Universidade de Brasília
Instituto de Ciências Biológicas
Programa de Pós-Graduação em Ecologia

Impactos de um grande incêndio na comunidade de mamíferos de médio e grande porte em uma área de Cerrado no Brasil central

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Resumo

Como eventos de fogo são comuns em savanas tropicais, o conhecimento dos efeitos desses eventos sobre a fauna é fundamental para um manejo adequado das áreas naturais nestes ecossistemas. No presente estudo, investigamos os efeitos de um grande incêndio não planejado (área queimada ~66 000 ha) na comunidade de mamíferos de médio e grande porte em uma área de Cerrado no Brasil central, no Parque Nacional da Chapada dos Veadeiros. O objetivo foi compreender, ao longo de três anos após o fogo, as mudanças na composição da comunidade, na diversidade e nos padrões de ocorrência (abundância absoluta e relativa) das guildas alimentares e das espécies mais abundantes do sistema. Nós comparamos áreas queimadas e não queimadas usando armadilhas fotográficas, registrando 26 espécies de mamíferos de médio e grande porte. A riqueza de espécies foi maior na área queimada (25 espécies) em comparação com a área não queimada (19 espécies). Uma análise de Correspondência Canônica (CCA) evidenciou uma mudança significativa na comunidade em até 3 anos após o fogo, com maior diferença na comunidade entre o primeiro e segundo ano de coleta de dados. Espécies herbívoras (anta e veado campeiro) foram mais comuns nas áreas queimadas, enquanto espécies carnívoras (e.g., puma, lobo-guará e gato palheiro) foram mais abundantes durante o segundo ano após o fogo nas áreas queimadas. Modelos lineares mistos evidenciaram que os efeitos do fogo variam de acordo com as guildas alimentares. O grupo de herbívoros da comunidade apresentou aumento na abundância relativa durante o primeiro ano após o fogo em relação aos valores pré-fogo. Espécies carnívoras (e.g., puma) foram mais abundantes nas áreas queimadas em comparação com as áreas não queimadas, enquanto espécies onívoras e insetívoras apresentaram efeitos do fogo menos evidentes em seus padrões de ocorrência. De maneira geral, houve um aumento na abundância, riqueza e diversidade de espécies, durante o segundo ano após o fogo na área queimada em comparação com a área não queimada e com os valores pré-fogo. Nossos resultados destacam a complexidade da resposta da comunidade de mamíferos de médio e grande porte a um grande incêndio não planejado em uma savana neotropical. Aparentemente, um manejo de fogo eficiente que inclua um mosaico de regimes de fogo (áreas não queimadas e áreas queimadas de um e dois anos), pode contribuir para a diversidade de mamíferos local.

Palavras-chave: efeitos do fogo, mamíferos de médio e grande porte, impacto do fogo na fauna, armadilha fotográfica

Abstract

Impacts of a large wildfire in the medium and large mammals community in a Cerrado area in central Brazil

Because fire events are common in tropical savannas, knowledge of the effects of these events on fauna is fundamental for proper management of natural areas in these ecosystems. In the present study, we investigated the effects of a large unplanned fire (burned area ~66 000 ha) on the community of medium and large mammals in a Cerrado area of central Brazil, in the Chapada dos Veadeiros National Park. The objective was to understand, over three years after fire, changes in community composition, diversity, and occurrence patterns (absolute and relative abundance) of food guilds and the most abundant species in the system. We compared burned and unburned areas using camera traps, recording 26 species of medium and large mammals. Species richness was higher in the burned area (25 species) compared to the unburned area (19 species). A Canonical Correspondence Analysis (CCA) showed a significant change in the community up to 3 years after fire, with the greatest difference in the community between the first and second year of data collection. Herbivore species (tapir and pampas deer) were more common in burned areas, while carnivore species (e.g., puma, maned wolf, and pampas cat) were more abundant during the second year after fire in burned areas. Linear mixed models showed that the effects of fire vary according to feeding guilds. The herbivore group showed an increase in relative abundance during the first year after fire compared to pre-fire values. Carnivore species (e.g., puma) were more abundant in burned areas compared to unburned areas, while omnivore and insectivore species showed less evident effects of fire in their occurrence patterns. Overall, there was an increase in species abundance, richness, and diversity during the second year after fire in the burned area compared to the unburned area and pre-fire values. Our results highlight the complexity of the medium and large mammal community response to a large unplanned fire in a Neotropical savanna. It seems that an efficient fire management that allows the occurrence of a mosaic of areas with distinct fire histories (unburned areas and areas burned one and two years before), may contribute to enhance the local mammal diversity.

Key words: Fire effects, medium and large mammals, fire impacts on fauna, camera trap

Prólogo

Distúrbios são considerados um dos principais mecanismos de manutenção e regulação da biodiversidade. Pode ser considerado um distúrbio qualquer evento que rompa com a estrutura de um ecossistema, comunidade e população, alterando a diversidade, riqueza e abundância de espécies, a disponibilidade de recursos e o ambiente físico (Picket e Thompson, 1978; Fox, 1982; White, 1985; Petraits et al., 1989; Hobbs e Huenneke, 1992). Esses eventos alteram a relação de adequabilidade entre as espécies locais e a área afetada, podendo atuar como propulsores do processo de sucessão ecológica. Este processo consiste na variação da importância e abundância relativa de cada espécie dentro do sistema ao longo do tempo, ou seja, dando espaço para a entrada e saída de espécies no sistema (Fox, 1979; Hobbs e Huenneke, 1992; Petraits et al., 1989). Nesse sentido, sistemas sem distúrbios podem apresentar tendência à dominância de algumas espécies com alto poder competitivo e ausência de espécies com poder competitivo inferior (Fox, 1979; Petraits et al., 1989).

Um dos distúrbios naturais que ocorre em diversos ecossistemas terrestres é o fogo (Bond and Keeley, 2005; Pausas e Keeley, 2009). Esse distúrbio assume particular importância na estruturação dos ecossistemas savânicos (Beerling E Osborne, 2006). Além da sua relevância na ciclagem de nutrientes (Bond e Keeley, 2005), o fogo exerce pressão moduladora na composição e estruturação da vegetação e, por consequência, da fauna (Fox, 1979; Haslem et al., 2011). Os eventos de fogo são caracterizados por um conjunto de atributos chamados de regime de fogo, que incluem padrões de intensidade, frequência, severidade, sazonalidade e distribuição espacial (White 1985, Bond e Keeley 2005). Os regimes de fogo variam globalmente em virtude de fatores como clima, topografia, ocupação territorial e vegetação (Bowman et al, 2011; Wu et al., 2021), o que implica em efeitos também variados na biodiversidade.

As ações humanas têm potencial para alterar os atributos do regime de fogo, seja diretamente, modificando a disponibilidade de combustível (i.e. tipo, continuidade, estrutura e quantidade de vegetação) ou a ignição do fogo (i.e. quantidade e periodicidade), e indiretamente por meio de mudanças ambientais globais e extremos climáticos (Bowman, 2011; Pyne, 2020; Wu et al., 2021). Embora a ignição de incêndios florestais possa ser natural (i.e. causada por raios), em uma escala global os incêndios florestais têm origem majoritariamente antrópica, principalmente ligada a atividades agrárias (e.g. limpeza de áreas, conversão de área natural em pastagem), negligência e ações criminosas (FAO, 2007).

O efeito do fogo na fauna

A dinâmica das comunidades de mamíferos de médio e grande porte em diferentes ecossistemas é influenciada pelos regimes de fogo. Alterações na abundância (Eby et al., 2014; Green et al., 2015), taxas de registro (Soyumert et al., 2010), uso da paisagem (Dees et al., 2001; Cherry et al., 2018;) e diversidade de espécies (Santosa e Kwarina, 2020; Soyumert et al., 2020) são relatadas em diversos estudos globalmente. Da mesma maneira que o tipo de fogo varia entre as localidades, os efeitos do mesmo também vão variar de acordo com as especificidades de cada espécie, aumentando a complexidade de se compreender a resposta da fauna (Eby et al., 2014; Green et al., 2015). De maneira geral esses efeitos podem ser agrupados em efeitos diretos e indiretos.

Efeitos diretos do fogo são aqueles que ocorrem durante ou imediatamente após o fogo e atuam diretamente na sobrevivência dos indivíduos (e.g. mortes, queimaduras, intoxicação respiratória) (Hobbs e Huenneke, 1992; Frizzo et al., 2011). Embora existam registros de mortalidade direta (Silveira et al., 1999; Fekse et al., 2004), características comportamentais e morfológicas que tornam eficientes a detecção e deslocamento (Silveira et al, 1999; Pausas e Parr, 2018) atenuam os efeitos diretos nos mamíferos de médio e grande porte. Espécies fossoriais (e.g. tatus) podem também diminuir os efeitos diretos durante incêndios de superfície, como é o caso no Cerrado (Miranda et al., 2002), se refugiando em tocas no subsolo que conservam a temperatura (Silveira et al., 1999). No caso de espécies com baixa mobilidade ou morfologia suscetível à inflamabilidade (e.g. pelagem inflamável), como o tamanduá-bandeira (*Myrmecophaga tridactyla*), o fogo pode ter efeitos diretos mais evidentes (Silveira et al., 1999). Esses efeitos também estão sujeitos à influência da intensidade e velocidade do fogo, que modulam a probabilidade do sucesso de escape dos indivíduos. No Parque Nacional das Emas (Goiás, Brasil), a comparação da mortalidade de mamíferos em dois incêndios com intensidades distintas revelou que os efeitos diretos são mais severos no evento de maior intensidade, para o qual houve registro de maior mortalidade e detecção de carcaças

(Silveira, 1999). Além disso, o potencial de dano por efeitos diretos pode ser potencializado pelos processos de fragmentação de habitat e expansão da fronteira agrícola, que podem também dificultar o movimento da fauna em busca de refúgio (Nimmo et al., 2019; Silveira et al., 1999).

Os efeitos indiretos do fogo estão intrinsecamente ligados à alteração no habitat e as consequentes alterações na disponibilidade de recursos para a fauna (Hobbs e Huenneke, 1992; Haslem et al., 2011), seja em quantidade, qualidade ou diversidade. O tempo pós fogo é amplamente utilizado na literatura como preditor dos efeitos do fogo na fauna devido a sua relação com a reestruturação do habitat (Hradsky et al., 2017; ver Swan et al., 2015). A complexidade e composição da comunidade vegetal da área queimada é fundamental para a recolonização pós fogo (Haslem et al., 2011), uma vez que é a base da cadeia alimentar dos sistemas ecológicos. Nesse sentido, percebemos também a relevância dos fatores climáticos (e.g. precipitação) após o fogo (Hale et al., 2016), interagindo diretamente com o processo de sucessão ecológica da vegetação, que ocorre em paralelo com o processo de sucessão de fauna (Fox, 1982).

Os impactos do fogo na paisagem não só alteram a disponibilidade de recursos, como interferem nas interações bióticas, intra e interespecíficas, dos sistemas (Geary et al., 2018; Gigliotti et al., 2021). Após a passagem do fogo, tem início o processo de rebrota da vegetação, que é responsável pela mediação do “Magnet effect” (“Efeito magnético”; Archibald et al., 2005), atraindo espécies de herbívoros para a área recém queimada por conta da melhoria na qualidade nutricional e palatabilidade da vegetação (Archibald et al., 2005; Gigliotti et al., 2021). Embora exista uma tendência de aumento na abundância de herbívoros nessas áreas, esse efeito vai variar de acordo com características específicas das espécies, como tamanho corporal, metabolismo, mobilidade, e técnicas de percepção e escape de predadores (Burkepile et al., 2013; Eby et al., 2014). Um processo de *trade-off* entre qualidade de alimento e risco de predação direciona a seleção de habitat por herbívoros em savanas africanas, resultando majoritariamente na seleção de ambientes mais seguros e de menor qualidade nutricional (Burkepile et al., 2013). No Parque Nacional Serengueti, espécies herbívoras de menor tamanho corporal se mostraram mais suscetíveis ao efeito magnético do que espécies maiores (Eby et al., 2014). O potencial de atração do efeito varia de acordo com o tempo de regeneração da vegetação, com estudos apontando para uma duração variando entre 4 (Eby et al., 2014; Green et al., 2015) e 12 meses após o evento de fogo em ambientes savânicos (Gigliotti et al., 2021).

A recolonização das áreas queimadas por espécies pioneiras herbívoras é fundamental para os carnívoros (Green et al., 2015), uma vez que representam os recursos alimentares necessários para sua sobrevivência. Porém, eventos de fogo tendem a reduzir a complexidade e densidade da vegetação (Durigan et al., 2020), criando áreas mais abertas, que podem tanto beneficiar (Gigliotti et al., 2021) como prejudicar o sucesso de predação dos carnívoros (Cherry et al., 2018). A diversidade funcional do grupo e especificidades das técnicas de caça de cada espécie, assim como a técnica de escape das principais presas, são fatores chaves na seleção e uso do habitat dos predadores (Gigliotti et al., 2021). De fato, o aumento no uso de áreas queimadas por herbívoros cria um cenário de acúmulo de presas disponíveis para os carnívoros (Gigliotti et al., 2021), refletindo em um aumento na abundância de predadores (Green et al., 2015). No entanto, a presença e uso dessas áreas por predadores de topo pode também inibir a presença de mesopredadores, que evitam encontros de interação antagônicos com essas espécies e não conseguem explorar o aumento na disponibilidade de presas (Geary et al., 2018; Gigliotti et al., 2021). Por exemplo, na província de KwaZulu-Natal, África do Sul, o predador de topo (leão - *Panthera leo*) apresentou aumento no uso de áreas queimadas, enquanto os outros carnívoros estudados apresentaram respostas neutras em relação ao fogo (Gigliotti et al., 2021).

Outro efeito do fogo nos predadores é a alteração na dieta devido a mudança na diversidade e disponibilidade de presas. Para os pumas (*Puma concolor*) da Reserva Nacional China Muerta, Chile, a ausência de presas médias e grandes nativas após um incêndio florestal é compensada pelo consumo de lebres (*Lepus europaeus*), uma presa menor e exótica (Zuniga et al., 2020). Essa alteração na dieta dos pumas também afetou a raposinha (*Lycalopex culpaeus*) que passou a ter maior representatividade de artrópodes em sua dieta em detrimento das lebres (Zuniga et al., 2020). Porém, a ausência de recursos adequados para o suprimento energético das espécies, independente da guilda alimentar, pode ser crítico para a sobrevivência, implicando em movimentos migratórios em busca de locais adequados e com os recursos necessários (Nimmo et al., 2019; Zuniga et al., 2020), podendo também resultar em mortes e queda no recrutamento de novos indivíduos (Cunningham e Ballard, 2004).

Eventos de fogo ocorrem com frequência no Cerrado, um domínio fitogeográfico savânico localizado na região central do Brasil (Miranda et al., 2002). Sua estrutura fitofisionomica consiste em um mosaico de vegetações que variam em composição de gramíneas, espécies arbustivas e arbóreas (Ribeiro & Walter, 2008). Essas formações abrigam rica diversidade de fauna (Paglia et al., 2012). Atualmente, o Cerrado é considerado um “Hotspot” de biodiversidade, ressaltando sua relevância na conservação de espécies endêmicas frente a um processo intenso de fragmentação de habitat e expansão da fronteira agrícola (Myers et al., 2000). Além disso, é uma região que ainda abriga espécies de mamíferos de médio e grande porte ameaçadas de extinção, como a onça-pintada (*Panthera onca*), o tamanduá-bandeira e o tatu-canastra (*Priodontes maximus*) (ICMBio, 2021).

Embora ocorra de forma natural durante a estação chuvosa (Ramos-neto e Pivello, 2000), o regime de fogo no Cerrado vem sendo modificado por ações antrópicas (Fidelis et al., 2018). O ano de 2017 foi marcado por mega incêndios na região, consumindo grandes áreas ao longo do bioma (Fidelis et al., 2018). Considerando a rica biodiversidade local e a crescente pressão do fogo, é de extrema relevância compreender como a fauna responde a esses eventos. Nesse sentido, com o presente estudo pretendi avaliar os efeitos do fogo na fauna de mamíferos de médio e grande porte numa área central do Brasil, no bioma Cerrado.

O estudo tem como objetivo responder três perguntas centrais: i) O fogo altera a composição da comunidade de mamíferos de médio e grande porte? ii) O efeito do fogo na fauna varia de acordo com as guildas alimentares? iii) A escala temporal (até 3 anos após o evento de fogo) é relevante nos efeitos do fogo na fauna? Para responder essas questões, um estudo de campo foi conduzido no Parque Nacional da Chapada dos Veadeiros, em Goiás, região de Cerrado no Brasil central. Para isso, usamos armadilhas fotográficas dispostas em áreas que foram acometidas pelo incêndio de 2017 e em áreas vizinhas não queimadas. Em relação a essas questões, formulei as seguintes hipóteses:

1: O fogo altera a composição da comunidade e seus efeitos variam de acordo com as guildas alimentares, regulando a abundância absoluta e relativa dos grupos. (considerando os outros componentes da comunidade). De maneira geral, o fogo reduz a abundância, alterando a riqueza e diversidade das espécies, assim como a abundância (absoluta e relativa) das guildas alimentares. Nesse sentido, esperamos encontrar um aumento na relevância dos herbívoros imediatamente após o fogo nas áreas queimadas, acompanhado também por um aumento espelhado na presença de carnívoros (Gigliotti et al., 2021). O efeito do fogo deve ser menos evidente em espécies onívoras e insetívoras (especialmente em termos de abundância relativa) devido à disponibilidade de recursos adequados (Silveira et al., 1999). A diversidade de espécies deve ser maior na área queimada por conta do processo de sucessão ecológica da fauna (Fox, 1982).

2*: Os efeitos do fogo estão relacionados ao tempo pós fogo.* Os efeitos do fogo na comunidade de mamíferos de médio e grande porte devem ser mais evidentes no primeiro ano de coleta de dados após o incêndio, tendo em vista a capacidade de regeneração da vegetação do Cerrado dentro de um ano após o fogo (Pilon et al., 2018) e sua relação com o habitat disponível para a ocupação dos mamíferos (Gigliotti et al., 2021).

Durante o período de amostragem (esforço amostral = 14 004 armadilhas.dia), foram registradas um total de 26 espécies de mamíferos de médio e grande porte. A área queimada (n=25) registrou riqueza total maior do que a área não queimada (n=19). Os resultados indicam uma inversão nos padrões de riqueza de espécies das áreas entre o primeiro e segundo ano de coleta de dados: no primeiro ano a riqueza foi maior na área não queimada, padrão já observado nos valores pré fogo, enquanto no segundo ano a riqueza foi maior na área queimada. A análise dos efeitos do fogo na diversidade de espécies evidenciou um padrão semelhante de inversão, com maior diversidade durante o primeiro ano de coleta nas áreas não queimadas, e maior diversidade no segundo ano nas áreas queimadas.

Os resultados da CCA destacaram a distinção entre o arranjo de espécies da área queimada e área não queimada, e o efeito significativo do tempo na composição da comunidade (matriz secundária; p=0.002). Na área queimada, os dois primeiros semestres após o fogo (ano 1) não apresentaram diferenças relevantes a nível de composição da comunidade. Porém, a composição de espécies foi alterada entre o primeiro e segundo ano de coleta, com maior presença de espécies carnívoras (puma e gato palheiro) e onívoras (lobo-guará, raposinha do campo e jaritataca) durante o segundo ano. A comunidade foi semelhante entre o segundo e terceiro ano de coleta de dados, indicando possível estabilidade dos efeitos do fogo dois anos após o evento de fogo. Além disso, os resultados evidenciaram que áreas abertas que não foram queimadas durante o incêndio tiveram composição de espécies semelhantes a áreas de habitat aberto, intermediário e fechado, que foram atingidas pelo fogo. A presença do veado campeiro nessas áreas ressalta sua preferência pela ocupação de áreas abertas.

De maneira geral, a taxa de registro da comunidade foi maior nas áreas não queimadas, o que está de acordo com os valores coletados antes do incêndio. Esse resultado indica que o fogo não alterou drasticamente a abundância das espécies durante o primeiro ano de coleta de dados. Porém, os resultados destacaram que a taxa de registro nas áreas queimadas começou a aumentar a partir do sexto mês, quando comparada com a taxa de registro pré-fogo, mantendo uma tendência de crescimento até o final do segundo ano da coleta de dados, quando atingiu seu valor máximo.

O grupo de onívoros da comunidade, de maneira geral, foi mais abundante nas áreas não queimadas. Nas áreas queimadas, os resultados indicaram um aumento na taxa de registro do grupo em relação aos valores pré-fogo a partir do décimo mês após o incêndio, permanecendo maior até o final do segundo ano de coleta. O cachorro do mato, espécie onívora mais abundante do sistema, esteve mais associado a áreas não queimadas. O tratamento não foi um fator de efeito significativo no registro do lobo-guará, porém, nas áreas queimadas, a espécie foi mais abundante durante o segundo ano de coleta de dados. Já a raposinha do campo, espécie endêmica do Cerrado, não apresentou influência significativa de nenhum dos efeitos testados.

Em geral, as espécies herbívoras foram relativamente mais abundantes nas áreas queimadas em comparação com as áreas não queimadas. Embora os valores da taxa de registro do grupo tenham oscilado entre valores maiores e menores que os mensurados antes do fogo na área queimada, a abundância relativa dos herbívoros foi consistentemente maior ao longo dos dois anos de coleta de dados na área queimada em comparação com os valores pré-fogo. Para as espécies mais abundantes de herbívoros, o veado campeiro e o grupo de Mazamas, o tratamento não foi um fator significativo na taxa de registro e abundância relativa das espécies. Porém, ambas as espécies apresentaram maior abundância de registros durante o segundo ano de coleta.

O grupo de carnívoros foi significativamente afetado pela incidência do fogo, sendo relativamente mais abundante na área queimada, e pelo tempo, sendo mais registrado durante o segundo ano. Em comparação com os valores pré-fogo, os carnívoros tiveram tanto taxa de registro, como abundância relativa, maiores durante o segundo ano de amostragem. A onça parda, um dos predadores de topo da comunidade, apresentou maior abundância (absoluta e relativa) na área queimada e durante o segundo ano de coleta de dados. Já para as espécies insetívoras da comunidade, os resultados evidenciaram que os padrões de ocorrência das espécies não foram significativamente afetados por nenhum dos efeitos testados nos modelos aplicados.

Nós investigamos os efeitos de um grande incêndio não planejado na comunidade de mamíferos de médio e grande porte de uma savana Neotropical (Cerrado) durante três anos após o evento de fogo. Os resultados mostraram que a incidência do fogo é de fato um fator que altera a composição e padrões de ocorrência da comunidade, sendo estes efeitos não uniformes entre as guildas alimentares e espécies mais abundantes do sistema. As análises evidenciaram um aumento na relevância de herbívoros na área queimada, assim como aumento no registro de carnívoros. Já as espécies onívoras e insetívoras apresentaram efeitos do fogo menos evidentes. O aumento na abundância da onça parda, e ausência de efeito negativo nos padrões de ocorrência da raposinha do campo, são de suma relevância para a conservação das espécies, ambas ameaçadas de extinção. De maneira geral, o efeito do fogo foi mais significativo durante o segundo ano de coleta de dados, com um aumento na riqueza, diversidade e abundância das espécies registradas. Aparentemente, um manejo de fogo eficiente que inclua um mosaico de áreas queimadas (áreas não queimadas e áreas queimadas de um e dois anos) pode contribuir para a diversidade local de mamíferos.

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Introduction

Fire is a natural agent with potential for drastically affecting ecosystem functioning and biodiversity maintenance (McLauchlan et al. 2020; González et al. 2022). In addition to its relevance in nutrient cycling (Bond and Keeley, 2005), fire exerts modulating pressure on the composition and structuring of vegetation and, consequently, on fauna (Fox, 1979; Haslem et al., 2011). Fire effects on flora and fauna have been altered by climate change and anthropogenic activities, wich may intensify the number of fire events and the total burned area worldwide, potentially threatening local biodiversity (Aragao et al., 2008; Pausas and Keeley 2009; Armenteras and Retana 2012). This threat assumes particular importance in ecosystems whose structure is highly influenced by fire, like savanna ecosystems (Beerling and Osborne, 2006; Pilon et al. 2021). In these fire-prone ecosystems, adequate fire management requires the understanding of the effects of large wildfires on their flora and fauna (Nieman et al. 2021).

Large wildfires may profoundly affect all faunal components of the savannas worldwide, including medium and large mammals (Nieman et al. 2021; González et al. 2022). The dynamics of medium and large mammal communities in different ecosystems are influenced by fire regimes. Changes in abundance (Eby et al., 2014; Green et al., 2015;), trap success (Soyumert et al. 2010), landscape use (Cherry et al., 2018; Dees et al., 2001) and species diversity (Santosa and Kwarina, 2020; Soyumert et al., 2020) are reported in several studies globally. Just as fire type varies between localities, the effects of fire will also vary according to the specifics of each species, adding to the complexity of understanding fauna response (Eby et al., 2014; Green et al., 2015). In general, these effects can be classified into direct (i.e. through fire-induced mortalities) and indirect (i.e.

through changes in food resources or habitat structure) effects, and both of them may result in local extinction of mammals (Brook et al., 2008; Ward et al. 2020; Nieman et al. 2021).

Indirect effects resulting from fire impacts on the landscape include not only changes in resource availability, but also interferences with the biotic, intra and interspecific interactions of the systems (Geary et al., 2018; Gigliotti et al., 2021). After the passage of fire, the process of vegetation regrowth begins, which is responsible for mediating the 'Magnet effect' (Archibald et al., 2005), attracting herbivore species to the newly burned area in response to improved nutritional quality and palatability of the vegetation (Archibald et al., 2005; Gigliotti et al., 2021). Although there is a trend toward increased abundance of herbivores in these areas, this effect will vary according to species-specific characteristics, such as body size, metabolism, mobility, and predator perception and escape techniques (Burkepile et al., 2013; Eby et al., 2014; Nieman et al. 2021). The attraction potential of the effect varies according to the timing of vegetation regeneration, with studies pointing to a duration ranging from 4 (Eby et al., 2014; Green et al., 2015) to 12 months after the fire event in savanna environments (Gigliotti et al., 2021). The increased use of burned areas by herbivores may trigger changes in abundance of other guilds. The scenario of herbivore prey accumulation available to carnivores (Gigliotti et al., 2021) may reflect in an increase in top predator abundance (Green et al., 2015). This increase may in turn inhibit the presence of mesopredators, which avoid antagonistic interaction encounters with these species and are unable to exploit the increase in prey availability (Geary et al., 2018; Gigliotti et al., 2021). The effects of burning on mammal communities may potentially last for more time, depending on the fire extent and habitat characteristics (Briani et al. 2004; Birtsas et al., 2012; Lindenmayer et al. 2016; Castro Rego et al. 2021).

The effects of wildfires on the medium and large mammals of the fire-prone neotropical savanna (Cerrado) are poorly understood, despite its high mammalian diversity (at least 33 species with body mass ≥3kg; Paglia et al. 2012) and the relevance of fire in affecting the patterns and processes of Cerrado ecosystems (Gomes et al., 2018; Pivello et al., 2021). The lack of studies investigating fire and mammals preclude general conclusions, but the few available data indicate that direct mortality occurs for some particularly vulnerable species (e.g., the giant anteater *Myrmecophaga tridactyl*a; Silveira et al. 1999) but indirect effects do not preclude the use of burned areas by large herbivores and Xenarthran mammals (Prada 2001, Prada and Marinho 2004). This current limited number of studies available is surely related not only to the intrinsic problems of studying wild mammals but also to the difficulties in designing experiments involving fire at the appropriate scale for evaluating mammal responses in the field. In general, the evaluation of the effects of fire on these animals must be conducted taking advantage of unplanned large-scale events. These fire events do not allow the conduction of properly designed experiments (i.e. with adequate replicates and unburned controls). Large wildfires represent, however, unique opportunities for assessing relevant patterns and processes that could not otherwise be evaluated (Legge et al. 2008, Cazetta and Vieira 2021).

We investigated the effects of an unplanned mega-fire on medium and large mammals in a well-preserved area of Cerrado in a Brazilian conservation unit (Chapada dos Veadeiros National Park). Specifically, we focused on fire-driven changes in species richness and diversity, community composition, and specific responses of feeding guilds and of the dominant species within the community. To evaluate these aspects of mammal communities we sampled areas that were affected by the fire and neighboring unburned areas, using camera traps. We formulated the following hypothesis: 1) *Fire alters community composition and its effects vary according to feeding guilds, regulating the absolute and relative abundance of groups within the community (considering the other components of the community).* Fire reduces overall abundance, altering species richness and diversity, also changing the relative abundance of the feeding guilds. In this sense, we expect an increase in the relative abundance of herbivores immediately after fire in burned areas, followed by an increase in the abundance of carnivores (Gigliotti et al., 2021). The effect of fire should be less evident on omnivorous and insectivorous species (especially in terms of relative abundance) due to the availability of adequate resources (Silveira et al., 1999). Species diversity should be greater in burned areas because of the ecological succession process of the fauna (Fox, 1982); 2) *The effects of fire are related to post-fire time.* The effects of fire on the medium and large mammal community should be more evident in the first year of data collection after the fire, given the rapid regeneration capacity of the Cerrado vegetation within a year after a fire (Pilon et al., 2018) and its relationship with the habitat available for mammal utilization (Gigliotti et al., 2021).

Material & Methods

Study area

We conducted the study in the Chapada dos Veadeiros National Park (CVNP), an integral protection Conservation Unit (UC) located within the Cerrado biome, in the northeast of the State of Goiás, Central-Western region of Brazil. The predominant climate in the region is tropical semi-humid (Aw Köppens), with well-defined seasons (rainy summer and dry winter) and annual rainfall ranging between 1100 mm and 1600 mm, which is concentrated in the rainy season (October to April) (Miranda, 1993).

Currently, the CVNP covers an area of 240 586.56 ha, including the municipalities of Alto Paraíso de Goiás, Cavalcante, Teresina de Goiás, Nova Roma, São João da Aliança and Colinas do Sul (Figure 1). The Park has areas of restricted visitation, with priority allocation for conservation and research, and areas with allowed visitation with a high flow of tourists throughout the year. The Park's vegetation is consistent with that expected for the Cerrado, comprising a heterogeneous mosaic of phytophysiognomies that vary between forest, grassland and savanna formations, sheltering a rich biodiversity (Rosa e Tolentino, 2009). In total, about 74% of the total area of the CVNP is composed of typical savanna vegetation and 16% of grassland formations (Porto et al. 2011).

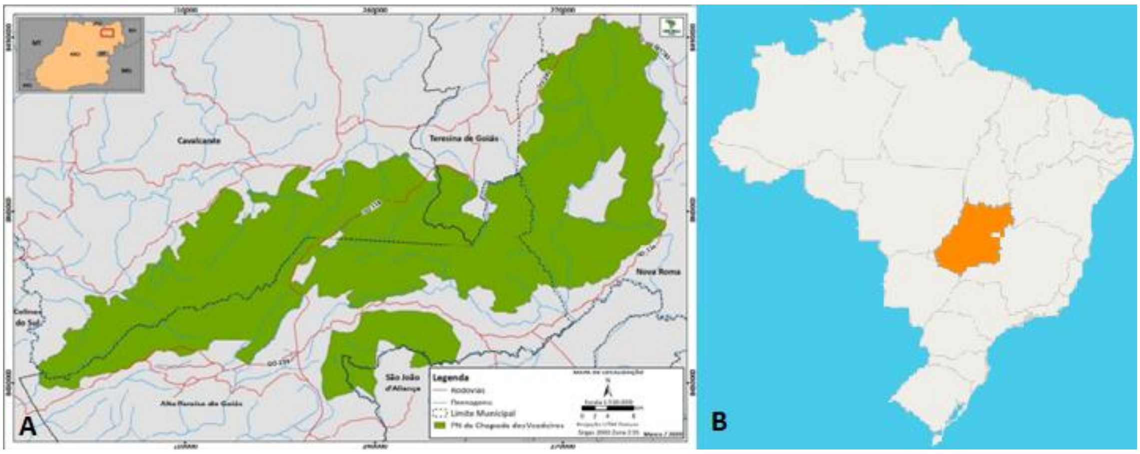

Figure 1. A) Map of the location and boundaries of the Chapada dos Veadeiros National Park. Source: CVNP Management Plan, ICMBio (2021); B) Map of the Brazilian territory highlighting (orange) the state of Goiás. Source: IBGE

The vertebrate fauna of the Park is rich, with approximately 2110 recorded species, with birds (837 species) and fishes (780 species) being the most representative groups (ICMBio, 2021). The mammal fauna in the CVNP has 117 recorded species, of which 39 species of medium and large terrestrial mammals (Rosa & Tolentino, 2009; mammals > 1Kg, according to Fonseca and Robinson, 1990; Bocchiglieri et al., 2010). Within the group of medium and large mammals, the protection area records viable populations of conservation-relevant, threatened and/or rare species (ICMBio, 2021). Even within de Conservation Unit, the fauna is still subject to threats from invasive species (domestic animals), trampling on highways, hunting, expansion of the agricultural frontier (habitat fragmentation), and fires (Lessa et al., 2016; ICMBio, 2021)

Fire is a recurring disturbance in the CVNP, with a history of occurrence in large areas within it for at least the last 30 years (Fiedler et al., 2006; Alves et al., 2013). Fires can have natural (lightning) and anthropic origin, the latter being the most representative within the UC (Fiedler et al., 2006). Human activities such as pasture renewal with the use of fire, mining, accidental or roadside burning, criminal motivations, incendiary or unknown motivation, are among the main origins of fires in the CVNP (Fiedler et al., 2006). Between 1992 and 2003, more than 88% of the recorded fires had anthropic origin, with ignition of criminal origin or unknown motivation being the major causes of these events (Fiedler et al., 2006). Due to favorable weather conditions, such as low humidity and winds, fires between the months of July to September are the most frequent, with the latter month being the most critical (Fiedler et al., 2006). Although the risk of fire occurrence in the CVNP area, in general, ranges from medium to high, the risk is even higher in locations associated with anthropic activities, such as on the edges of the park and adjacent to roads and trails (Aguiar et al., 2015). Studies point to a fire behavior that consumes vegetation from outside to inside the UC, that means, starting in the Park's surroundings and following to consume the areas whitin it (Alves et al., 2013).

In 2017, one of the largest fire events in the CVNP history occurred. This fire burned, between October 10 and 31, about 66 015 hectares (>27% of its total area). The conditions of high fuel availability, relative air humidity below 15%, temperature above 34ºC, winds between 40 and 60 km/h, and severe water drought contributed to a complex fire event of high intensity and speed (ICMBio, 2017). This fire, of criminal origin, cost the federal government more than 3 million reais (about $630 000) to control and fight the fire, in addition to 190 thousand reais (about $40 000) from civil society donations (ICMBio, 2017).

Data collection

The present study is part of a broad program of research and monitoring of the medium and large mammal fauna of the CVNP conducted by the Mammal Conservation Program of the Chapada dos Veadeiros (PCMCV) in partnership with ICMBio, UnB, and the UnB Cerrado Center, ongoing since July 2017. The sampling design of the camera traps was defined aiming to answer different questions, such as the impact of tourism and domestic animals on fauna, for example. During this ongoing research, the CVNP was hit by the major fire, in 2017. The already established design contained areas that burned and areas that did not burn during this 2017 fire. In this new scenario, it was possible to evaluate the effects of fire on fauna, following the sampling design model previously established by the monitoring program of the areas of the CVNP, as illustrated in Fig. 2. However, because it was not specifically designed for this evaluation, due to the impossibility of predicting events of this magnitude, this experimental design was not ideal for a study of this type (due mainly to the lack of adequate pre-fire sampling in the areas). Still, it provided a unique opportunity to evaluate the effect of a large-scale fire on the community of medium and large mammals in neotropical savanna in a Cerrado area.

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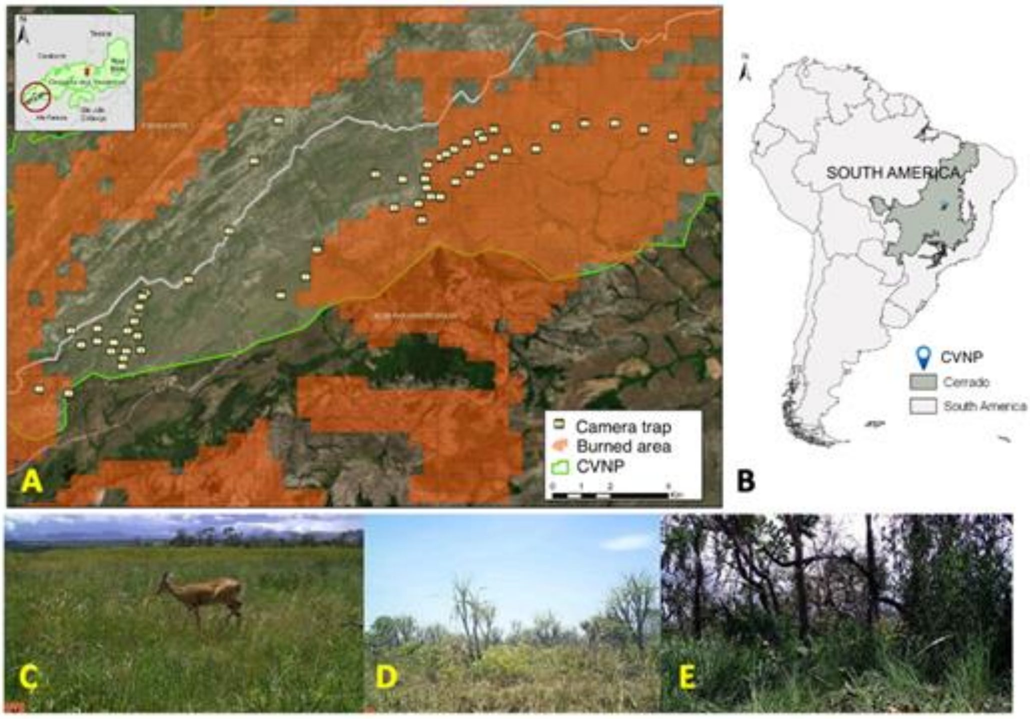

Figure 2. Arrangement of camera traps used for monitoring medium and large mammals in the study area in the Chapada dos Veadeiros National Park (CVNP), central Brazil, with differentiation between burned areas (in red) and unburned areas during the 2017 fire (burned areas accessed with LANDSAT 4 images). B) Location of the CVNP in the Cerrado (neotropical savanna) and in South America. C-E) Pictures rom

camera traps showing the habitat gradient observed in the study. We divided the habitat into 3 categories, from left to right: open (type 1), intermediate (type 2), and closed (type 3).

Data collection of medium and large mammals in the CVNP was carried out using camera traps (Bushnell Trophy Cam HD), which were placed in the field continuously recording the fauna through a motion sensor that activates the trigger of the traps, capturing photos or videos depending on the configuration. This methodology has proven efficient in studies on the effects of fire on mammals (Borchet, 2012; Swan et al., 2015; Chia et al., 2016; Leahy et al., 2016; Hradsky et al., 2017; Soyumert et al., 2010Soyumert et al., 2020; Santosa and Kwarina, 2020; Stiede, 2020; Gigliotti el al., 2021). The sampling units were arranged in the selected areas with one trap per unit, keeping a minimum spacing of 0.5 - 1 km between traps. Over the course of the study, 54 sampling units were installed, of which 24 were in unburned and 30 in burned areas. Due to mechanical failures, repositioning, acquisition and implementation of new traps in the sampling design, the configuration of triggering and recording of traps varied between areas. Thus, the traps were not active simultaneously during the entire study period but overall trapping effort was similar between both areas.

The traps were set to operate 24 hours a day, with 5-second intervals between records, and installed approximately 30-40 cm from the ground on tree trunks of sufficient diameter to support them. When suitable trunks were not found, a steel bar cemented to the ground was installed to follow the standardization. The installation process also included cleaning the space in front of the trap, with the removal of small bushes, leaves and branches that could interfere with the motion sensor, leading to excessive shooting, or harm the visibility of the images recorded. Bait was not used to attract the fauna. The installation process was standardized and replicated in all sampling units.

The sampling units were in operation between July 2017 and October 2020, being removed only during the fire period (10/10/2017 - 31/10/2017) to protect the equipment and then reinstalled for continued monitoring and research. For the maintenance of the traps, field campaigns were conducted with an approximate interval of two months between them. During these expeditions, field data were collected, the batteries of the equipment were replaced, the area was maintained and cleaned, and the operation of the traps was checked.

The identification of the animals was done at the species level by a group of researchers with a similar level of experience. For dubious records, a team of experts was consulted for a conclusive definition. Due to the similarities and difficulty in identifying the deer species - *Mazama goazoubira* and *Mazama americana*, both were considered as *Mazama* spp. Records with impossibility of identification (e.g. blurs, undefined parts of the animals) were classified as unidentified species and removed from the sample. We also excluded animals that were not part of the focal group of the study, such as rodents, birds, and domestic animals (i.e. *Canis familiaris* and *Felis catus*).

Data analysis

For data analysis, we considered the recording of only one individual per species in a 24-hour interval in each camera trap, for ensuring the independence of the data. The records within this 24-h period in which distinct individuals were identified, or with more than one individual in the same photograph, were considered independently. The total sampling effort was counted considering the number of days that the traps were active, measured in traps/day.

Before data analysis, we evaluated the spatial autocorrelation of the sampling units through the Moran index (I), using the SAM software, which indicates the degree of spatial association present in the data set and tests the null hypothesis that spatial independence exists (Rangel et al. 2010). Since this preliminary analysis indicated significant spatial correlation at a scale of 2 km, we grouped the data obtained from nearby traps within this distance. This grouping of camera traps and their respective data was done according to four criteria: the fire treatment of the unit (burned and unburned); the type of habitat (type 1 – open habitat, type 2 – intermediate habitat, type 3 – close habitat); the proximity of the traps; and the spatial arrangement. Thus, traps with the same treatment and habitat, close to each other (0.5 km to 2.5 km) and that, on a landscape scale, made it possible to configure the same continuous patch, were grouped together. This new configuration resulted in 29 sampling units, of which 15 were in the burned and 14 in unburned area. Independent records were readjusted to match the new sampling units.

Data analysis, in general, was based on four main response variables: species richness, Shannon diversity index, trap success (an index of absolute abundance), and relative abundance. Species richness refers to the composition of the community (raw number of species recorded). Shannon diversity index (H') characterizes the community in terms of abundance and heterogeneity (Krebs, 1989). We used the exponential value of H' ("true diversity"; Jost, 2006) for the analyses. We also considered the number of independent records divided by the sampling effort, which indicates the trap success of a given period ($Trap\ success = \frac{N\ of\ Independent\ Records}{Sampling\ Effort}$). The relative abundance, on the other hand, is a metric that indicates the representativeness of the species or animal group within the community in a given period ($Relative\ Abundance = \frac{N\ of\ Independent\ Records}{N\ of\ Total\ Independent\ Records}$). The total data collection period was divided into bimesters and the data from each sampling unit during this period were grouped, allowing for better data treatment and temporal visualization of the results.

To evaluate the effects of fire on guilds we used linear mixed-effect models (LMEs), which describe the relationship of a response variable with the covariates of interest, allowing the incorporation of random and nested factors (Pinheiro and Bates, 2000). For that, we considered trap success, relative abundance, and Shannon's exponential as response variables. Fixed effects considered as covariates of interest were fire treatment (burned or unburned), time after fire (1^{st} or 2^{nd} year), and seasonality (dry or wet season). Sampling units were considered as a random factor in the analyses, sampled in more than one bimester throughout the study. The post-fire time, subdivided into bimesters, was considered in the model by the autocorrelation function of order 1 (AR1), allowing the comparison of time series. Models were run in IBM SPSS 20.0 and the lme4 package (Bates et al. 2015) using the RStudio program (RStudio Team, 2020; RStudio: Integrated Development for R. RStudio, PBC, Boston, MA, United States, http://www.rstudio.com). Effects were considered at the 0.05 significance level ($p<0.05$). We analyzed the fixed effects table of the LME model and used the Bonferroni post hoc contrast test to investigate paired effects.

Treatment was binary coded (fire and no fire), indicating whether the area was burned during the 2017 fire or not. For the coding of the sampling units, we generated a map accessing the burned areas with LANDSAT 4 images and plotting the positioning of the traps to analyze whether they were in a burned or unburned area during the fire (Fig.2). The fixed effect of post-fire time was measured in years (365 days) after the fire, with only the first and second post-fire years being included in the LMEs (year 1: November/2017 - October/2018; year 2: November/2018 - October/2019). Seasonality was coded into dry season (May to October) and rainy season (November to April), totaling two dry and two rainy moments for the models. Due to the adoption of bimesters as the time scale of the study, the month of October (September/October) was classified as dry.

We also evaluated the habitat type, which was classified into three levels, according to the vegetation of the sample unit: (type 1) open habitat, with dominance of grasses; (type 2) intermediate habitat, with dominance of shrubs or few spaced tree species; and (type 3) closed habitat with dominance of densely woody species. This classification was made through a gradient created from images of the camera traps themselves in their respective sampling units (Fig. 2), corresponding to a gradient between grassland areas and areas of typical savanna (cerrado *sensu stricto*). Due to insufficient data for habitats 1 (open) and 3 (closed), the fixed habitat effect was disregarded in the LMEs.

The LMEs were applied both for the isolated effects of the fixed factors and for the interaction between these factors. Thus, the overall model applied for the trap success and relative abundance of each guild was:

*Response variable ~ treatment * year * seasonality*

For the analysis of richness and diversity (Shannon exponential), the sampling effort was incorporated into the global model, since this variable can directly influence the results. For species richness we adjusted the model to a Poisson distribution. The models were also applied independently to the six most abundant species of the mammalian community (*Cerdocyon thous, Chrysocyon brachyurus, Lycalopex vetulus, Mazama spp, Ozotoceros bezoarticus*, and *Puma concolor*) to assess the fire effects on these species.

To assess whether fire alters the community composition of medium and large mammals in the CVNP we conducted a Canonical Correspondence Analysis (CCA) using PAST 4 software (Hammer et al., 2001). This multivariate analysis method presents an ordering of communities as a function of species composition and indicates how environmental variables are related to this composition (Terbraak et al. 1995). The graphical response distributes species according to their abundances and correspondence with selected environmental factors, providing information on the realized niche occupied by the species in the system (Terbraak et al., 1995). For this analysis, data from independent species records were grouped according to the selected environmental factors by pooling records from the same habitat, year, and treatment. In the case of CCA, the data used encompassed the entire period sampled (July/2017 to Oct/2020). For this analysis, the time factor was divided into year 0 (pre-fire), year 1a (first semester of year

1), year 1b (second semester of year 1), year 2 and year 3, which were the "environmental variables" in the analysis. The division of the first year into two semesters was done to detect possible immediate short term (up to six months) effects caused by fire. Only species with independent total records greater than 10 and sampling units with total records greater than 15 were used.

The behavior of the response variables (guilds and most abundant species) over time was graphically represented by comparing areas with and without fire and their respective pre-fire values. For this, we applied a relativization model to the raw values of the trap success and relative abundance, aiming to correct a possible difference between the areas due to their inherent characteristics, independent of fire occurrence. Thus, the following formula was applied for each post-fire bimester:

$$Log(\frac{N+1}{N_0+1})$$

N = mean value of the trap success or relative abundance of the i-th post-fire bimester
N_0 = mean value of the trap success or relative abundance of the pre-fire moment

Results

The total sampling effort was 14,004 traps/day, of which 7,670 were in the burned and 6,334 in the unburned area. During this period, we counted 2,380 independent records (997 in the burned 1,383 in the unburned area), with 26 species of medium and large mammals recorded, belonging to 14 different families (Appendix 1). The community was mostly composed of omnivorous species (n=10), followed by carnivores (n=7), herbivores (n=6) and insectivores (n=3).

Effects of fire on fauna

In the burned area, a total of 25 species was recorded compared to a total of 19 in the burned area (Appendix 1). The seven species recorded only in the burned area were: peccary (*Pecari tajacu*), coati (*Nasua nasua*), jaguarundi (*Puma yagouaroundi*), pampas cat (*Leopardus braccatus*), agouti (*Dasyprocta azarae*), bush dog (*Speothos venaticus*), and giant armadillo (*Priodontes maximus*). Of the 26 species recorded, only one was exclusive to the unburned area (*Tamandua tetradactyla*). Monthly total species richness in both areas ranged from 3 to 15 species over the three years of study (Appendix 2). In the first 4 months after the fire, species richness was greater in the unburned area, which maintains a pattern already observed before the fire. From this period on, however, the burned area showed a pattern relatively similar to the unburned area until the second rainy season, when the values for the burned area were recurrently higher (Appendix 2). In this sense, the results indicate an inversion in species richness of the areas between the first and second year: in the first year, the burned area had lower species richness than the unburned area; in the second, this scenario was reversed, with higher species richness in the burned area (Figure 3A). This inversion was corroborated by the results of the LMEs, in which we identified the significant effect of treatment (z=2.848, p=0.004), year (z=2.702, p=0.007) and the interaction between treatment and year (z=-2.880, p=0.004) on species richness of the community (Appendix 3). In addition, sampling effort also had a significant effect on this metric (z=5.560, p=0.000) (Appendix 3).

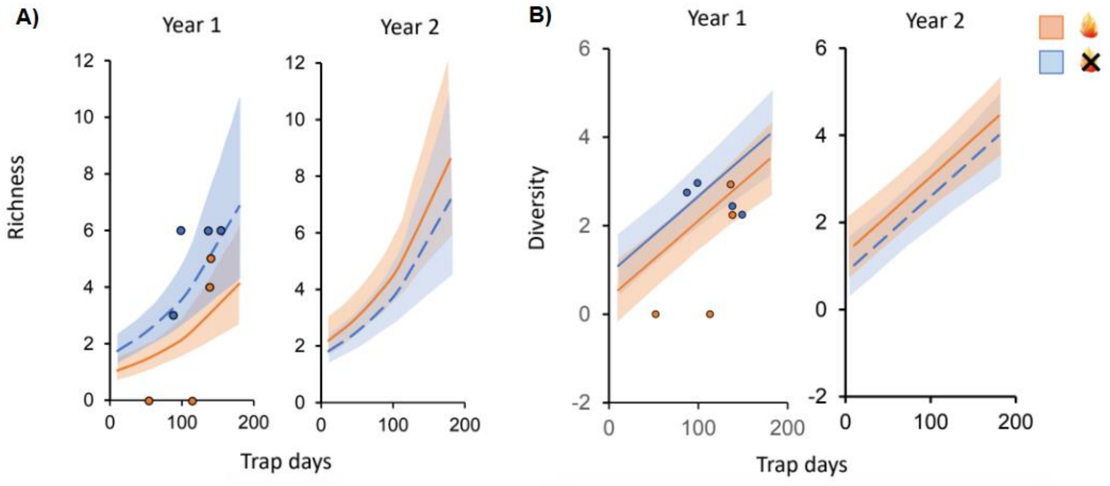

Figura 3. Comparison of the estimates of mammal richness (A) and mammal diversity (exponential of Shannon's entropy index, B) as a function of trap effort (trap days) between unburned (broken blue line) and burned (continuous orange line) areas in the first and second years after a large wildfire in the Brazilian savanna (Cerrado). Shaded areas show the confidence intervals (95%). Circles in the left graphic (Year 1) indicate the values obtained in the pre-fire sampling in the same areas

The diversity of species, measured by the Shannon Diversity Index (exp H'), showed a pattern similar to that observed for species richness. During the first year, diversity was higher in unburned areas, a pattern already observed in pre-fire areas. However, during the second year of sampling, diversity was greater in the burned area (Figure 3B). The results of LME corroborate this pattern, indicating significant effect of the year (F= 14.599, p= 0.000) and the interaction between treatment and year (F=10.263, p=0.002) on the diversity of species in the community (Appendix 4). In general, the community was more diverse during the second year of the study (Bonferroni post hoc test, Appendix 6).

The effects of fire on the structure of the medium and large mammal community, performed with CCA, indicated that species composition (primary matrix) was significantly affected by the temporal factor (secondary matrix; p=0.002). The arrangement of species along the CCA plot indicated that community composition differed between burned and unburned areas. Species such as the crab eating fox, crab eating racoon (*Procyon cancrivorus*), ocelot (*Leopardus pardalis*) and the two species of *Mazama* were associated with the unburned areas. In burned areas, in the first two semesters after fire, there were no relevant differences in terms of species occurrence, although the presence of the giant anteater was more associated with the second post-fire semester. Species composition also tended to be similar between the second and third year after fire, indicating that the community reached certain stability two years after the fire. The community in this period was characterized by the presence of carnivores (puma and pampas cat) and omnivores species (maned wolf *Chrysocyon brachyurus,* hoary fox *Lycalopex vetulus,* and striped hog-nosed skunk *Conepatus semistriatus*). The positioning of the pampas deer (*Ozotoceros bezoarticus*) in the plot highlights its association with open areas, in both open areas (grasslands) that were not burned and areas that became open due to the action of fire. The results showed that the open areas that did not burn during the 2017 fire presented community composition similar to the areas that burned, whether they were open, intermediate or closed habitats (Figure

4).

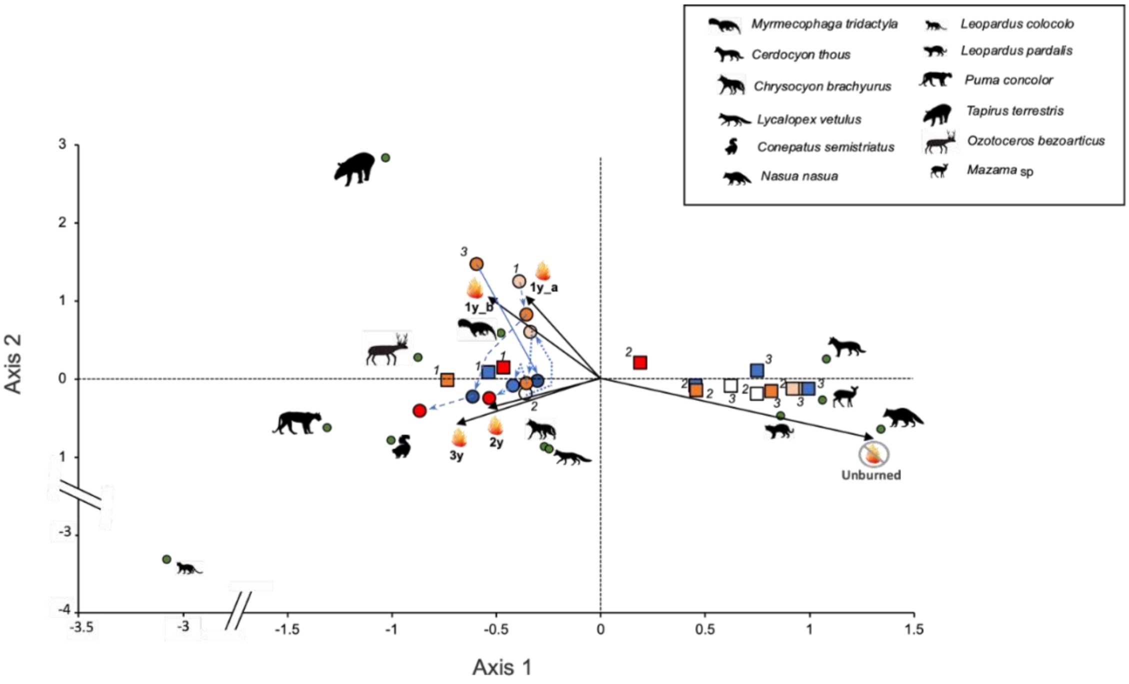

Figure 4. Canonical correspondence analysis (CCA) plot showing the variation in community composition of medium and large mammals in burned and unburned sites before and after a large wildfire in the Neotropical savanna (Cerrado). Time since fire occurrence ('environmental variables') is plotted as black vectors with their codes in bold (1y_a = six months after fire, 1y_b= 1 year after fire, 2y = 2 years after fire, and 3y = 3 years after fire), the position of the sampled sites (groups of camera traps, see text for details) is given by geometric symbols (squares indicate sites located in unburned areas and circles indicate sites located in burned areas) and mammal species are indicated by green dots. Symbol colors indicate time since burning (open symbols = pre-fire sampling, light orange = 6 months after fire, dark orange = 1 year after fire, blue = 2 years after fire, and red = 3 years after fire). Blue lines link the same sites sampled in the burned area in different periods (each site is linked by a unique line pattern). Numbers close to symbols indicate an index of tree cover ranging from open grasslands (1) to typical savanna habitat - cerrado *sensu stricto* (3).

In general, fire incidence (F=6.274, p=0.019) and seasonality (F=6.34, p=0.013) were significant factors on the mammal community trap success (Appendix 4), which was higher in the unburned area compared to the burned area, and in the dry season compared to the rainy season (Bonferroni post hoc test, Appendix 6). The interaction between time and treatment was also significant (F=9.827, p=0.003, Appendix 4), with the burned area showing a higher trap success in the second year after fire when compared to the first one (Bonferroni post hoc test, Appendix 6). The patterns presented by both areas in the first year did not differ from those obtained in the pre-fire sampling, indicating that in the first year the fire event did not drastically alter mammal abundance in the areas (Figure 5). This pattern was corroborated by the evaluation of trap success relative to pre-fire patterns, which was similar between the areas immediately after fire and increased in the burned area from the sixth month after fire, maintaining a growth trend until the end of the second year of collection, when it reached its maximum value (Appendix 5).

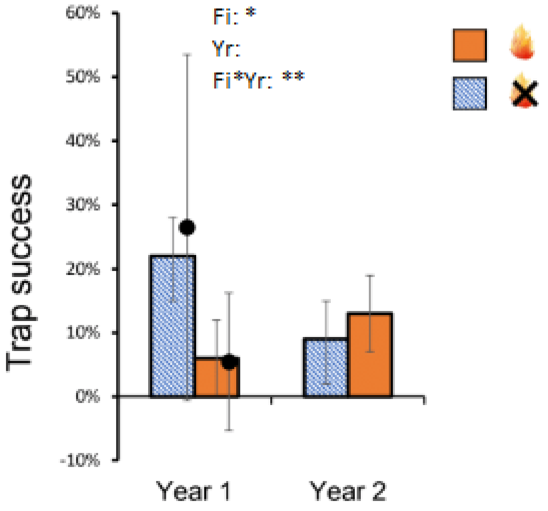

Figure 5. Variation in abundance (trap success) of a community of medium and large mammals in a Neotropical savanna (Cerrado). The factors analyzed were fire occurrence (treatment) and year (1st and 2nd year after fire). The bars indicate the confidence intervals (95%). The significance of the effect of the tested parameters (treatment, year, and interaction between treatment and year) on the LMEs (See text for details) is indicated in the text box inside the graphs. The dark dots represent the pre-fire values. Significant difference is indicated by use of asterisk: p<0.01 = **, p <0.05 = *, NS= not significant.

As for the guild-specific response, the omnivore group showed significant response of treatment (F=25.785, p<0.001) and the interaction between treatment and year (F=8.837, p=0.004) in trap success (Appendix 8), this being higher in the unburned area and in the first year of sampling (Bonferroni post hoc test, Appendix 6; Figure 6). The relative abundance of the group showed significant value for the same effects (F=25.964, p<0.001; F=6.185, p=0.015; Appendix 8), with higher relative abundance also in the unburned area (Bonferroni post hoc test, Appendix; Figure 6). In the burned area, omnivorous species showed an increase in trap success in relation to the pre-fire pattern from the tenth month after fire, remaining higher until the end of the second year of data collection (Appendix 9A).

The herbivore group, on the other hand, showed significantly higher relative abundance in the burned areas (F=6.235, p=0.02, Appendix 8; Bonferroni post hoc test, Appendix 7). During the two years of post-fire sampling, the relative abundance values of the group in the burned areas were higher than the values found in the pre-fire period (Appendix 9B). The trap success of herbivores was not significantly affected by the incidence of fire (Appendix 8, Figure 6). The values of trap success oscillated over time between values higher and lower than those recorded before the fire (Appendix 9B). The temporal factor had a significant effect on trap success (F=18.959, p<0.001) and relative abundance of the group (F=10.597, p=0.002, Appendix 8), with more animals being recorded in the second year of data collection (Bonferroni post hoc test, Appendix 6 and Appendix 7; Figure 6). The herbivore group was the only one for which seasonality had a significant influence on trap success (F=8.347, p=0.005, Appendix 8), being higher during the dry season (Bonferroni post hoc test, Appendix 6). Overall, the herbivore group had the highest relative abundance within the burned area mammal community (Figure 6).

The occurrence of fire significantly affected the relevance of carnivores in the community. This group was relatively more abundant in fire-affected areas compared to unburned areas (F=6.675, p=0.017, Appendix 8; Bonferroni post hoc test, Appendix 7; Figure 6). The temporal factor (F=4.18, p=0.047) and the interaction of treatment and year (F=4.791, p=0.034) were significantly relevant to carnivore’s trap success (Appendix 8), with more records in the burned area during the second year of collection (Bonferroni post hoc test, Appendix 6; Figure 6). Both trap success and relative abundance of carnivores were significantly higher during the second year of collection than in the pre-fire period (Appendix 9C).

The occurrence of fire did not seem to affect markedly the insectivore group. This was the only guild for which none of the factors tested (trap success or relative abundance) were significant (Appendix 8).

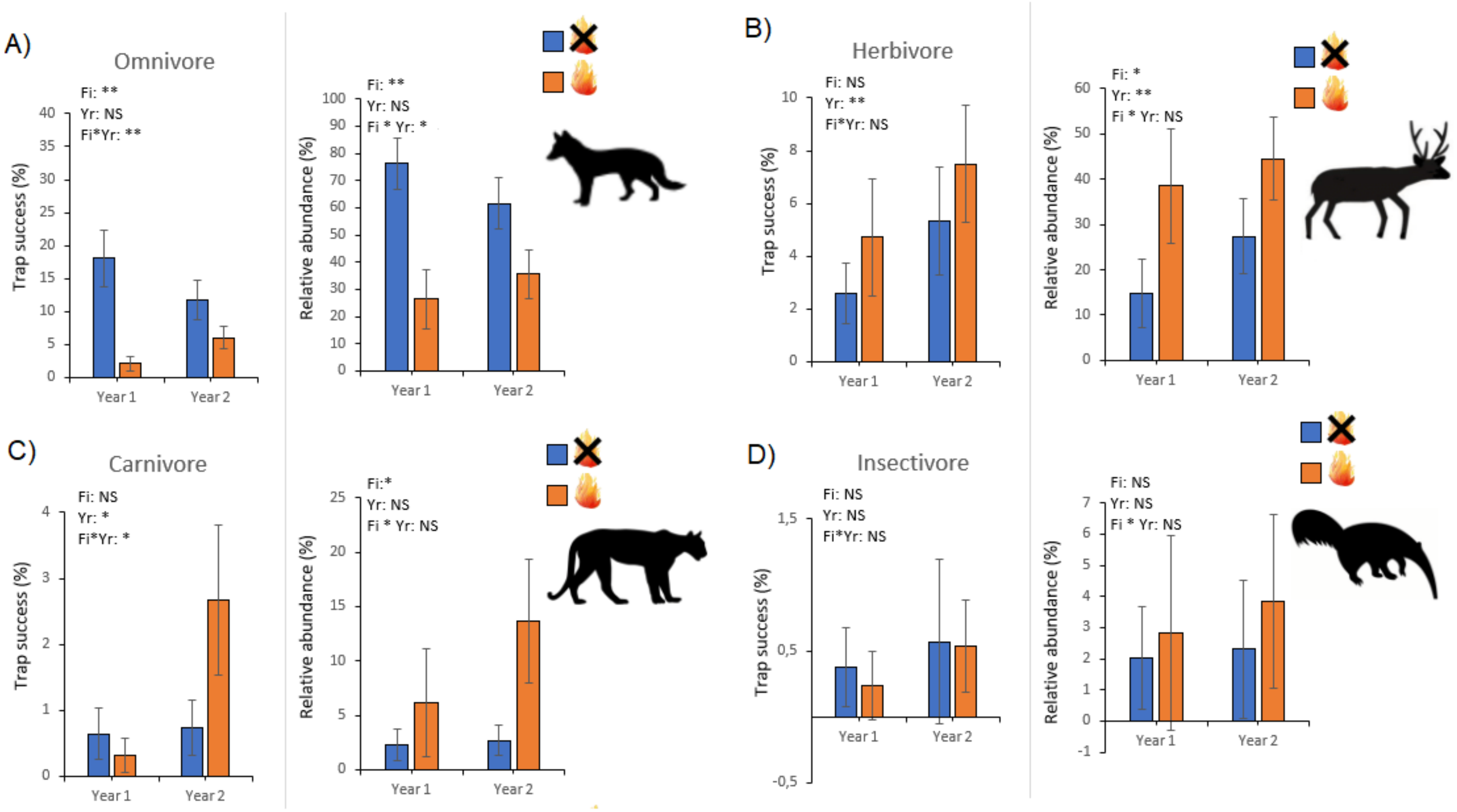

Figure 6. Variation of Trap success (left) and Relative Abundance (guild abundance in relation to total abundance; right) of guilds in a community of medium and large mammals of a Neotropical savanna (Cerrado). The factors analyzed were fire occurrence (treatment) and year (1st and 2nd year after fire) for the group of omnivores (A), herbivores (B), carnivores (C), and insectivores (D). The bars indicate the confidence interval (95%). The significance of the effect of the tested factors (treatment, year, and interaction between treatment and year) on the LMEs (See text for details) is indicated in the text box inside the graphs. Significant difference is indicated by asterisks ($p<0.01$ = **, $p<0.05$ = *, NS= not significant).

The effects of fire on the most abundant species in the community revealed the species-specific nature of the responses to this disturbance. Among the canids, treatment and year were factors that individually affected trap success (F=35.425, p=0.000; F=5.396, p=0.023) and relative abundance (F=42.865, p=0.000; F=8.939, p= 0.004) of the crab eating fox (Appendix 10), with more records in the unburned areas and in the first year (Bonferroni post hoc test, Appendix 6 and Appendix 7; Figure 7). The maned wolf was the only canid species with a significant effect of seasonality (F=5.069, p=0.026, Appendix 10), with higher relative abundance during the rainy season (Bonferroni post hoc test, Appendix 7). Although the effect of treatment alone was not significant for relative abundance, the interactions between year and treatment (F=17.366, p<0.001) and treatment, year and season (F=5.069, p=0.030) were significant for the species (Appendix 10, Figure 7). The results showed that in the burned areas, this canid was more relatively abundant during the second year (Bonferroni post hoc test, Appendix 7). In this period, it was even more abundant in the rainy season (Bonferroni post hoc test, Appendix 7). Trap success was also significantly affected by the interaction between treatment and year (F=9.611, p=0.004, Appendix 10), with more records in burned areas during the second year of sampling (Bonferroni post hoc test, Appendix 6; Figure 7). For the other canid species, the hoary fox, there was no significant influence of the effects tested (Appendix 10).

For the herbivore species analyzed, the pampas deer and the *Mazama* group, treatment alone did not affect significantly the relative abundance or trap success (Appendix 10). For *Mazama spp*, however, both these variables were affected significantly by year (F=5.874, p=0.018; F=6.572, p=0.013, Appendix 10), with higher number of records during the second year of collection (Bonferroni post hoc test, Appendix 6 and Appendix 7; Figure 7). For the pampas deer, trap success was significantly affected by year (F=6.033, p=0.017) and the interaction between treatment and year (F=5.125, p=0.028, Appendix 10). This species was more abundant in the burned areas, during the second year of sampling (Bonferroni's "post hoc" test, Appendix 6; Figure 7). Its relative abundance was not significantly affected by any of the factors tested (Appendix 10).

The burning significantly affected the occurrence of the puma, one of the top predators of the sampled community. For this species there was a higher number of records in the burned areas (Bonferroni post hoc test, Appendix 6 and Appendix 7), with significant effect of treatment on trap success (F=4.444, p=0.045) and relative abundance (F=8.99, p= 0.007, Appendix 10; Figure 7). The year and the interaction between treatment and year were also significant on trap success of the species (F=4.238, p=0.045; F=5.181, p=0.027, Appendix 10), with more records in the burned areas during the second year (Bonferroni post hoc test, Appendix 6; Figure 7).

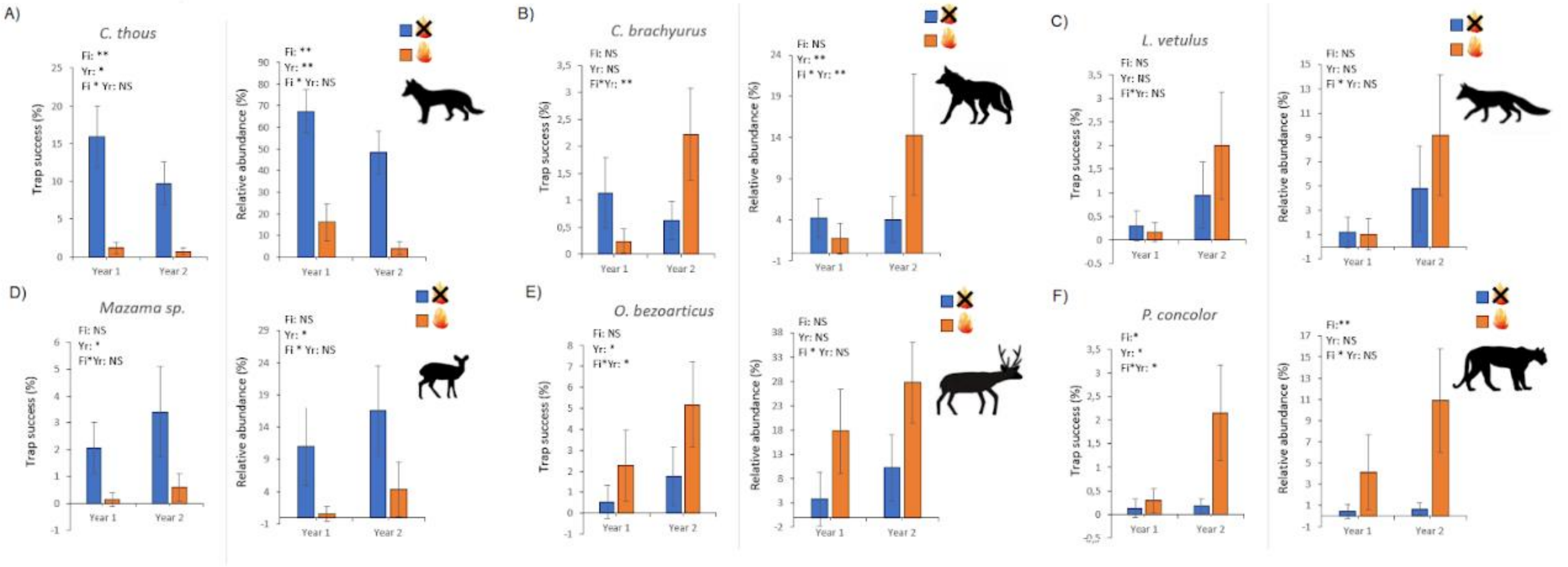

Figure 7. Variation of Trap success (left) and Relative Abundance (guild abundance in relation to total abundance; right) of the most abundant species of a community of medium and large mammals of a Neotropical savanna (Cerrado). The factors analyzed were fire occurrence (treatment) and year (1st and 2nd year after fire) for the species: crab eating fox (A), maned wolf (B), hoary fox (C), pampas deer (D), Mazama group (E), and puma (F). The bars indicate the confidence interval (95%). The significance of the effect of the parameters tested (treatment, year and interaction between treatment and year) on the GLEs (See text for details) is indicated in the text box inside the graphs. Significant difference is indicated by use of asterisk: p<0.01 = **, p <0.05 = *, NS= not significant.

Discussion

We investigated the effect of a large wildfire on the occurrence patterns of a medium and large mammal community in a Neotropical savanna (Cerrado) during three years after the fire event. Results showed that fire incidence was indeed a factor that alters community composition, and these effects are not uniform across species and guilds in the system. Fire did not markedly alter the occurrence patterns of mammals in the burned area during the first year after the fire event (as suggested by the pre-fire assessment), except for the herbivore group. This group showed a marked increase in relative abundance during the first year. For most species and guilds, in the second year, there was generally an increase in both abundance and overall richness and diversity in the burned area relative to the unburned area and the pre-fire period.

This study contributes to the understanding of the effects of a large-scale unplanned fire on a natural environment and is of major importance given the trend of increasing frequency and intensity of fire events in the face of global environmental change and anthropogenic actions (Pyne, 2020; Bowman, 2011; Wu et al., 2021). Our evaluation of the effects of a mega-fire on mammals, however, may be subject to criticism because of the opportunistic nature of the ‘experiment’, considering the lack of real replicates and short pre-fire sampling period. Our limited pre-fire sampling, however, although short, is extremely relevant given the rarity of studies with this approach for medium and large mammals (Nieman et al., 2021). These experimental limitations, generally inevitable, must not devalue the importance of opportunistic studies in building knowledge about unplanned fire events (e.g. Fox, 1982; Mendonça et al., 2015; Legge et al., 2008; Cazetta and Vieira, 2021), although conclusions and generalizations should be made with caution (Davies and Gray, 2015).

Mammal community composition and diversity

The record of 26 species of medium and large mammals in a Neotropical savanna region (Cerrado) is in agreement with that found in studies in Emas National Park (26 species; Silveira et al., 2003) and in the CVNP region itself (23 species; Ferrenguetti et al., 2019), confirming the effectiveness of camera trapping sampling for recording local fauna.

The higher total species richness recorded in the burned areas was in line with what was expected due to the process of ecological succession of vegetation and fauna caused by the incidence of fire. The restructuring of the community after a disturbance, responds to the interaction between the regeneration time of habitat and the availability of resources, which determine the possibility of the animal occupying, or not, the community in a given period of time ("habitat accommodation model"; Fox, 1982). In this sense, the variation in community composition over time and the significant increase in species richness in the second year after fire are possibly due to the variation in resource availability.

The community composition of the burned area differed between the first and second year of sampling, the latter being more diverse (higher H'). The results indicated, however, a similar composition between the second and third year, indicating possible tendency in the stability of the effects two years after the fire event. Emphasis on the relevance of the second year after fire is also highlighted in the trend of increasing species richness, registration rates, and relative abundance of species and food guilds during this period. A long duration of fire effects on mammals was also observed in a forest area in Macedonia, Greece. In this region, the effects of a fire on the record of carnivores in the area lasted for three years, with more records of carnivore species in the intensely burned area compared to the unburned area (Birtsas et al., 2012). On the other hand, the effects of prescribed fires on fauna in African savannas are estimated to persist between three and twelve months after fire (Eby et al., 2014; Green et al., 2015; Gigliotti et al., 2021). This difference may be related to the type and extent of fire (i.e. forest fire vs prescribed burning) and its relationship to the vegetation restructuring process, as well as specific environmental characteristics (i.e. climate, topography, local biodiversity) of each fire event. In this sense, our results indicate a minimum interval of two years between burnings in the studied region, since in this period we observed an increase in the diversity and presence of fauna in areas with fire incidence.

Our results indicated clear differences in the community composition between burned and unburned areas, indicating the species-specific nature of the faunal response to fires. The environmental conditions of the burned areas seemed to favor species associated with the occupation of open areas, such as the pampas deer and the pampas cat, for example (Duarte et al., 2012a, Silveira et al., 2005). The unburned areas had more ocelot and the two species of Mazama (*M. goazoubira and M. americana*) present in the community, which are associated with forest environments (Duarte et al., 2012b; 2012c; Wang et al., 2019). However, the results point to a similarity in community composition between areas of open habitat that were not burned and areas of open, intermediate, and close habitats that were affected by the 2017 fire (Figure 6). This result is a consequence of the effects of fire on vegetation, reducing biomass and simplifying habitat structure in favor of more open environments (Smit et al., 2010)

We evaluated two similar, nearby areas, whose main difference between them was the occurrence of a large burn. However, the results of the pre-fire assessment indicated differences between the areas that were not related to the fire event. Other local factors could be differentially affecting these areas, such as the flow of tourism, which is greater in areas that were not burned (Souza, 2020). This effect of tourism on the mammal fauna can in some cases alter the composition of the local community (Souza, 2020; but see Barcelos et al. 2022). Thus, for some species, such as the crab eating fox, fire by itself probably was not responsible for the differences detected in the first year after fire. However, the interaction between fire occurrence and year indicated differences between areas caused by fire, which were detectable mainly in the second year after the fire event. A study conducted with the medium and large mammal community of the CVNP found that tourist visitation is a relevant factor in the community composition, with less diversity in the most visited areas and with more records of rare species (e.g. puma, bush dog) in the areas without visitation (Souza, 2020). In addition, the higher overall trap success in unburned areas should be analyzed with caution due to the possible effect of well-delineated trails on increasing fauna detectability (Klowski and Forrester, 2017).

Effects on mammalian guilds

The higher relative abundance of herbivores in burned areas indicates greater representativeness of the group in the community composition of these areas, as predicted by the magnetic effect hypothesis (Archibald et al., 2005). The attraction of herbivores to newly burned areas is evidenced in several studies in African savannas and can also be observed in the present study in the increased relative abundance of the group in the burned area during the two years after the fire event compared to the pre-fire period. In African savanna areas, in Bénoué National Park (Klop et al., 2017) and Serengueti National Park (Eby et al., 2014), herbivores showed a preference in using newly burned areas, despite species-specific variation. This pattern was also observed in Hluhluwe-Umfolozi Park, where herbivores are reported to disperse from unburned to burned areas (Archibald et al., 2005). In the present study, however, the absence of a significant effect of fire occurrence on the group's trap success indicates a limitation in the expected effect. On the other hand, the herbivores were not as negatively affected by fire as other groups. The attraction effect of herbivores may have been less evident in the present study due to the low variety, abundance, and specificity of the herbivore species recorded: of the six species, only three (pampas deer, *Mazama spp*, and tapir - *Tapirus terrestris*) were recorded more than eight times during the entire study period (Appendix 1). The two species of *Mazama* with confirmed occurrence in the study region (*M. goazoubira* and *M. americana*) are associated with forest environments (Duarte et al., 2012b; 2012c). This is also the case of the tapir, which prefers forest environments associated with water bodies (Medici et al., 2012). The pampas deer, on the other hand, is a species that occurs in open environments (Duarte et al., 2012a). The specificity in habitat use of the main herbivore species of the sampled community may be a determining factor in limiting the observed magnet effect, since the tendency of fire passage is to reduce biomass and create open environments. Corroborating the results we found, a study conducted in a cerrado reserve in Mato Grosso showed that the records of tapirs and pampas deer were not significantly affected by the incidence of fire (Prada, 2001). The author points out that the presence of herbivore species throughout the study period indicates the absence of a clear ecological succession process among herbivores in the area, unlike what is observed in African savannas (Prada, 2001).

One of the factors that can modulate the occupancy of burned areas is the presence of predators and consequent predation risk (Burkepile et al., 2013). Our results indicated an increase in the record and relative abundance of carnivore species in the burned area after fire, as we expected. In African savannas, the response of predators varies between studies. In Kenya, there was an increase in the overall record of carnivores following a prescribed burn, although the duration of the effect ranged from 3 months for larger species, to 12 months for smaller species (Green et al., 2015). In South Africa, the effects of prescribed fire on the intensity of use of burned areas by the carnivore group were not significant, but species responded in specific ways to burning (Gigliotti et al., 2021). In our study, the lack of a significant increase in the absolute abundance of herbivores may indicate that other species (e.g. small mammals, Vieira, 1999) served as attractants for the carnivores in the burned area. This attraction could at the same time inhibit the attraction of herbivores due to increased risk of predation (Burkepile et al., 2013). Furthermore, the richness of carnivores recorded in the two years following the fire in the burned area (n=6), indicates variety in the available food resources. Also, the higher tourism flow in the unburned areas may also be a factor inhibiting the presence of carnivores (Ngosprasert et al., 2016), with comparatively higher utilization of the burned areas (i.e. those with lower tourism flow).

For the top predator puma, the higher trap success and relative abundance in burned areas indicate that this may be the carnivore species that benefits most from the effects of fire on habitat and prey availability (i.e. richness and diversity). The significant increase in records in the second year of sampling indicates greater benefits in obtaining resources over the long term (i.e. >1 year). In California, puma presence was also positively associated with burned areas (Jennings et al., 2015). In this case, the species was associated to areas with fire history between 2 and 5 years, with evidence that the species avoided newly burned areas (i.e. <1 year) (Jennings et al., 2015). These results differ from that found for the species in Florida (Dees et al., 2016), where an analysis on puma habitat use in a prescribed burned mosaic revealed higher intensity of use in recently burned areas (i.e < 1 year) compared to late post-fire areas (i.e > 2 years) (Dees et al., 2016). A similar result was found for a top predator in South Africa (i.e. lion, *Panthera leo*), with an increase in intensity of use of burned areas immediately after fire (i.e < 1 year) (Gigliotti et al., 2021). In this sense, evidence of increased recording of the puma in burned areas is of major importance for the conservation of the currently endangered species.

Vegetation simplification may have opposite effects, potentially benefiting predators (Leahy et al., 2016) but also harming them in some cases (Eby et al., 2012), depending on the species hunting tactics and the prey's escaping behavior. In the case of the puma, the scenario appears to be favorable, due to the increased trap success in the post-fire period, which may indicate an increase in hunting success or an increase in the rate of resource foraging for this species, resulting in a greater number of records in the area. It has been suggested that the presence of a top predator in an area may inhibit the occurrence of mesopredators (Geary et al., 2018; Gigliotti et al., 2021) and our results support this hypothesis. The records of the pampas cat and jaguarundi only occurred in the daytime period, which may be a form of temporal niche segregation to avoid antagonistic interactions with the puma, which has preferentially nocturnal foraging habits (Azevedo et al., 2018). Furthermore, the results indicated that the occurrence of the ocelot in the study area is associated with unburned environments. This habitat preference by this medium carnivore may be a reflection of the inhibition caused by the presence of the top predator (i.e. puma). This pattern of mesopredator suppression was also observed in a community on the African savanna (Gigliotti et al., 2021). In this case, the top predator (i.e. lion) increased the use of burned areas with high prey availability, while smaller species showed mostly neutral response to fire (Gigliotti et al., 2021). This effect was also observed in Australian savannas, with a significant increase in the presence of dingoes (*Canis dingo*) soon after fire, associated with inhibition of the presence of foxes (*Vulpes vulpes*) (Geary et al., 2018) and feral cats (*Felis catus*) (Leahy et al., 2016). In our study, however, this pattern did not occur for other mesopredator mammals, such as the maned wolf and hoary fox. This pattern might be explained by a higher tolerance between the puma and these omnivore canids than for other felids (more strictly carnivores).

The omnivorous species were more recorded and relatively more abundant in the unburned area. However, these results should be viewed with caution because of the high abundance of crab eating fox records in the sample, which was the only omnivore whose trap success and relative abundance were significantly affected by treatment (fire occurrence). This high dominance of *C. thous* may have masked the effects of fire on the less abundant omnivorous species. In general, the mostly generalist habits of omnivorous species are expected to mitigate the effects of fire. As already discussed, the greater presence of carnivores in burned areas may also be a factor that drives away omnivore species because of the risk of predation.

The absence of a significant effect on the recording and relative abundance of the hoary fox indicates similar occurrence patterns for the species when comparing areas, seasons, and over time. The species has a diet, although omnivorous, mostly composed of insects (Juarez and Marinho-Filho, 2002). In the Cerrado, the availability of invertebrates is not markedly reduced after fire (Briani and Vieira, 2013), which may decrease the negative indirect effects on the species. The results are of great importance for the conservation of the field fox, since it is the only endemic canid species of Cerrado.

Similarly to the hoary fox, the generalist feeding habits of the maned wolf possibly diminished the indirect effects of fire. This characteristic may have resulted in the absence of significance of fire occurrence on its trap success and relative abundance. The results indicated that the species was relatively more abundant in the second year of the study in the burned area. This indicates that, as with the puma, a two-year period is necessary to observe positive effects of fire on maned wolf occurrence.

As expected, the effects of fire on the insectivore group of the community were not significant. A study conducted in Mato Grosso state, Brazil, also highlighted that Cerrado insectivore species do not differ in intensity of use between burned and unburned areas (Prada and Marinho-Filho, 2004). The study highlights that insects remain available after fire (Prada and Marinho-Filho, 2004). In this sense, the availability of resources for insectivorous species mitigates the indirect effects of fire.

Conclusion

Our results highlight the complexity of community-level responses of medium- and large-sized mammals to a large-scale unplanned fire in a Neotropical savanna area in Brazil. Contrary to our hypothesis (stronger effects during the first year after the mega-fire), the effects of fire were more evident in the second year of data collection, with increasing diversity and species richness in the burned area, as well as overall abundance, compared to the first year. We also hypothesized that the effects of fire would alter the patterns of occurrence of mammals in a species-specific manner, varying among feeding guilds. In general, the results corroborated what was expected, since the responses varied among the food guilds and species analyzed. The increase in the relevance of herbivore species and in the recording of carnivore species was also in line with what was hypothesized, although to a lesser extent than we expected in the case of herbivores. The evidence of increased recording of pumas in the burned areas, as well as the absence of negative effects of fire on the abundance of the hoary fox are relevant for fire management and the conservation of these endangered species. Furthermore, the results suggest a minimum interval of two years between fire events for the management of local fauna. In the current scenario of intensification of fire events in Brazil, and worldwide, this study is valuable contribution for increasing the knowledge about the effects of fire on the fauna of medium and large Brazilian mammals.

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Appendix

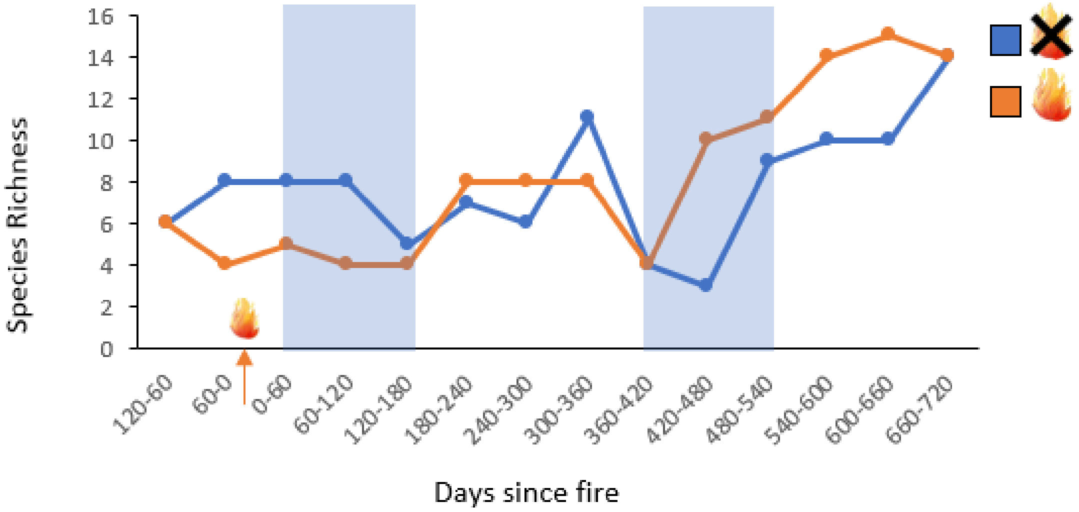
Appendix 1. List of medium and large mammal species recorded in the Chapada dos Veadeiros National Park (2017 - 2020), their respective abundances in the areas sampled (Independent Record) and conservation status according to the IUCN (International Union for Conservation of Nature) and ICMBio (Chico Mendes Institute for Biodiversity Conservation).

				Independent Record			**Conservation Status**	
Family	**Species**	**English name**	**Guilds**	**Total**	Fire	**No fire**	**IUCN**	**ICMBio**
Canidae								
	Cerdocyon thous	Crab eating fox	Onivore	909	74	835	LC	LC
	Chrysocyon brachyurus	Maned wolf	Onivore	154	101	53	NT	VU
	Lycalopex vetulus	Hoary fox	Onivore	176	126	50	NT	VU
	Speothos venaticus	Bush dog	Carnivore	1	1	0	NT	VU
Caviidae								
	Hydrochoerus hydrochaeris	Capybara	Herbivore	2	1	1	LC	LC
Cervidae								
	Mazama spp	-	Herbivore	202	22	180	-	-
	Ozotoceros bezoarticus	Pampas deer	Herbivore	395	285	110	NT	VU
Chlamyphoridae								
	Euphractus sexcinctus	Yellow armadillo	Onivore	4	2	2	LC	LC
Dasypodidae								
	Dasypus novemcinctus	Nine banded armadillo	Onivore	6	2	4	LC	LC
	Priodontes maximus	Giant armadillo	Insectivore	1	1	0	VU	VU
Dasyproctidae								
	Dasyprocta azarae	Agouti	Herbivore	1	1	0	DD	LC
Didelphimorphia								
	Didelphis albiventris	White eared opossum	Onivore	7	2	5	LC	LC
Felidae								
	Leopardus braccatus	Pampas cat	Carnivore	11	11	0	NT	VU
	Leopardus pardalis	Ocelot	Carnivore	46	9	37	LC	LC
	Leopardus tigrinus	Nothern tiger cat	Carnivore	2	1	1	VU	EN
	Panthera onca	Jaguar	Carnivore	5	2	3	NT	VU
	Puma concolor	Puma	Carnivore	207	190	17	LC	VU
	Puma yagouaroundi	Jaguarundi	Carnivore	1	1	0	LC	VU
Mephitidae								

Conepatus semistriatus	Striped hog-nosed skunk	Onivore	49	37	12	LC	LC
Mustelidae							
Eira barbara	Tayra	Onivore	6	3	3	LC	LC
Myrmecophagidae							
Myrmecophada tridactyla	Giant anteater	Insectivore	48	26	22	VU	VU
Tamandua tetradactyla	Southern tamandua	Insectivore	7	0	7	LC	LC
Procyonidae							
Nasua nasua	Coati	Onivore	2	2	0	LC	LC
Procyon cancrivorus	Crab eating fox	Onivore	24	3	21	LC	LC
Tapiridae							
Tapirus terrestris	Tapir	Herbivore	106	86	20	VU	VU
Tayassuidae							
Pecari tacaju	Peccary	Herbivore	8	8	0	LC	LC

Note: conservation categories according to IUCN and ICMBIO: DD = Data Deficient; EN = Endangered; LC = Least Concern; NT = Near Threatened; VU = Vulnerable

Appendix 2. Temporal variation of species richness of medium and large mammals in areas with and without fire of a Neotropical savanna (Cerrado) between July 2017 and October 2019. Time is represented in post-fire days and richness expressed by raw number of species. The rainy season is represented by shading on the timeline. Fire incidence is represented on the timeline by an arrow.



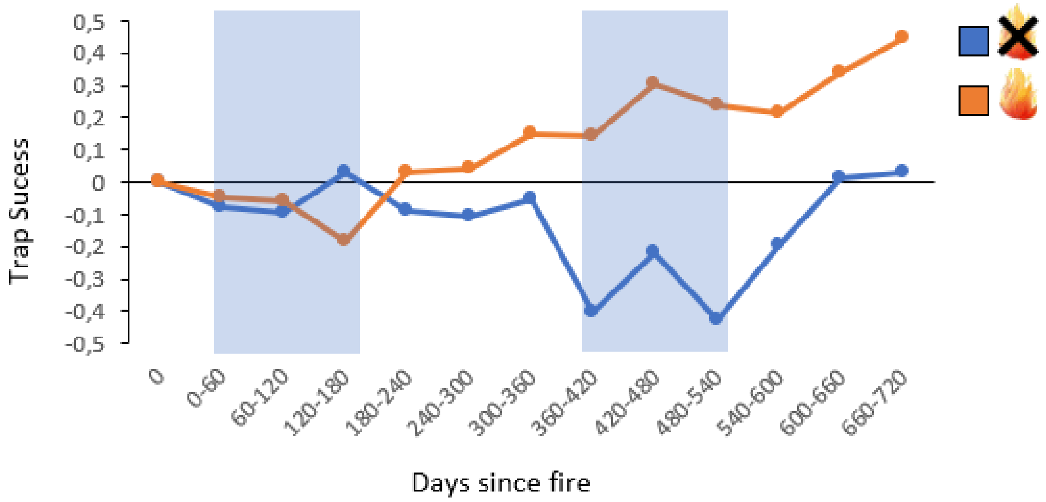
Appendix 3. Results of fixed effects of linear mixed models for species richness of a community of medium and large mammals in a Neotropical savanna (Cerrado) in central Brazil. The factors evaluated were: treatment (burned x unburned), year (1st year x 2nd year of sampling) and season (dry x rainy). Significant results are highlighted with an asterisk (*), indicating p<0.05.

	Richness	
Covariates	z	p
Treatment	2,848	0,004*
Year	2,702	0,007*
Sazonality	0,286	0,775
Sample effort	5,56	0,000*
Treatment*Year	-2,88	0,004*
Treatment*Sazonality	-1,118	0,264
Year*Sazonality	0,235	0,814
Treatment*Year*Sazonality	1,144	0,253

Appendix 4. Results of fixed effects of linear mixed models for Shannon Exponential (exp[H']) and Trap Success of a community of medium and large mammals of a Neotropical savanna (Cerrado) in central Brazil. The factors evaluated were: treatment (burned x unburned), year (1st year x 2nd year of sampling) and season (dry x rainy). Significant results are highlighted with an asterisk (*), indicating p<0.05

	H’		Trap Sucess	
Covariates	F	p	F	p
Treatment	0,044	0,836	6,274	0,019*
Year	14,599	0,000*	1,235	0,271
Sazonality	6,269	0,014*	6,34	0,013*
Treatment*Year	10,263	0,002*	9,827	0,003*
Treatment*Sazonality	0,494	0,483	0,619	0,433
Year*Sazonality	2,168	0,144	5,26	0,024*
Treatment*Year*Sazonality	0,116	0,734	3,652	0,059

Appendix 5. Temporal variation of the General Trap Success of a community of medium and large mammals in burned and unburned areas in a Neotropical savanna (Cerrado). Time is represented in days post-fire, with the value "0" representing the mean of the metric in the pre-fire period. The values presented are relative to the mean value of the Trap Success in the pre-fire period, according to the formula: $Log\left(\frac{N+1}{N_0+1}\right)$ (See Fox, 1982). The rainy season is highlighted by shading.



Appendix 6. Significant results of contrast analysis using Bonferroni's post hoc test for paired effects for Shannon Exponential and Trap Success of a medium to large mammal community from a Neotropical savanna (Cerrado).

Response variable		Covariate	(I)	(J)	Mean Difference (I- J)	Std. Error	df	Sig	95% Confidence Interval	
									Lower Bound	Upper Bound
Shannon Exponential		Year	Year 1	Year 2	-0,64	0,207	52,058	0,003	-1,055	-0,226
		Treatment * Year	Fire * Year 1	Fire * Year 2	-1,188	0,311	54,941	0,000	-1,811	-0,565
Trap Success	General	Treatment	Fire	No fire	-0,072	0,029	24,326	0,019	-0,132	-0,013
		Sazonality	Rain	Dry	-0,042	0,017	125,91	0,013	-0,074	-0,009
		Treatment * Year	Fire * Year 1	Fire * Year 2	-0,082	0,029	66,318	0,006	-0,14	-0,024
		Year * Sazonality	Year 2 * Rain	Year 2 * Dry	-0,081	0,023	120,87	0,001	-0,126	-0,035
	Carnivore	Year	Year 1	Year 2	-0,818	0,4	45,687	0,047	-1,624	-0,012
		Treatment * Year	Fire * Year 1	Fire * Year 2	-1,695	0,598	46,751	0,007	-2,899	-0,491
	Herbivore	Year	Year 1	Year 2	-3,667	0,842	54,937	0,000	-5,355	-1,979
		Sazonality	Rain	Dry	-2,044	0,708	111,17	0,005	-3,446	-0,642
	Onivore	Treatment	Fire	No fire	-10,746	2,116	27,368	0,000	-15,086	-6,407
		Treatment * Year	No fire * Year 1	No fire * Year 2	6,561	2,11	65,518	0,003	2,347	10,775
		Treatment * Year * Sazonality	No fire * Year 2 * Rain	No fire * Year 2 * Dry	-8,105	2,519	131,55	0,002	-13,089	-3,121
	C. thous	Treatment	Fire	Sem fogo	-11,329	1,903	28,251	0,000	-15,227	-7,432
		Year	Year 1	Year 2	3,347	1,441	68,153	0,023	0,472	6,223
		Treatment * Year * Sazonality	No fire * Year 2 * Rain	No fire * Year 1 * Dry	-6,629	2,319	131,74	0,005	-11,216	-2,043
	C. brachyurus	Treatment * Year	Fire * Year 1	Fire * Year 2	-1,929	0,449	67,513	0,000	-2,824	-1,033
	Mazama spp	Year	Year 1	Year 2	-1,411	0,582	63,879	0,018	-2,573	-0,248
	O. bezoarticus	Year	Year 1	Year 2	-1,446	0,589	54,245	0,017	-2,626	-0,266
		Treatment * Year	Fire * Year 1	Fire * Ano 2	-2,778	0,896	56,208	0,003	-4,574	-0,983
	P.concolor	Treatment	Year	No fire	1,059	0,502	24,636	0,045	0,024	2,095
		Year	Year 1	Year 2	-0,637	0,309	47,504	0,045	-1,259	-0,015
		Treatment * Year	Fire * Year 1	Fire * Year 2	-1,34	0,464	49,273	0,006	-2,272	-0,409

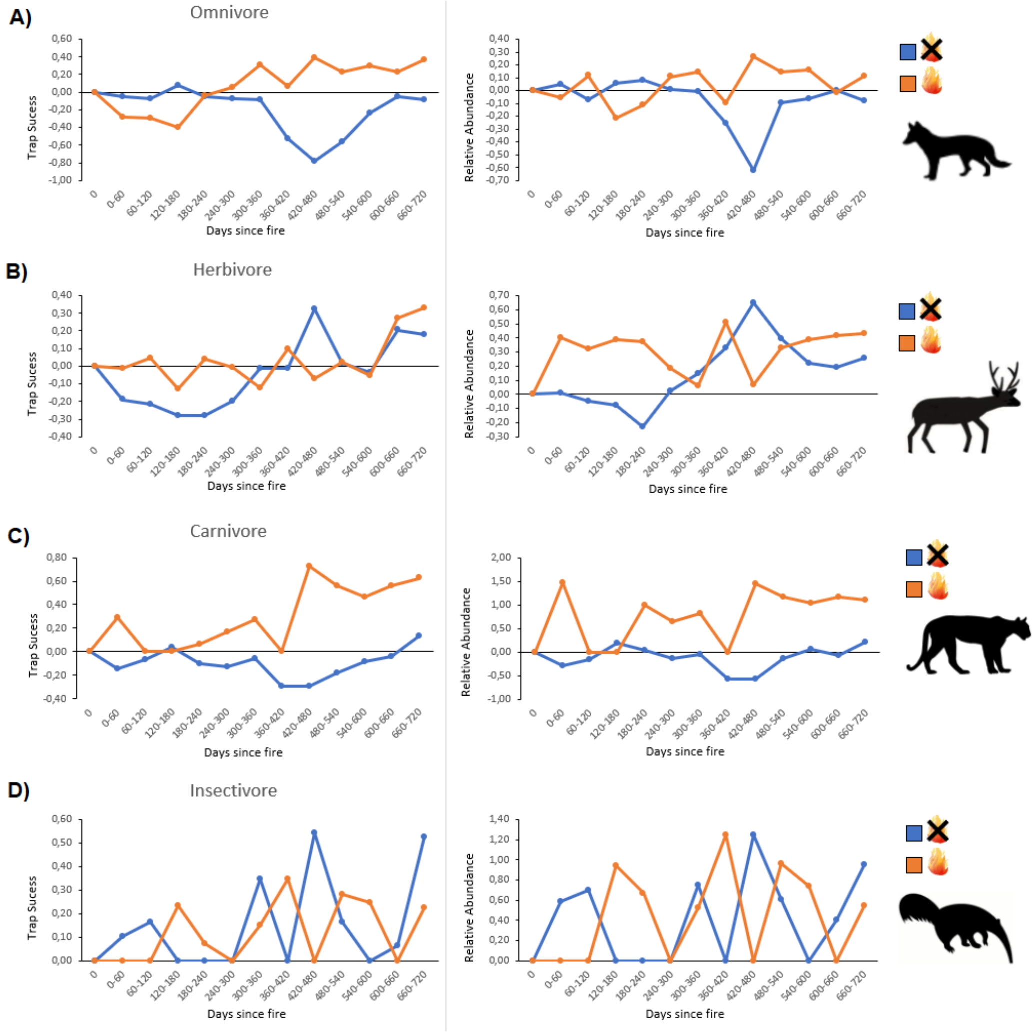
Appendix 7. Significant results of contrast analysis using Bonferroni's post hoc test for paired effects on Relative Abundance of a community of medium to large mammals from a Neotropical savanna (Cerrado).

Response variable		Covariate	(I)	(J)	Mean Difference (I- J)	Std. Error	df	Sig	95% Confidence Interval	
									Lower Bound	Upper Bound
Relative Abundance	Carnivore	Treatment	Fire	No fire	7,449	2,883	20,976	0,017	1,453	13,445
	Herbivore	Treatment	Fire	No fire	26,629	10,665	24,779	0,020	4,655	48,603
		Year	Year 1	Year 2	-13,836	4,25	47,238	0,002	-22,385	-5,287
	Onivore	Treatment	Fire	No fire	-41,667	8,177	26,143	0,000	-58,471	-24,863
		Treatment * Year	No fire * Year 1	No fire * Year 2	15,127	6,496	62,865	0,023	2,144	28,11
	C. thous	Treatment	Fire	No fire	-48,29	7,376	26,038	0,000	-63,45	-33,13
		Year	Year 1	Year 2	13,159	4,401	57,864	0,004	4,348	21,97
	C. brachyurus	Year	Year 1	Year 2	-7,405	1,92	68,14	0,000	-11,236	-3,575
		Estação	Rain	Dry	4,179	1,856	102,987	0,026	0,498	7,86
		Treatment * Year	Fire * Year 1	Fire * Year 2	-15,406	2,83	64,588	0,000	-21,058	-9,754
		Year * Estação	Year 2 * Rain	Year 2 * Dry	9,974	2,613	106,784	0,000	4,794	15,154
		Treatment * Year * Estação	Fire * Year 2 * Rain	Fire * Year 2 * Dry	17,111	3,814	84,673	0,000	9,526	24,695
	Mazama spp	Year	Year 1	Year 2	-6,694	2,611	49,671	0,013	-11,94	-1,448
	P. concolor	Treatment	Fire	No fire	7,2	2,401	19,461	0,007	2,182	12,217

Appendix 8. Results of fixed effects of linear mixed models for Trap success and Relative Abundance of feeding guilds of a community of medium and large mammals of a Neotropical savanna (Cerrado). Significant results are highlighted with an asterisk (*) indicating p<0.05

	Onivore				Herbivore				Carnivore				Insectivore			
	Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance	
Covariates	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
Treatment	25,785	0,00*	25,96	0,00*	2,252	0,146	6,235	0,02*	1,719	0,202	6,675	0,017*	0	0,995	2,048	0,156
Year	1,423	0,24	0,36	0,55	18,959	0,00*	10,597	0,002*	4,18	0,047*	1,892	0,176	1,004	0,32	0,272	0,603
Sazonality	2,627	0,107	0,657	0,42	8,347	0,005*	0	0,985	0,007	0,932	0,05	0,823	0,241	0,624	1,175	0,28
Treatment*Year	8,837	0,004*	6,185	0,015*	0,487	0,488	0,067	0,797	4,791	0,034*	1,898	0,175	0,204	0,653	0,291	0,591
Treatment*Sazonality	0,052	0,82	0,053	0,819	0,986	0,323	0,8	0,373	0,398	0,529	0,573	0,451	2,04	0,156	2,438	0,121
Year*Sazonality	3,839	0,053	0,001	0,974	0,886	0,349	0,132	0,718	0,093	0,761	0,144	0,705	0,29	0,592	0,031	0,861
Treatment*Year*Sazonality	4,442	0,037*	1	0,239	0	0,996	1,62	0,207	1,403	0,238	1,076	0,303	0,116	0,734	0,687	0,409

Appendix 9. Temporal variation of Trap Success (right) and Relative Abundance (left) of food guilds of a community of medium and large mammals in burned and unburned areas in a Neotropical savanna (Cerrado). Time is represented in days post-fire, with the value "0" representing the mean of the metric in the pre-fire period. The values of Trap Success and Relative Abundance presented are relative to the mean values in the pre-fire period for both metrics, according to the formula: $Log\left(\frac{N+1}{N_0+1}\right)$ (See Fox, 1982). The guilds analyzed are: Onivores (A), Herbivores (B), Carnivores (C) and Insectivores (D).



Appendix 10. Results of fixed effects of linear mixed models of Trap Success and Relative Abundance of the most abundant species in a community of medium and large mammals of a Neotropical savanna (Cerrado). Significant results are highlighted with an asterisk (*) indicating p<0.05

	Cerdocyon thous				*Chrysocyon brachyurus*				*Lycalopex vetulus*				*Mazama spp*				*Ozotoceros bezoarticus*				*Puma concolor*			
	Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance		Trap success		Relative abundance	
Covariates	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
Treatment	35,43	0,00*	42,865	0,00*	0,406	0,529	2,3	0,141	0,02	0,889	0,005	0,95	2,996	0,095	2,773	0,107	1,792	0,192	4,069	0,054	4,444	0,045*	8,99	0,007*
Year	5,396	0,023*	8,939	0,004*	3,759	0,057	14,88	0,00*	3,819	0,056	2,84	0,1	5,874	0,018*	6,572	0,013*	6,033	0,017*	2,121	0,15	4,238	0,045*	1,716	0,20
Sazonality	1,013	0,316	0,165	0,685	0,384	0,537	5,069	0,026*	1,639	0,203	3,021	0,09	3,116	0,08	0,881	0,35	2,673	0,105	1,657	0,2	0,009	0,924	0,279	0,598
Treatment*Year	3,695	0,059	0,528	0,47	20,16	0,00*	17,37	0,00*	0,521	0,473	0,076	0,78	2,698	0,105	1,628	0,208	5,125	0,028*	0,531	0,47	5,181	0,027*	1,881	0,178
Treatment*Sazonality	0,112	0,738	1,355	0,247	1,246	0,266	2,768	0,099	0,03	0,863	0,072	0,79	2,299	0,132	0,247	0,62	0,134	0,715	0,82	0,367	0,787	0,376	1,182	0,279
Year*Sazonality	3,393	0,068	1,045	0,31	0,343	0,559	9,972	0,002*	1,039	0,311	2,096	0,15	0,126	0,723	0,000	0,99	1,003	0,319	0,059	0,808	0,149	0,7	0,778	0,38
Treatment*Year*Sazonality	4	0,041*	0	0,812	3	0,111	5	0,03*	0	0,684	0	0,54	0	0,816	1	0,434	0	0,812	1	0,354	0	0,508	1	0,281