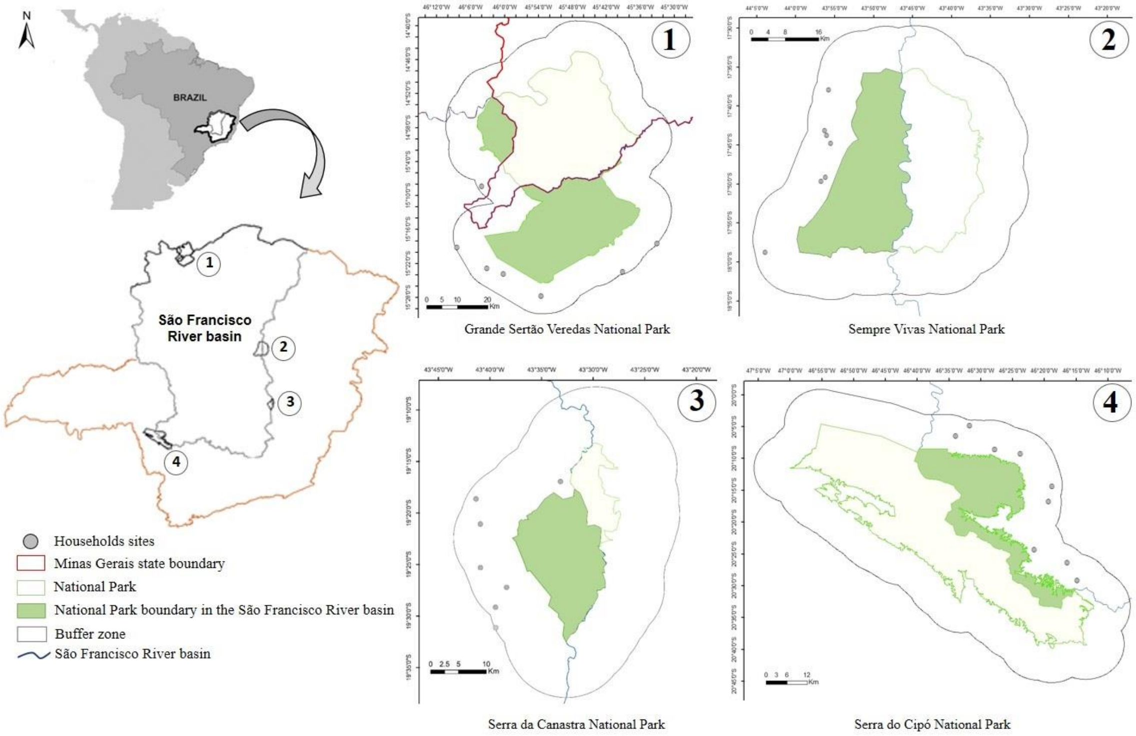

Figure 1 Study area in strictly protected areas in the Brazilian savanna. Household sites were selected from buffer zones around four National Parks (NP): Grande Sertão Veredas NP, Sempre-Vivas NP, Serra do Cipó NP and Serra da Canastra NP.

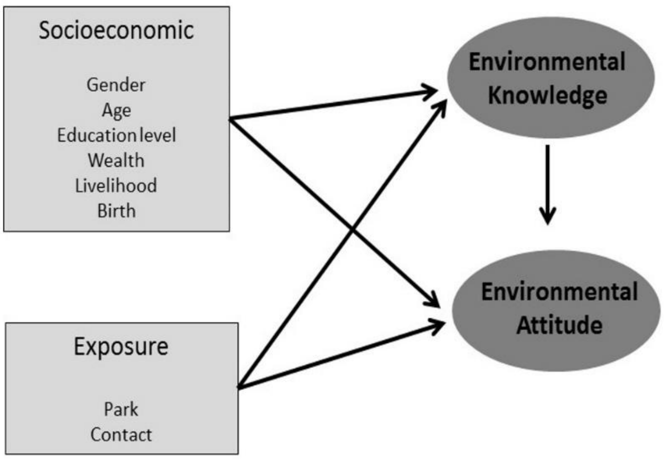

Figure 2 Conceptual framework for understanding the linkages between the socioeconomic and Park exposure factors of neighbors to Brazilian National Parks in relation to their ‘knowledge’ and ‘attitudes’ and the influence of ‘knowledge’ on the individual’s ‘attitudes’.

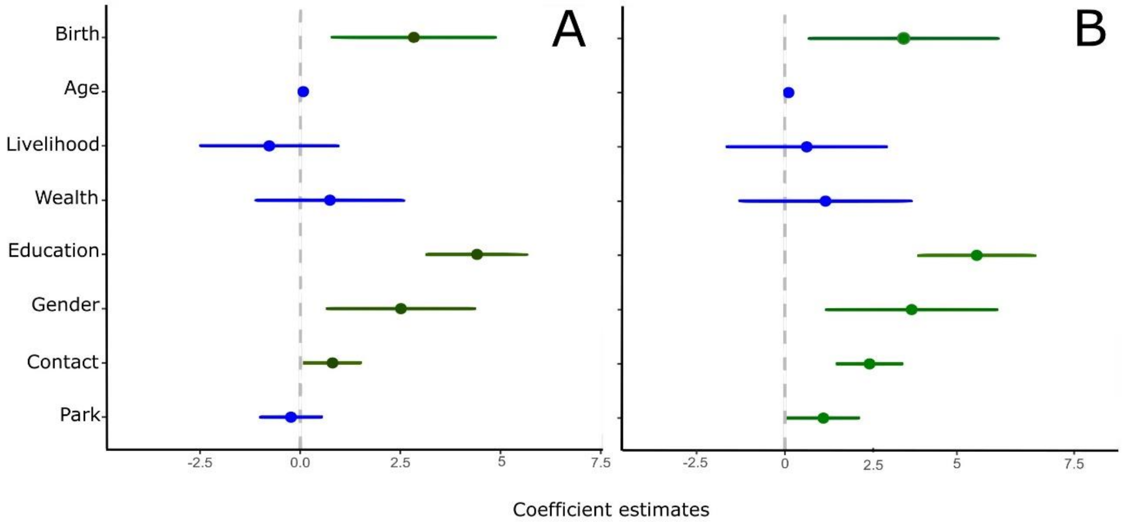

Figure 3 Relationship of respondents' social factors with pro-environmental knowledge and attitudes. Coefficient estimates (dots) and 95% confidence intervals (lines) for each social factors are shown for environmental knowledge (A) and environmental attitude (B). Social factors whose confidence intervals intersect the line at 0 indicate a lack of relationship between social predictors and the summed score of 'knowledge' and 'attitudes'. Positive effects of social factors are indicated in green and non-significant effects ($p > 0.05$) are shown in blue. The reference category for birth-place is non-native and gender is male.

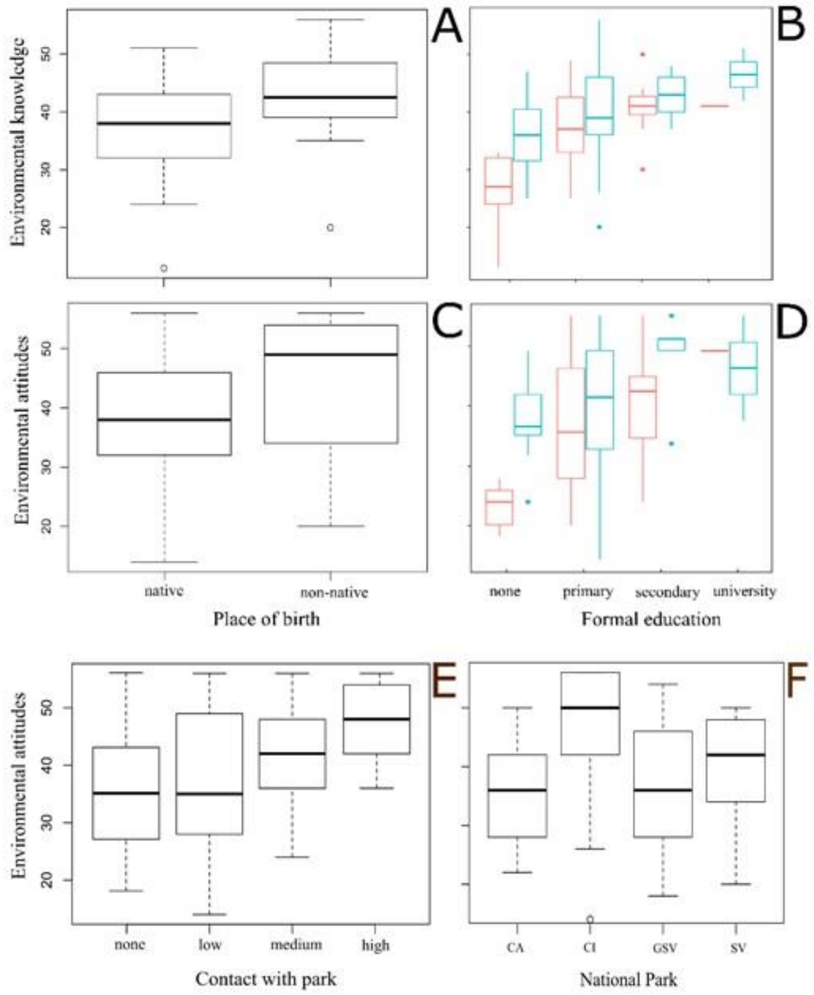

Figure 4 Boxplot representation showing the data mean (horizontal line) of relationship between social factors and the response variable significantly presented by Generalized Linear Model results. Variation of ‘knowledge’ and ‘attitudes’ regarding to place of birth (A and C) and formal education per gender (female - red line; male - blue line) (B and D). Environmental attitude variation with park exposure: contact with National Park (E) and local to the National Park (F). Serra da Canastra NP [CA]; Serra do Cipó NP [CI]; Grande Sertão Veredas NP [GSV]; Sempre Vivas NP [SV].

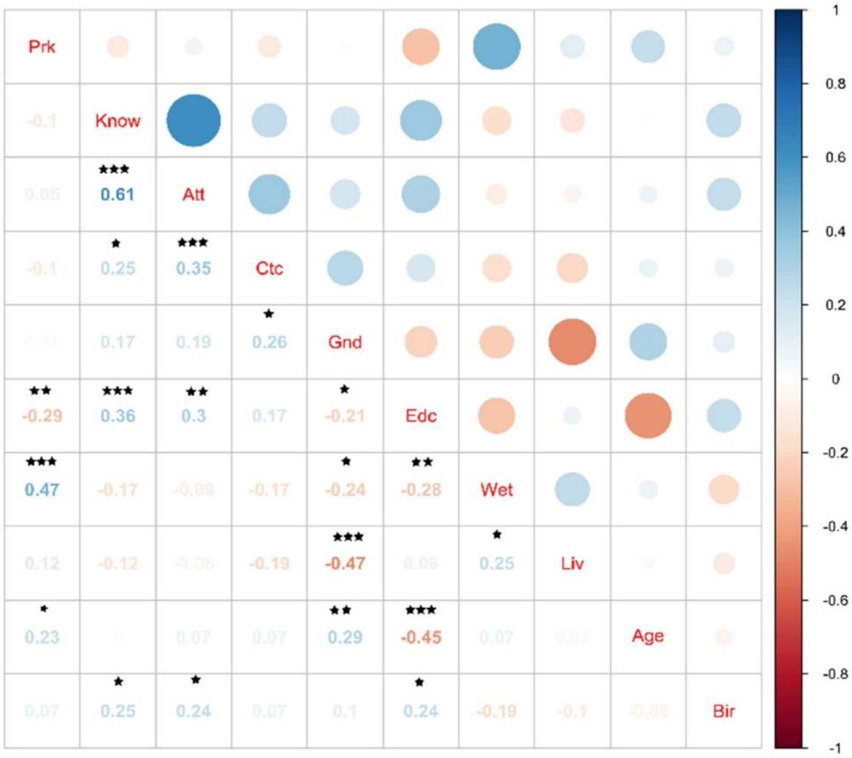

Figure 5 Pearson's correlation coefficient matrix with color-coded correlation coefficients (on the top of the diagonal denotes correlation coefficients as bubble size while on the bottom provides the actual coefficients as numbers). Each significance level is associated to a symbol: p-values (0.001= ***, 0.01= **, 0.05 = *). Positive and negative correlations are indicated in blue and red, respectively. Prk: park; Know: environmental knowledge; Att: environmental attitude; Ctc: contact; Gnd: gender; Edc: education level; Wet: wealth; Liv: livelihoods; Bir: birth-place.

MANUSCRIPT 3

STRICTLY PROTECTED AREAS IN THE BRAZILIAN SAVANNA: INFLUENCE OF POSITIVE THOUGHT AND ATTITUDES ON PHYSICAL HABITAT AND ICHTHYOFAUNA CONSERVATION

Submission: Journal of Environmental Management

(normas do periódico - versão preliminar)

ABSTRACT

Understanding which habitat changes are subject to some degree of human disturbance, differing from natural variation, can potentially result in a robust scientific knowledge in management. Our study seeks to understand how environmental knowledge and attitude of neighbors of the National Parks are associtaed with physical habitat characteristics of nearby streams, where small changes are potentially capable of altering the structure of aquatic fauna. We tested the hypothesis that (1) fish fauna structure is related to instream physical habitat features (2) such physical habitat metric will vary according to the neighbor's environmental knowledge and environmental attitude. We conducted our study in streams surrounding four National Parks in central Brazil, along freshwater ecosystems of the São Francisco River basin. We created a circular 10-km-wide buffer around each National Park boundary, in which we randomly chose streams and selected households with a maximum 2-km radial distance from the watercourse. We evaluated the influence of habitat complexity on the structure of the ichthyofauna. Questionnaires designed to quantify attitudes and knowledge based on a Likert- type scale were administered to households. We found that the streams located in different surrounding areas of National Parks did not show differences among fish community. Substrate, bed stability and presence of fish shelter were the most important habitat characteristics structuring fish communities, and their variation was related to both environmental knowledge and environmental attitude. Our study shows that ensuring the effectiveness of biodiversity conservation initiatives requires evaluating the metrics of physical habitat, as well as applying the broad notion of human influence on nature.

Keywords: Icthyofauna; Conservation psychology; São Francisco basin; Watershed management.

1. INTRODUCTION

The tropical forests are experiencing rapid urbanization, agricultural expansion and degradation resulting in higher impact on the region considered holding the greatest levels of biodiversity on Earth (Carmenta et al., 2016; Newbold et al., 2014; Tregidgo et al., 2017). In a typical tropical biome, the *cerrado* (‘‘Brazilian savanna’’), the transformation of the physical structure of the habitat can be mainly attributed to the intensification of land use in natural areas. Such changes are reflected on low order streams, where minor alterations are potentially able to change the structure of the aquatic fauna (Maceda-Veiga et al., 2014). Physical habitat variation is one of the most important structural drivers of the freshwater biodiversity (Zeni and Casatti, 2014; Leal et al., 2018; Leitão et al., 2018). The survival and reproduction of the species are determined by their tolerance and demand for habitat conditions (Begon et al., 2007) and alterations throughout a system can affect the health and productivity of aquatic environment (Magurran, 2009). Although many habitats have undergone transformations or may be critically influenced by human activities (Chu et al., 2015; Newbold et al., 2014; Smith et al., 2016), physical habitat conditions vary naturally (Caldeira, 2016). Therefore, the understanding of such variation is a fundamental tool used in assessing biological integrity, which can be used to measure ecosystem health or restoring it efficientilly (Karr et al., 1986; Karr and Chu, 1999; Kosnicki et al., 2014).

The effects of land use on the instream physical habitat have been well documented (Angermeier and Karr, 1994; Silva et al., 2007; Beltrão et al., 2009; de Carvalho et al., 2017; Leal et al., 2016). Stream physical habitat characteristics include habitat volume and stream size, habitat complexity and cover for aquatic biota, streambed particle size, bed stability, hydrologic regime and the condition and extent of the riparian vegetation (Kaufmann et al., 1999; Leal et al., 2016). Therefore, understanding which changes in the habitat are subject to some degree of human disturbance aside from natural variation can potentially provide a robust scientific knowledge in land management.

Protected areas may be considered as natural reference areas where the structure of the physical habitat is considered to be minimally disturbed (Caldeira, 2016). A preserved condition is particularly evident in strictly protected areas such as National Parks, for which there are restrictions on land-use, resource extraction and human habitation (Category II, IUCN 1994, SNUC; Law 9.985, 18 July 2000). Those areas are especially dedicated to the protection and maintenance of biological diversity (Primack and Rodrigues, 2001; Liu et al., 2010), but they are often immerse in an urban matrix of residents where the significant population growth in the vicinity may represent an environmental threat (Zommers et al., 2012; Salerno et al., 2014).

Effective land management aims to minimize negative human impacts on ecosystems (Ives and Kendal, 2014) and several studies have reported that human expressions about what they think and know about the environment may be a determinant for environmental conservation success (Mascia et al., 2003; Devine and Campbell, 2010; Bennett and Dearden, 2014). Therefore, the collaboration of social science is becoming increasingly prominent in environmental decision-making (Fox et al., 2006; Vaske and Manfredo, 2012; Bennett and Roth, 2015). The recent study of Bennet et al. (2016) indicated that local people could change their perception, supporting conservation efforts, by aligning their attitude with conservation goals. In some situations, environmental knowledge and attitude are particularly useful for understanding the effectiveness of conservation and acceptability of management actions (Bennett et al., 2016). Consequently, the link between understanding the natural states of ecosystems (*i.e*. environmental knowledge) and desires of conservation (*i.e*. environmental attitude) with the decision making process is especially important in areas established for protection of biological diversity (Fricky et al., 2000; Fryxell and Lo, 2003; Bamberg and Mo 2007; Wiernik et al., 2013; Bennett and Roth, 2015). We aimed to understand how environmental knowledge and environmental attitude of neighbors of the National Park are associated with important instream fish fauna structuring physical habitat conditions of nearby streams. We tested the hypothesis that (1) fish fauna structure is related to instream physical habitat features (2) and such characteristics will vary according to the neighbor's environmental knowledge and attitude.

2. METHODS

2.1 *Study Area*

We conducted our study in streams surrounding National Parks (NPs) in central Brazil, along the São Francisco River basin, in Minas Gerais state (Figure 1). The NPs in Brazil are categorized as strictly protected areas, which means within their limit there are restrictions on extraction of resource and human habitation. Tourism and research are allowed and the parks principal objective is ensuring the conservation of biodiversity (Category II, IUCN 1994, SNUC 2000). The Instituto Chico Mendes de Biodiversidade (ICMBio) is a governament institution responsible for administering and supervising NPs, enforcing rules and developing NP-specific management plans. Serra da Canastra (46°26' W, 20°14' S), Serra do Cipó (43°34' W, 19°23' S), Sempre-Vivas (43°48' W, 17°55' S) and Grande Sertão Veredas (45°53' W, 15°11' S) are the four national parks evaluated. Among the NPs, only Serra da Canastra and Serra do Cipó have buffer zones (borders) under land use regulation, with strict rules important to reduce and mitigate human impacts (MMA/IBAMA 2005, MMA/ICMBio 2009). The National Parks are dominated by *cerrado*, one of the world's biodiversity hotspots. However, the regions around NPs are characterized by a matrix of pasture in which there have been the expansion of mechanized agriculture and cattle-ranching in recent decades (Klink and Machado 2005; Diniz-Filho et al. 2009; Kaschuk et al. 2011).

2.2 *Survey design*

To define our streams, using on ArcGIS software (version 10.1), we first created a circular 10-km-wide buffer around each NP boundary. Each buffer was subdivided in 10 cross-sectional polygons in order to cover more diverse possible regions along NP´s. We randomly chose one stream and selected households with a maximum 2-km radial distance from the watercourse within each quadrant. The selection of each stream and house was obtained from census-tract data from the 2010 Brazilian national demographic census (IBGE 2010) and Google Earth. A hypothetical maximum sample of 10 streams and a maximum of five houses per polygon were sampled with a hypothetical maximum sample of 50 questionnaires per park in the buffer zones (Figure 1). We set second or third order streams (Strahler 1957) with headwaters out the park boundary (N = 30). We sampled seven streams in the buffer zone of Serra do Cipó, Sempre Vivas and Grande Sertão Veredas NP´s, and nine streams in Serra da Canastra NP. To assess the ichthyofauna structure and characterize the water quality and physical habitat, each stream was sampled once during the dry season, on September of 2014 or April of 2015. The dry season is considered the best for habitat characterization of a watercourse (Kaufmann et al. 1999), however the number of streams was reduced because of the hydro scarcity in 2014 and 2015. Therefore, we further selected streams based on the presence of water and our capacity to access them. We sampled streams following the methods described by Peck et al. (2006) and Hughes and Peck (2008). We delimited 150 m long stretches of the stream which were subdivided into 10 continuous sections by 11 cross-sectional transects (Figure 2). Physical habitat data were collected along the stream and from 11 sections every 15 m. We characterized the water quality (pH, conductivity, temperature, and dissolved oxygen) at each transect, below the water surface at the center of the transect (Hughes and Peck, 2008). We took depths measurements and evaluated the presence of fine sediment and the type of flow. Furthermore, we counted the number of channel bars, wood debris in the bankfull stage channel, lateral channels, and backwater pools along each transect.

We characterized the habitat complexity of the stream channel and riparian zones in each of the 11 cross-sectional transects. We first measured depth and visually estimated substrate type (from bedrock to fine litter) and its immersion at five equidistant points along the cross-section. We visually determined and quantified the abundance of potential fish shelters (algae, aquatic macrophytes, wood debris, tree roots, leaf banks, overhanging vegetation, undercut banks, artificial structures) 5 m upstream and downstream from each cross-section. We measured bank angle with a clinometer and used a measuring tape to determine undercut banks length, channel wetted width, channel bar width, channel height and width at bankfull stage, and channel incision height. We characterized the vegetation canopy based on a 10-m^2 quadrat on each bank. The quadrats extended 5 m upstream and 5 m downstream from the cross-section and we visually estimated the percentage cover of each type of vegetation for the canopy layer, understory, and ground cover layer. We also visually identified potential human disturbance (e.g. pasture, agriculture, and mining) in each site-transect and estimated their distance from the banks (Figure 2 (b)). We used a GPS to obtain the elevation of the points at the end of the reach and used the difference in elevation to calculate reach slope. For those assessments of the physical habitat protocol we used convex spherical densitometer, portable digital meter, a compass, clinometer, measuring tape and GPS.

We sampled fish after assessing the physical habitat. Two people collected fish from downstream to upstream with hand nets made of mosquito netting (80 cm in diameter, 1 mm stretched mesh size). Two hand nets were used for sampling, and time of collection was standardized by 12 minutes per stream section, summing to 120 minutes for each stream. We euthanized all sampled fishes in anesthetic Eugenol solution and then fixed them in 10% formalin. In the laboratory, we transferred fishes to 70% ethanol, identified them to the species level, and determined the fish assemblages of streams. Voucher specimens from all species sampled at the buffer zone of each national park were deposited in the fish collections of the Universidade Federal de Lavras (UFLA) and Pontifícia Universidade Católica de Minas Gerais (PUC), Brazil.

Social questionnaires were applied to households between April and November 2015 and in March 2016. A team of two researchers – both native to the state of Minas Gerais - conducted all interviews. The questionnaires were administered to one resident per sample-household. A maximum of five houses per quadrant was sampled with a hypothetical maximum sample of 50 questionnaires per park (10 quadrants with 5 houses in each). Prior to data collection, the questionnaire was pre-tested in the field during a pilot phase (March 2015) when we identified and modified or removed questions which were ambiguous to interviewees or led to unclear answers. The questionnaire was designed to quantify environmental attitude (‘attitudes’) and environmental knowledge ('knowledge') of the participants based on a Likert- type scale (Likert 1932). We conducted interviews only with the household head (≥ 18 years). A total of 93 household heads from Serra da Canastra (n=29), Serra do Cipó (n=22), Sempre Vivas (n=25) and Grande Sertão Veredas (n= 17) were sampled. We investigated variation in 'attitudes' and 'knowledge' using questions with a Likert-type format: "agree", "agree in part", "neutral/or indifferent", "disagree in part", and "disagree". For each statement, we attributed scores from 0 to 4. Four represents the maximum level of 'knowledge' or 'attitudes' towards the environment, whereas 0 represents "neutral/or indifferent", and 1 indicates the extreme of unfavorable 'knowledge' and 'attitude' towards the environment. Among the 21 statements in the questionnaire, 14 related to 'knowledge' and 7 to 'attitude'. We categorized each assertion as 'knowledge' or 'attitudes' by drawing on relevant literature: (Fryxell and Lo, 2003; Zsoka et al., 2012; Wiernik et al., 2013). For each respondent and each set of questions about environmental 'knowledge' and 'attitude', we summed the points assigned to all statements. Hence, a higher score (hypothetical maximum of 56 points) reflects a high level of environmental knowledge and a highly favorable attitude toward the local environment.

2.2. *Data Analyses*

We calculated 255 physical habitat related metrics from the field sampling data following Peck et al. (2006) and Hughes and Peck (2008). Out of this 255 metrics, we selected 52 distributed in categories of water chemistry, substrate, fish shelter, riparian vegetation, human impact, and channel morphology based on the results of correlation analyses between metrics (one metric was excluded whenever the correlation was statistically significant and the coefficient greater than 75%) (Caldeira, 2016). We applied a Non-metric multidimensional scaling (nMDS) to evaluate the structure of the fish assemblage. The ordination method was based on the matrix that used the Bray-Curtis' similarity index to compare fish community of streams. Additionally, we tested the statistical significance (0.05 significance value) of potential groups of streams visually detected in the NMDS ordination with an Analysis of Similarity (ANOSIM) with 999 permutations. We used distance-based linear models (DISTLM) to evaluate if the metrics of physical habitat characteristics could explain the fish composition variation among streams (Anderson et al., 2008). We used the Bray-Curtis's similarity index for the fish community matrix because it is an appropriate method for species abundance. We identified statistically significant (0.05 significance value) explanatory metrics through sequential tests, where the DISTLM models analyzed the contribution of variables together. For the models, we used the forward selection. We performed all analyzes in the software Primer+Permanova (Clarke and Gorley, 2006).

We used a generalized linear model (GLM) to investigate the additive and the linear relationship between one or more metrics from DISTLM results with each response variable, ‘knowledge’ and ‘attitudes’. We ran the GLM with a Gaussian distribution and all metrics of physical habitat were included in the modelling process. We ran models using the MuMIn package (version 1.15.6, Bartoń 2013) and dredge function for a hierarchical distribution of possible models. We selected models based on the Akaike’s Information Criterion (ΔAICc). All models with value of ΔAICc≤2 in relation to the first-ranked model were chosen. A table of importance was created showing the value of the influence of 'knowledge' and 'attitudes' for each physical habitat metric selected in the models. The statistical analyses were implemented using the statistical platform R 3.1.0 (Gentleman and Ihaka 2014).

3. RESULTS

The fish fauna composition of streams did not present significant differences among parks (ANOSIM p= 0,30; R= 0,21; Figure 3). Five physical habitat metrics were part of the best statistically significant model of the DISTLM analysis. The metrics ‘percentage of fine gravel and smaller substrate’ (% PCT_SFGF)’, ‘relative bed stability’ (LRBS), ‘mean size of channel substrate’ (SUB_X)’, ‘abundance of large wood debris for fish shelter’ (XFC_LWD), ‘undercut bank cover for fish shelter’ (XFC_UCB) were able to explain 35% of the variation fish fauna structure among stream systems (adjusted $R^2 = 0.35$; $p < 0.05$) (Table 1).

The ‘knowledge’ and ‘attitudes’ values were associated with some physical habitat metrics, showing that most heads of households living around National Parks are conservation influencers. Percentage of fine gravel and smaller substrate was the most important variable associated to ‘knowledge’ and was included in 81% of the models (Figure 4A). ‘mean size of channel substrate’ (Figure 4B) and ‘undercut bank cover for fish shelter’ were also included in some models (Tables 2 and 3). The same variables were related to ‘attitudes’, however ‘mean size of channel substrate’ was the most important one (Figures 4C and 4D; Tables 3 and 4).

4. DISCUSSION

The streams in the surrounding areas of different National Parks did not show differences among fish communities, allowing analyzing them together. Features related to substrate, bed stability and the presence of fish shelter were the most important determining the structure of such communities, and their variation was related to both environmental knowledge and environmental attitude of residents. We found that knowledge and attitudes toward conservation by neighbors of the national parks were associated with the variety of habitat conditions in the unprotected streams. Our study shows the importance of understanding the "people and nature" combination, showing the interaction among human expression, modification of stream physical habitat and structure of fish community.

The streams studied were located in a heterogeneous area, and freshwater ecosystems overall are highly complex and vulnerable to variation both at large- and small-scales (Castello et al., 2013; Molina et al., 2017). Geographic position has been proposed as one of the main predictors of species composition of streams located inside of the five National Parks in the São Francisco river basin (Caldeira, 2016). However, the fish fauna from the streams located in the buffer zones did not present a segregation pattern among regions, reaffirming the great biogeographical variability of the freshwater areas covered by these systems (Pereira et al., 1994; Saadi, 1995; Alves and Leal, 2010; Fragoso et al., 2011). Geology, geomorphology, and climate may influence the spatial distribution of species (Heino et al., 2015), but our study showed that an important portion of the fish community structure in those streams can be explained by small-scale conditions.

In our findings, 'mean size of channel substrate' and 'percentage of fine gravel and smaller substrate' were important conditions of habitat influencing the structure of fish fauna in streams around National Parks. In addition, those conditions were associated with environmental knowledge and attitude of Park neighbors. Substrate characteristics are considered important local-scale variables for the structuring of fish communities in streams (Angermeier and Schlosser, 1989). The influence of human practices and land use changes on the instream physical habitat is well known (Molina et al., 2017), and land use has been considered an important driver of habitat alterations (Leal et al., 2016). Siltation is an example of habitat change driven by land use leading to the homogenization of the environment and consequent loss of biodiversity (Casatti et al., 2006; Shahnawaz et al., 2010; Kemp et al., 2011; zeni and Casatti, 2014). Fine sediment input can also reduce the availability of food resources and habitat for fish and invertebrates (Nerbonne and Vondracek, 2001; Leal et al., 2016).

Environmental attitude and knowledge of Park neighbors are associated with variation in physical habitat and consequently structuring of the fish community. The conservation status of the riparian vegetation has also been associated with habitat variability, since bed instability due to the suppression of vegetation results in an increase of fine sediment in channel substrate and loss of species diversity (Berkman and Rabeni, 1987; Simon and Collinson, 2002; Pusey and Arthington, 2003; Zeni and Casatti, 2014). The maintenance of vegetation has an important role in bed stabilization, including reinforcement of the soil (Simon and Collinson, 2002). In addition, the integrity of the riparian zone is also related to density of wood (Molina et al., 2017). Thus, modification of riparian zones may influence the provision of large wood for the streams (Crook and Robertson, 1999; Cordova et al., 2007). Wood debris supply a large variety of microhabitats where fish species can shelter against predators and find a wide variety of feeding resources and places for reproduction (Wootton, 1998; Oliveira et al., 2016). The riparian vegetation not only directly provides bed stability and contributes to instream wood debris density, but it is also critical for the development and maintenance of undercut banks (Jowett et al., 2010). The presence of instream fish cover (e.g. Undercut banks) may influence habitat heterogeneity by providing cover for fish (Jowett et al., 2010). Modifications in 'relative bed stability', 'abundance of large wood debris for fish shelter' and 'undercut bank cover for fish shelter' had greater influence on fish assemblages in the streams surrounding National Parks. This suggests the importance of considering the human presence and conservation of stream systems together.

We found that thought and desire toward conservation by neighbors of the national parks were associated with the variety of habitat conditions in streams located inside the buffer zone of four national parks in Brazil. Therefore, the human relationship with the natural environment could be a relevant input for policy of conservation. Finally, our study highlights the importance of understanding "people and nature" combination, showing the result of interactions between human expression, modification of stream physical habitat and structure of the fish community.

Our study shows that ensuring the effectiveness of biodiversity conservation initiatives requires evaluation of physical habitat conditions, as well as applying the broad notion of human influence on nature. In addition, the assessment and understanding of human knowledge and attitude related to the environment and the inclusion of those into land use management planning could improve biodiversity conservation, especially for ecosystems close to important biodiversity protection areas such as National Parks. We conclude that managers should attempt to account for the strong local-scale interactions between variables related to icthyofauna structure and stream physical habitat when monitoring protected streams. Moreover, it is clear that conservation is a multidisciplinary challenge. Thus, projects that lead the population in the vicinity of National Parks to better understanding the importance of land uses to biodiversity conservation in protected areas should be implemented.

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Table 1 Relationship between fish assemblages from buffer zone streams and their main structuring metrics. The best significant ($p < 0.05$) DISTLM model is presented.

Variables	Adjusted R_2	Pseudo-F	P-value
percentage of fine gravel and smaller substrate	0.14	5.76	0.001
+ relative bed stability	0.18	2.56	0.012
+ mean size of channel substrate	0.28	2.79	0.011
+ abundance of large wood for fish shelter	0.32	2.26	0.041
+ undercut bank cover for fish shelter	0.35	2.21	0.036

Table 2 Physical habitat affected by predictors of 'knowledge' of people living around National Parks. Only selected models with weight ΔAICc≤ 2 are shown. AICc: Akaike value, ΔAICc: difference in AICc value compared to the first-ranked model, ωi: Akaike weight.

Model description	df	logLik	AICc	ΔAICc	ω_i
'mean size of channel substrate + percentage of fine gravel and smaller substrate'	4	-91.813	193.3	0.00	0.202
'percentage of fine gravel and smaller substrate'	3	-93.597	194.2	0.86	0.131
'mean size of channel substrate' + 'percentage of fine gravel and smaller substrate' + 'undercut bank cover for fish shelter'	5	91.300	195.2	1.92	0.078

Table 3 The relative importance of predictors of environmental knowledge and environmental attitude based on multi-model inference and selection of plausible models using AICc.

	'percentage of fine gravel and smaller substrate'	'mean size of channel substrate'	'undercut bank cover for fish shelter'
Environmental knowledge			
Relative importance (0 to 1)	0.81	0.55	0.15
Included in N models	3	2	1
Environmental attitude			
Relative importance (0 to 1)	0.37	0.78	0.29
Included in N models	2	4	2

Table 4- Physical habitat affected by predictors of ‘attitudes’ of people living around National Parks. Only selected models with weight ΔAICc≤ 2 are shown. AICc: Akaike value, ΔAICc: difference in AICc value compared to the first-ranked model, ωi: Akaike weight.

Model description	**df**	logLik	AICc	**ΔAICc**	**ωi**
‘mean size of channel substrate’	3	-97.464	201.9	0.00	0.130
‘mean size of channel substrate’ + ‘percentage of fine gravel and smaller substrate’	4	-96.228	202.1	0.24	0.116
‘mean size of channel substrate’ **+** ‘undercut bank cover for fish shelter’	4	-96.608	202.9	1.00	0.079
‘substrate size average ‘ + ‘percentage of fine gravel and smaller substrate’ **+** ‘undercut bank cover for fish shelter’	5	-95.268	203.1	1.26	0.069

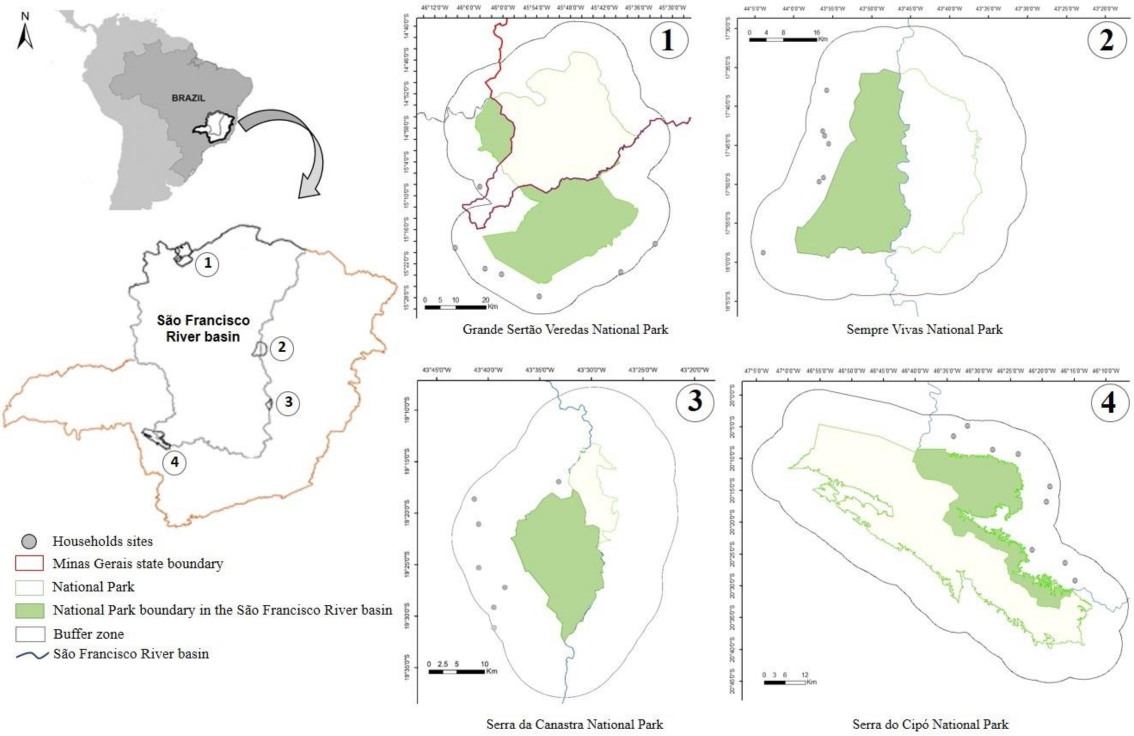

Figure 1 Study area in strictly protected areas in the Brazilian savanna. Household sites were selected from buffer zones around four National Parks (NP): Grande Sertão Veredas NP, Sempre-Vivas NP, Serra do Cipó NP and Serra da Canastra NP (from Casarim, 2018).

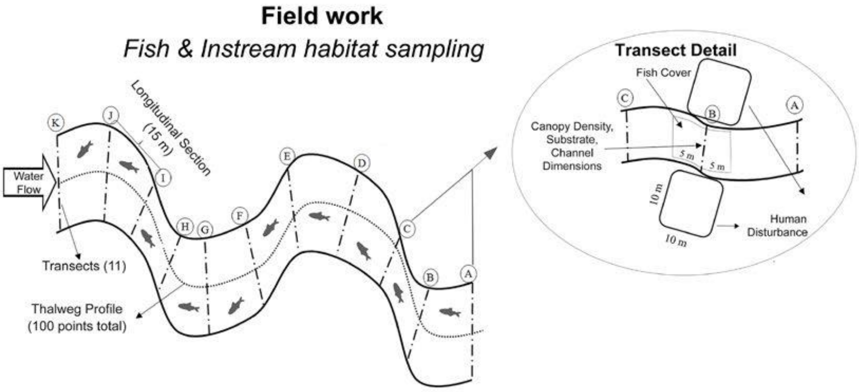

Figure 2 Schematic of the data sampling of the stream habitat characterization (from Leal et al., 2017).

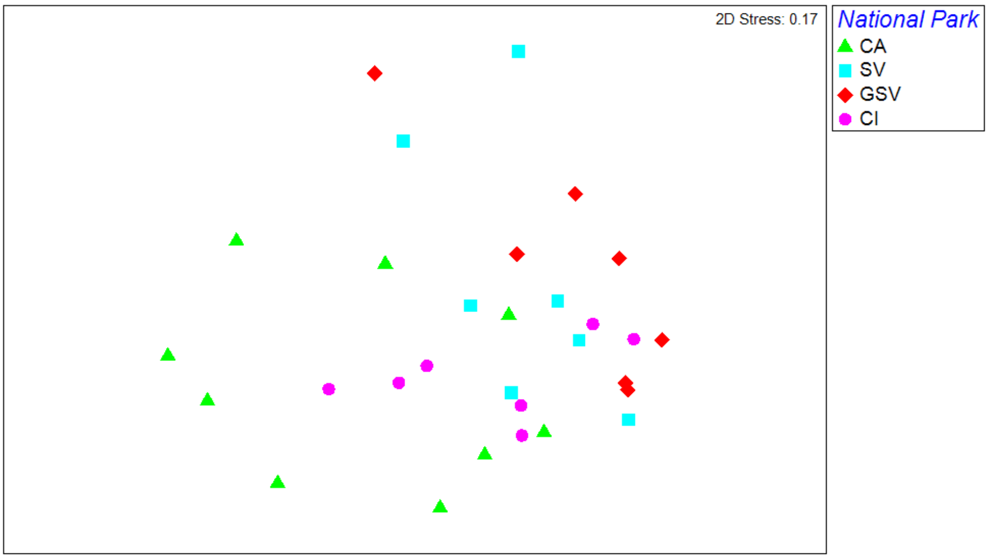

Figure 3 Two-dimensional non-metric multidimensional scaling (nMDS) of the fish fauna (based on fish abundances) according to Bray–Curtis similarity (stress value =0.17). The fish assemblage separation of Serra da Canastra NP [CA]; Sempre Vivas NP [SV]; Grande Sertão Veredas NP [GSV]; Serra do Cipó NP [CI] was not confirmed (ANOSIM, global R= 0,2; p= 0,30).

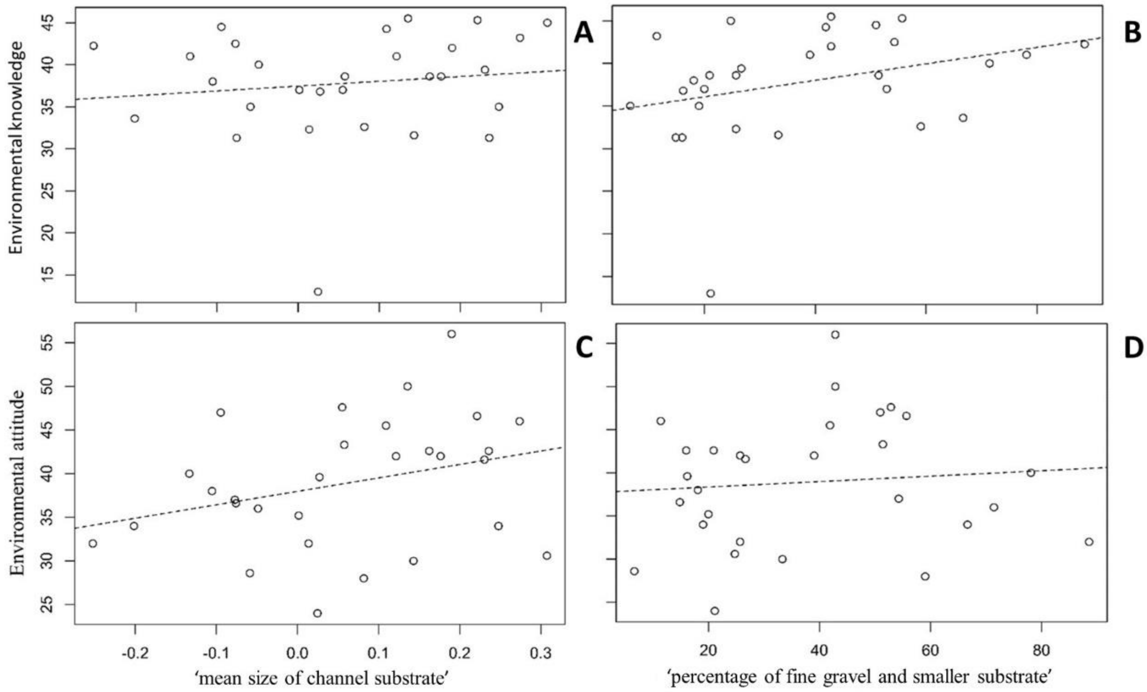

Figure 4 Relationship between environmental knowledge and environmental attitude with the physical habitat metrics of the best statistically significant model of the DISTLM: 'mean size of channel substrate (A), 'percentage of fine gravel and smaller substrate' (B), 'mean size of channel substrate' (C), 'percentage of fine gravel and smaller substrate' (D).

THIRD PART

1. CONCLUSÃO GERAL E APLICAÇÃO DOS RESULTADOS DA PESQUISA

Com a presente tese fica clara que a conservação da diversidade de peixes é um desafio multidisciplinar onde a ecologia deveria caminhar com a ciência social. Essa tese destaca a relevância dos Parques Nacionais e das zonas de amortecimento para conservação da ictiofauna. Uma parcela importante da fauna de peixes de riacho da bacia do São Francisco se encontra preservada dentro dos Parques Nacionais, parcela ainda maior quando considerado a área de entorno. A inclusão do entorno dos Parques Nacionais nos planos de manejo a partir da implementação de estratégias relacionadas ao uso da terra adequado teria enorme impacto positivo sobre a preservação da ictiofauna. Entretanto, é de extrema importância entender e conhecer as pessoas do entorno, bem como a gestão dos Parques Nacionais. O envolvimento da pesquisa com os gestores, as comunidades locais e os formuladores de políticas públicas ambientais são um excelente intercâmbio de informações que serve de linha de base para o planejamento e gestão eficiente dos projetos de proteção ao ambiente aquático.

Acreditamos que uma estratégia eficiente de conservação do ambiente aquático é a troca de conhecimentos. Dessa forma, a fim de apresentar os resultados obtidos com a pesquisa desenvolvida realizamos reuniões com os gestores de alguns Parques Nacionais junto a comunidade do entorno. Preparamos apresentações para cada Parque Nacional, confeccionamos e entregamos banners informativos com a fauna coletada na região de cada Parque, além de elaborar uma carta aos gestores com as nossas recomendações para aprimorar a conservação e o manejo de riachos na bacia do rio São Francisco em Minas Gerais. Assim, abordamos nessa tese a lacuna de conhecimento entre homem e natureza. E cada vez mais, com o atual cenário político que o Brasil se encontra, se faz necessária essa ligação entre a pesquisa acadêmica e a comunidade, pois é com essa interação que possíveis mudanças negativas no meio ambiente poderão ser evitadas.

2. MATERIAL SUPLEMENTAR

1.1 *Questionário*

UNIVERSIDADE FEDERAL DE LAVRAS		Data de entrevista: ____/____/______ Início: ____:____ hs **Término:** ____:____ hs **Entrevistador:**
1	**ENTREVISTA COM O CHEFE E A CHEFA**	**Registro** |___||_ __||_ __| |_ __| |___||___|||___||

Etapa	**Nome do responsável pela Entrevista**	**Data**	**Situação dos dados** (ok ou dados faltantes)	**Dados faltantes** (indicar os módulos e questões com dados faltantes)
Revisão				

IDENTIFICAÇÃO DO DOMICÍLIO

Identificação e localização da unidade doméstica – tabela a ser preenchida logo após a entrevista.

Município		**Parque:**	
Nome Ponto Córrego			
Coordenadas da UD	**ZONA** |__||__|- |___|	**UTM (X)** |__|__|__|__|__|__|__|	**UTM (Y)** |__|__|__|__|__|__|__|

NOME DO CHEFE DA CASA: ____

Apelido:______________________________

NOME DA CHEFA DA CASA: ____

Apelido:______________________________

1 – Naturalidade do entrevistado- Origem e Tempo na região

Profissões: ____

Faixa etária: ☐ **1-** 18 a 29 ☐ **2-** 30 a 59 ☐ **3-** 60 ou mais

1.01 Em qual cidade o Senhor (a) nasceu?________________________________

1.02 Em qual município? ______________________________ (Se não souber depois completa)

1.03 O Senhor(a) tem essa propriedade como moradia principal?

☐ 1- Sim → Siga para 1.04

☐ 2- Não → Siga para 1.07

1.04 Há quanto tempo o senhor (a) mora neste município? ____________________

1.05 Há quanto tempo senhor (a) mora nesta propriedade (casa)? ______________________

1.06 Essa propriedade sempre foi do senhor (a)? ☐ 1- Sim ☐ 2- Não

Siga para 1.11

1.07 Essa propriedade (casa) sempre foi do senhor (a)? ☐ 1- Sim ☐ 2- Não

1.08 Há quanto tempo o senhor (a) possui esta casa? ________________________

1.09 Em qual cidade o senhor (a) mora? _________________________

1.10 Tem mata próximo onde o senhor (a) tem a moradia principal? ☐ 1- Sim ☐ 2- Não

1.11 O Senhor (a) costuma alugar essa casa para turistas?

☐ 1-Sim ☐ 2- Não → Siga para 2.1

1.12 Qual o principal motivo do aluguel da casa pelos turistas?

☐ 1- Cachoeiras

☐ 2- Próximo ao parque

☐ 3- Próximo à mata

☐ 4- Boa estrutura da casa (piscina, churrasqueira)

☐ 5- Outro ______________________________

Siga para 2 .1

Registro da UD	Número do módulo	Página
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2– EDUCACÃO e RENDA

2.1. Até qual ano da escola o senhor (a) estudou?

	Marque um X	OBS:
1- Ensino fundamental incompleto		
2- Ensino fundamental completo		
3- Ensino médio incompleto		
4- Ensino médio completo (normal)		
5- Superior incompleto		
6- Superior Completo		
7- Mestrado		
8- Doutorado		
9- Pós Graduação		
10- Nunca estudou		

2.2. Assinale os salários do mês de OUTUBRO/ NOVEMBRO. Por favor, inclua todos que moram com você.

	Marque um X	OBS
1- Até 1.576,00		
2- DE R$ 1.575,00 A R$ 3.152,00		
3- DE R$ 3.152,00 A R$ 7.880,00		
4- DE R$ 7.880,00 A R$ 15.760,00		
5- Acima de R$ 15.760,00		

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3 –Características do domicilio

Nesta parte da entrevista, perguntarei ao senhor (a) algumas coisas sobre esta CASA.

3.01 Esta propriedade é?

- ☐ 1- Própria
- ☐ 2- Alugada
- ☐ 3- Cedida por Empregador
- ☐ 4- Cedida de outra forma

3.02 Qual (is) o (s) tipo (s) de abastecimento de água da casa? (O principal ou os dois principais)

- ☐ 1- Rede pública de água → Siga para 3.03
- ☐ 2- Capta água de chuva
- ☐ 3- Nascente ou mina d'água
- ☐ 4- Poço artesiano
- ☐ 5- Córrego, Lagoa ou Rio
- ☐ 6- Outro. Qual? ____________________
- ☐ 7- Não sabe

(2 a 7) → Siga para 3.04

3.03 Sua casa tem medidor (relógio) de água?

- ☐ 1- Sim
- ☐ 2- Não

→ Siga para 3.05

3.04 O senhor (a) pagou pelo direito de uso da água? Por exemplo, outorga?

- ☐ 1- Sim
- ☐ 2- Não

3.05 Você usa a água abastecida pelo _____________ (1° tipo) para?

- ☐ 1- Higiene (lavar roupa, lavar louça, descarga)
- ☐ 2- Irrigação de plantações
- ☐ 3- Para beber, Você filtra antes? |__| SIM |__| NÃO
- ☐ 4- Para os animais (criação) Quantos animais? _______
- ☐ Outros ________________________

3.05b Você usa a água abastecida pelo _____________ (2° tipo, **SE HOUVER**) para?

- ☐ 1- Higiene (lavar roupa, lavar louça, descarga)
- ☐ 2- Irrigação de plantações
- ☐ 3- Para beber, Você filtra antes? |__| SIM |__| NÃO
- ☐ 4- Para os animais (criação) Quantos animais? _______
- ☐ Outros ________________________

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3 –Características do domicilio

3.06 Esta casa tem banheiro dentro?

☐ 1- Sim, Quantos?__________________

☐ 2- Não ⟶ Siga para 3.08

3.07 Qual o tipo de banheiro é o de dentro da casa?

☐ 1- Rede pública de esgoto

☐ 2- Fossa séptica

☐ 3- Fossa rudimentar

☐ 4- Cano Ligado ao Córrego

☐ 5- Vala

☐ 6- Outro. Qual? ___________________________

3.08 Este domicílio tem banheiros fora de casa?

☐ 1- Sim, Quantos?__________________

☐ 2- Não ⟶ Siga para 3.10

3.09 Qual o tipo de banheiro é o de fora da casa?

☐ 1- Rede pública de esgoto

☐ 2- Fossa séptica ☐ 4- Fossa rudimentar

☐ 3- Cano Ligado ao Córrego ☐ 5- Vala

☐ 6- Outro. Qual?_____________________

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3.10 Sempre foi este tipo de banheiro na propriedade?

☐ 1- Sim

☐ 2- Não, Qual tipo era?________________________________

Quando houve a mudança? __________________________

3.11 APENAS para quem respondeu ter FOSSA:
Sua fossa já deu algum problema?

☐ 1- Sim. Qual ?__________________________ ☐ 2- Não

3.12 O esgoto da pia da cozinha é do tipo de?

☐ 1- Rede pública de esgoto

☐ 2- Fossa séptica

☐ 3- Fossa rudimentar

☐ 4- Cano Ligado ao Córrego

☐ 5- Vala

☐ 6- Joga no terreiro

☐ 7- Outro. Qual? ___________________________

3.13 Você tem alguma plantação na propriedade?

- [ ] 1- Sim
- [ ] 2- Não → Siga para 3.16

3.14 Qual tipo de plantação você tem em sua propriedade?

- [ ] 1- Soja
- [ ] 2- Milho
- [ ] 3- Feijão
- [ ] 4- Café
- [ ] 5- Hortaliças e Legumes
- [ ] 6- Outros ________________

3.15 Qual o tamanho da plantação?

Plantação 1: ________________ Plantação 2: __________________

Tamanho: __________________ Tamanho: _________________

3.16 Qual o destino do lixo da sua casa?

- [ ] 1- Coletado
- [ ] 2- Queimado
- [ ] 3- Enterrado
- [ ] 4- Jogado no rio
- [ ] 5- Leva para cidade
- [ ] 6- Outro destino_______________

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4 –Características do entrevistado

4.01 Quais as suas atividades de lazer?

- ☐ 1- Fazer trilhas (andar a cavalo, bicicleta, caminhar) → Siga para 4.02
- ☐ 2- Nadar no rio, córrego, cachoeiras ou lagoa → Siga para 4.02
- ☐ 3- Ir à Igreja ou cultos → Siga para 4.04
- ☐ 4- Ver televisão → Siga para 4.06
- ☐ 5- Ouvir música → Siga para 4.06
- ☐ 6- Usar internet → Siga para 4.06
- ☐ 7- Ler jornal ou revistas → Siga para 4.06
- ☐ 7- Participar de oficinas (pintar, tocar instrumentos, palestras) → Siga para 4.08
- ☐ 8- Outras atividades. Quais? ____

4.02 Onde o (a) senhor (a) costuma fazer suas trilhas?

- ☐ 1- Próximo de casa (no máximo 5km distante)
- ☐ 2- Longe de casa (mais que 5km)
- ☐ 3- Dentro do Parque

4.03 Onde o (a) senhor (a) costuma fazer suas trilhas possui muitas árvores ou tem mais plantação/pasto?

- ☐ 1- Pasto
- ☐ 2- Mata

Siga para 4.08

4.04 Quantas vezes o (a) senhor (a) vai a Igreja ou culto?

- ☐ 1- Uma vez por semana
- ☐ 3- Duas vezes por semana
- ☐ 2- Três vezes ou mais
- ☐ 4- Raramente (1 ou 2/por mês)

4.05 Além de assuntos religiosos é abordado outro tipo de assunto? (Assinale quantos for preciso).

- ☐ 1- Assuntos de política(leis dos Brasil e do município)
- ☐ 2- Assuntos ambientais (escassez de água, conservação das plantas e animais, desmatamento, poluição).
- ☐ 3- Assuntos da comunidade (problemas com área do parque, saúde, educação).
- ☐ 4- Outros assuntos. Quais foram abordados pelo entrevistado?

____

____

4.06 Na televisão e no rádio qual programação o (a) senhor (a) costuma assistir?

- ☐ 1- Novela
- ☐ 3- Programa de Natureza
- ☐ 5- Outros __________
- ☐ 2- Jornal
- ☐ 4- Religião

4.07 Com que frequência o senhor costuma ver ou ouvir sobre questões ambientais? (escassez de água, conservação das plantas e animais, desmatamento ou poluição).

- ☐ 1- Frequentemente
- ☐ 2- Nunca
- ☐ 3- Às vezes

Siga para 4.10

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4 –Características do entrevistado

4.08 O (a) Senhor (a) já participou de alguma oficina oferecida por ONG´s, ou Parque ou pela comunidade ou pela Prefeitura?

☐ 1- Sim ☐ 2- Não → Siga para 4.10

4.09 Durante a oficina o que foi oferecido?

____

____

____

____

4.10 O (a) Senhor (a) saberia me dizer se nesta região existe alguma área de preservação (Parques, Flonas)?

☐ 1- Sim ☐ 2- Não ☐ 3- Não soube responder

4.11 O (a) Senhor (a) já visitou o Parque Nacional?

☐ 1- Sim ☐ 2- Não → Siga para 5.0

4.12 Quantas vezes o (a) senhor (a) visitou o Parque?

☐ 1- Uma vez ☐ 2- Duas vezes

☐ 3- Três vezes ou mais

4.13 O que você mais gosta de fazer dentro do Parque?

☐ 1- Ir nas cachoeiras ☐ 3- Ver os animais ☐ 5- Caminhar

☐ 2- Ver a mata ☐ 4- Nada

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5 - PERCEPÇÃO E COMPORTAMENTO DO AMBIENTE

Frases afirmativas	Concorda	Concorda em parte	Indiferente	Discorda em parte	Discorda
P1. As matas (Cerrado) são importantes porque dela conseguimos produtos para se alimentar no nosso dia-dia.	4	3	0	2	1
A1. Prefiro morar em lugar sem mata (Cerrado) perto.	1	2	0	3	4
P2. A vegetação do Cerrado é mais pobre que a vegetação de matas com muitas árvores (Mata Atlântica e Amazônia)	1	2	0	3	4
A2. Ao caminhar gosto de ir no meio do Cerrado, da mata.	4	3	0	2	1
P3. No Cerrado não tem muitos animais (veado, siriema, cobra, pássaros)	1	2	0	3	4
A3. Seria bom se pudéssemos retirar mais mata (Cerrado), porque teria mais lugar para construir, plantar ou usar para pasto.	1	2	0	3	4
P4. O que eu faço no córrego que passa perto da minha propriedade pode ser percebido por muitos metros abaixo pelo vizinho	4	3	0	2	1
P5. Os córregos perto da propriedade não tem nenhum peixe.	1	2	0	3	4
P6. A água que tem hoje no córrego é bem menos em quantidade do que tinha a alguns anos atrás	4	3	0	2	1
A4. Não gosto de deixar mata na propriedade porque atrai bichos (veado, siriema, cobra, pássaros)	1	2	0	3	4
P7. Todo o córrego da região possui os mesmos tipos (qualidade) de peixes.	1	2	0	3	4
A5. É melhor retirar as matas ao redor do córrego porque facilita o nosso acesso ou dos animais à água.	1	2	0	3	4
P8. Se tivesse mais fiscalização da prefeitura ou do IBAMA teríamos nossos rios menos poluídos	4	3	0	2	1
P9. O Parque Nacional faz com que tenhamos mais bichos na região (veado, siriema, cobra, pássaros)	4	3	0	2	1
P10. Preservar a mata próxima ao córrego faz com que a água não acabe.	4	3	0	2	1
P11. Estar próximo a um Parque melhora a minha condição de vida	4	3	0	2	1
P12. Substituir a mata nativa por culturas (café, eucalipto) pode alterar a qualidade da água	4	3	0	2	1
P13. Os peixes que encontramos nos córregos perto da propriedade são diferentes dos de dentro do Parque	4	3	0	2	1
P14. A retirada de mata aqui na propriedade não influencia em nada no Parque.	1	2	0	3	4
P15. As queimadas criminosas que acontecem na época de seca não prejudicam a vegetação do cerrado.	1	2	0	3	4
P16. As leis de proteção deveriam ser menos rigorosas no Cerrado, já que é um ambiente ideal para plantar culturas ou ter pastagens	1	2	0	3	4

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1.2 *Carta aos Gestores*

UNIVERSIDADE FEDERAL DE LAVRAS

Departamento de Biologia – Setor de Ecologia
Universidade Federal de Lavras
Campus Universitário – Lavras, MG
37.200-000 Brasil
Tel/Fax: 35-3829.1201

Prezados Senhores (as),

Nós, pesquisadores do Laboratório de Ecologia de Peixes da Universidade Federal de Lavras, viemos por meio desta oferecer sugestões para aprimorar a conservação e o manejo de riachos na bacia do rio São Francisco em Minas Gerais. Nossas recomendações são embasadas nos resultados do projeto que desenvolvemos na região de cinco Parques Nacionais (Serra da Canastra, Serra do Cipó, Sempre-Vivas, Cavernas do Peruaçu e Grande Sertão Veredas) de 2014 a 2016.

Nosso projeto intitulado “O papel dos parques nacionais na conservação de peixes de riachos da bacia do São Francisco em Minas Gerais: definindo estratégias para a conservação da ictiofauna” contou com o apoio da Fundação Grupo Boticário de Proteção à Natureza. Nossos principais objetivos foi avaliar a eficiência dos Parques Nacionais como ferramenta para conservação de peixes de riachos e identificar as principais características físicas do habitat relacionadas à manutenção da diversidade de peixes. Nós amostramos 17.053 indivíduos de 64 espécies de peixes em 60 riachos no interior dos Parques e num raio de 10 km ao entorno deles. Além disso, nós analisamos 255 características (métricas) do habitat físico dos riachos.

Nossos resultados mostraram que 24% das espécies de peixes registradas para toda a bacia do rio São Francisco estão preservadas dentro dos Parques Nacionais mineiros. Esse percentual é ainda maior (32%) quando consideradas também as áreas de entorno. Logo, a ampliação dos parques já existentes aumentaria a proporção de espécies protegidas. Porém, a constatação das diferenças na composição da ictiofauna relacionadas à variação espacial do habitat físico entre os parques nacionais indica que para se conservar a fauna da bacia a criação de novas unidades também é uma excelente estratégia para a proteção da fauna de peixes. O investimento ideal seria a criação de Parques Nacionais em regiões mais afastadas daqueles já estabelecidos e, preferencialmente, em menores altitudes, uma vez que a maioria dos parques da bacia localiza-se em regiões serranas.

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37.200-000 Brasil
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Adicionalmente, seria fundamental a inclusão do entorno dos Parques Nacionais nos planos de manejo, já que estas regiões abrigam considerável biodiversidade. Assim, estratégias de conservação e uso adequado da terra nas regiões de entorno seriam de grande relevância para as unidades de conservação e para a preservação da ictiofauna da bacia.

Constatamos ainda que a manutenção e recuperação do fluxo natural dos riachos (frequência de corredeiras e heterogeneidade de fluxo) e uma atenção especial à mata ciliar (fornecendo abrigos de madeira para peixes) são fundamentais, já que estes fatores estiveram altamente associados à integridade da fauna de peixes dos riachos estudados. Assim, sugerimos um cuidado especial ao construir estradas que cortem os riachos, barramentos que impeçam o fluxo natural do curso d'água, ou com a substituição / retirada da mata ciliar.

Desde já, nos colocamos à disposição para repassar os resultados obtidos.

Atenciosamente,

Ma. Ruanny Casarim (rucasarim@gmail.com)
Me. Yuri Malta Caldeira (yurimc86@gmail.com)
Prof. Dr. Paulo Santos Pompeu (pompeu@dbi.ufla.br)

Lavras, 03 de Outubro de 2016

2.3 Banners


O papel dos Parques Nacionais na conservação de peixes de riachos da bacia do São Francisco: definindo estratégias para a conservação da ictiofauna
SJC Entrada PARNA São João Batista da Canastra
SR Entrada PARNA São Roque de Minas
VB Entrada PARNA Vargem Bonita
Entorno PARNA Serra da Canastra
Limite do PARNA na bacia do São Francisco
PARNA Serra da Canastra
0 3 6 12 Km
O presente estudo foi realizado pela equipe do Laboratório de Ecologia de Peixes da Universidade Federal de Lavras. O objetivo do nosso trabalho foi contribuir para o melhor entendimento do papel dos Parques Nacionais (PARNA) na conservação da fauna de peixes da bacia do São Francisco. A área de estudo compreendeu córregos da bacia do São Francisco dentro dos limites do PARNA Serra da Canastra (CAD) e no entorno do PARNA Serra da Canastra (CAE) em Minas Gerais. Nós utilizamos peneiras para amostrar os peixes ao longo de 150 metros em cada córrego. Em cada curso d'água, a amostragem ocorreu uma única vez no ano de 2014. Os peixes amostrados exclusivamente no parque, exclusivamente no entorno do parque e os peixes amostrados em ambos os ambientes foram identificados.
Equipe: Ruanny Casarim ---- rucasarim@gmail.com Doutoranda Ecologia Aplicada UFLA
Yuri Caldeira ---- yurimc86@gmail.com Mestre Ecologia Aplicada UFLA
Paulo Pompeu ---- pompeu@dbi.ufla.br Professor pela UFLA
PONTOS DO PARQUE
1CAD 2CAD 3CAD 4CAD 5CAD 7CAD 8CAD 9CAD
PONTOS DO ENTORNO
1CAE 2CAE 4CAE 5CAE 6CAE 7CAE 8CAE 9CAE
PARQUE
Neoplecostomus franciscoensis
PARQUE E ENTORNO
Astyanax fasciatus
Astyanax rivularis
Trichomycterus variegatus
Pareiorhina cepta
Hisonotus sp.
Harttia torrenticola
ENTORNO
Astyanax lacustris
Astyanax sp.
Piabina argentea
Characidium cf. zebra
Hoplias malabaricus
Phalloceros uai
Poecilia reticulata
Geophagus brasiliensis
Corydoras multimaculatus
Hypostomus sp.
Harttia sp.
Rhamdia aff. quelen
Rhamdiopsis cf. microcephala
Cetopsorhamdia iheringi
FUNDAÇÃO GRUPO BOTICÁRIO

O papel dos Parques Nacionais na conservação de peixes de riachos da bacia do São Francisco: definindo estratégias para a conservação da ictiofauna

O presente estudo foi realizado pela equipe do Laboratório de Ecologia de Peixes da Universidade Federal de Lavras. O objetivo do nosso trabalho foi contribuir para o melhor entendimento do papel dos Parques Nacionais (PARNA) na conservação da ictiofauna da bacia do São Francisco. A área de estudo compreendeu córregos da bacia do São Francisco dentro dos limites do PARNA Grande Sertão Veredas (VED) e no entorno do PARNA Grande Sertão Veredas (VEE) em Minas Gerais. Nós utilizamos peneiras para amostrar os peixes ao longo de 150 metros em cada córrego. Em cada curso d'água, a amostragem ocorreu uma única vez no ano de 2015. Os peixes amostrados exclusivamente no parque, exclusivamente no entorno do parque e os peixes amostrados em ambos os ambientes foram identificados.

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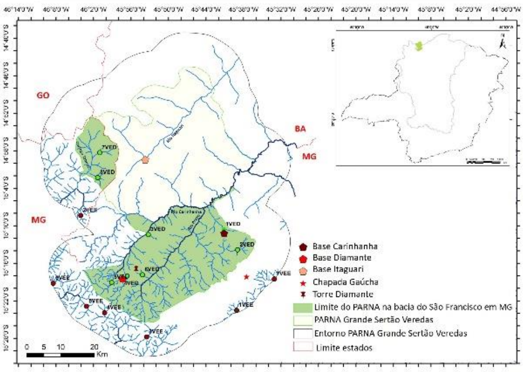


PARQUE

Leporinus piau, *Astyanax cf. bockmanni*, *Bryconops sp.*, *Lepidocharax burnsi*, *Serrapinnus piaba*, *Phenacogaster franciscoensis*, *Moenkhausia sanctaefilomenae*, *Geophagus brasiliensis*, *Cichlasoma sanctifranciscense*, *Phenarcorhamdia tenebrosa*, *Centromochlus bockmanni*, *Sternopygus macrurus*, *Corydoras garbei*, *Harttia leiopleura*, *Rineloricaria sp.*

PARQUE E ENTORNO

Astyanax fasciatus, *Astyanax lacustris*, *Astyanax rivularis*, *Hemigrammus marginatus*, *Piabina argentea*, *Serrapinnus heterodon*, *Characidium fasciatum*, *Characidium cf. zebra*, *Gymnotus carapo*, *Eigenmannia gr. trilineata*, *Synbranchus marmoratus*, *Cetopsorhamdia iheringi*, *Imparfinis minutus*, *Pimelodella lateristriga*, *Rhamdia aff. quelen*, *Trichomycterus variegatus*, *Hypostomus sp.*, *Hisonotus sp.*

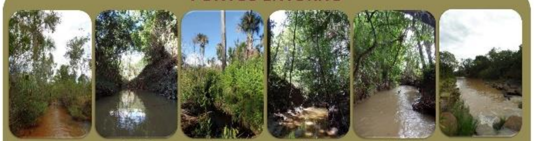
PONTOS PARQUE

1VED, 2VED, 3VED, 4VED, 5VED, 6VED, 7VED

ENTORNO

Bryconamericus stramineus, *Hasemania nana*, *Harttia leiopleura*, *Pareiorhina cepta*, *Trichomycterus brasiliensis*, *Hoplias intermedius*, *Hypostomus sp1.*, *Hypostomus sp2.*, *Hypostomus sp3.*

PONTOS ENTORNO



1VEE, 2VEE, 3VEE, 4VEE, 5VEE, 6VEE

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CAPES

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O presente estudo foi realizado pelo Laboratório de Ecologia de Peixes da Universidade Federal de Lavras. O objetivo do nosso trabalho foi contribuir para o melhor entendimento do papel dos Parques Nacionais (PARNA) na conservação da fauna de peixes da bacia do São Francisco. A área de estudo compreendeu córregos da bacia do São Francisco dentro dos limites do PARNA Serra do Cipó (CD) e no entorno do PARNA Serra do Cipó (CE) em Minas Gerais. Nós utilizamos peneiras para amostrar os peixes ao longo de 150 metros em cada córrego. Em cada curso d'água, a amostragem ocorreu uma única vez no ano de 2014. Os peixes amostrados exclusivamente no parque, exclusivamente no entorno do parque e os peixes amostrados em ambos os ambientes foram identificados.

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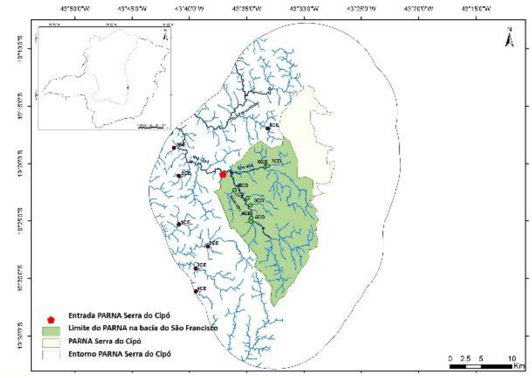

PONTOS PARQUE

PONTOS ENTORNO

PARQUE

PARQUE E ENTORNO

ENTORNO

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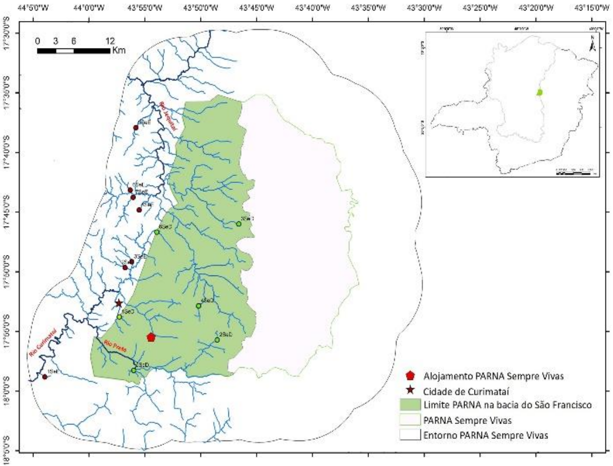

PONTOS PARQUE

1SeD 2SeD 3SeD 4SeD 5SeD 6SeD

PONTOS ENTORNO

1SeE 2SeE 3SeE

PARQUE

Characidium fasciatum

PARQUE E ENTORNO

Astyanax rivularis, *Hoplias intermedius*, *Trichomycterus brasiliensis*, *Hypostomus sp.*, *Characidium cf. zebra*

ENTORNO

Moenkhausia sanctaefilomenae, *Astyanax cf. bockmanni*, *Knodus moenkhausii*, *Poecilia reticulata*, *Serrapinnus heterodon*, *Astyanax fasciatus*, *Astyanax lacustris*, *Lepidocharax burnsi*, *Gymnotus carapo*, *Sternopygus macrurus*, *Eigenmannia gr. trilineata*, *Neoplecostomus franciscoensis*, *Rhamdia aff. quelen*, *Parodon hilarii*

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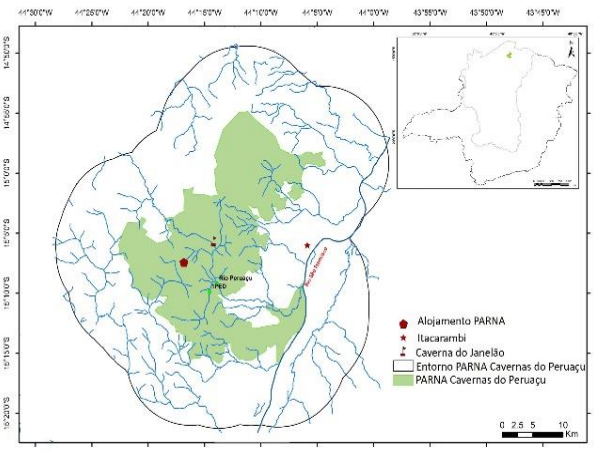

1PED

Rio Peruaçu

PEIXES PARNA CAVERNAS DO PERUAÇU

Astyanax fasciatus — *Astyanax rivularis* — *Hysteronotus megalostomus*

Piabina argentea — *Parodon hilarii* — *Characidium fasciatum*

Poecilia reticulata — *Cetopsorhamdia iheringi* — *Phenacorhamdia tenebrosa*

Imparfinis minutus — *Rhamdia aff quelen* — *Trichomycterus brasiliensis*

Hisonotus sp. — *Hypostomus sp1.* — *Hypostomus sp2.*

Hypostomus sp3. — *Hypostomus sp4.*

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