UNIVERSIDADE FEDERAL DE UBERLÂNDIA

INSTITUTO DE BIOLOGIA

Programa de Pós-graduação em ECOLOGIA e Conservação de Recursos Naturais

ECOLOGIA DE AVES DE CAMPOS HIDROMÓRFICOS DO CERRADO: MONITORAMENTO DE POPULAÇÕES, ESPÉCIES AMEAÇADAS, VARIAÇÕES ESTACIONAIS E SUCESSÃO EM ÁREAS ATINGIDAS PELO FOGO.

DIMAS PIOLI

UBERLÂNDIA
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Orientador
Prof. Dr. Oswaldo Marçal Júnior

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Dados Internacionais de Catalogação na Publicação (CIP)
Sistema de Bibliotecas da UFU, MG, Brasil.

P662e
2017

Pioli, Dimas, 1961-
Ecologia de aves de campos hidromórficos do cerrado [recurso eletrônico] : monitoramento de populações, espécies ameaçadas, variações estacionais e sucessão em áreas atingidas pelo fogo / Dimas Pioli. - 2017.

Orientador: Oswaldo Marçal Júnior.
Dissertação (mestrado) - Universidade Federal de Uberlândia. Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais.
Modo de acesso: Internet.
Disponível em: http://doi.org/10.14393/ufu.di.2021.5546
Inclui bibliografia.
Inclui ilustrações.

1. Ecologia. I. Marçal Júnior, Oswaldo, 1960-, (Orient.). II. Universidade Federal de Uberlândia. Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais. III. Título.

CDU:574

Glória Aparecida
Bibliotecária - CRB-6/2047

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Aprovada em 22 / 02 / 2017.

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UBERLÂNDIA
FEVEREIRO – 2017.

AGRADECIMENTOS

À minha esposa, Carla Eponina Hori, que tem sido minha companheira há três décadas, melhor amiga entre todos os amigos, que me deu todo o incentivo para iniciar mais esta etapa, e carinho, compreensão e ajuda em horas incertas. Te amo sem fim!

À minha mãe, pelo seu amor incondicional, por ter sido o instrumento mais fundamental para a minha formação e por me colocar na trilha certa da busca pela felicidade. Ao meu falecido pai, pescador, grande amigo e um dos grandes responsáveis pelo meu amor à natureza.

A tantos amigos, que foram comigo ou me levaram em trabalhos de campo e passarinhadas de lazer, companheiros fundamentais na minha paixão pelas aves, pela natureza e pelo meu aprendizado. José Fernando Pacheco, "meu mestre das aves" e querido amigo. Alexandre Gabriel Franchin, grande amigo e companheiro de inúmeras passarinhadas. Em especial a Gustavo Bernardino Malacco da Silva, que me apresentou a área onde o trabalho foi realizado e pelas inúmeras passarinhadas juntos nos campos hidromórficos do Cerrado.

Ao muito especial casal Liliane Martins de Oliveira e Carlos Henrique Nunes, pela amizade e por tanto apoio, sugestões e auxílio em várias fases do trabalho.

À secretária do PPGECO, Maria Angélica pelos seus serviços, amabilidade e apoio.

Aos professores que compuseram a banca.

Agradeço em especial a dois excelentes professores do Instituto de Biologia, que me deram todo o apoio em momentos difíceis. Prof. Oswaldo Marçal Junior, meu orientador, que me aceitou em sua equipe, aberto, gentil e generoso como poucos, que tem sido grande inspiração e um grande amigo acima de tudo. Prof. Kleber Del Claro, um modelo de cientista a ser perseguido, também um amigo que confiou e me apoiou incondicionalmente. Não sei se eu teria vencido esta batalha sem eles.

A José Valdo Costa Santos, meu ajudante de campo, pelo humor inabalável, boa vontade e auxílio em todas as minhas 35 viagens a campo.

À Universidade Federal de Uberlândia e ao Programa de Pós Graduação em Ecologia e Conservação de Recursos Naturais.

Ao Instituto de Biologia e a todos seus funcionários.

Aos vários professores do corpo docente do Programa de Pós Graduação em Ecologia e Conservação de Recursos Naturais.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), pelo apoio financeiro, e à Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

ÍNDICE

RESUMO

O fogo é um agente estruturante do bioma Cerrado, a maior savana da América do Sul, desde que não seja frequente. Seus campos são o lar de várias espécies vulneráveis de aves e estão entre os tipos de habitat mais ameaçados no Brasil. Seis áreas de campos hidromórficos foram estudadas no Triângulo Mineiro, Brasil, três delas haviam sido queimadas um mês antes e três não haviam sofrido ação do fogo há pelo menos três anos. Em cada área, foram escolhidos cinco transectos de 200 m de comprimento, com um ponto de observação no final, totalizando trinta pontos. Eles foram acompanhados por um período de doze meses, a partir de outubro de 2015. A sucessão ecológica de aves campestres foi monitorada e o índice de Diversidade Efetiva foi comparado usando um teste de ANOVA. As diferenças entre tratamentos queimado e não queimado, entre as estações chuvosa e seca, e para a interação foram significativas ($f = 5.542$, $p = 0.022$; $f = 5.909$, $p = 0.0183$; $f = 5.699$, $p = 0.021$, respectivamente). As histórias de vida das espécies de aves foram monitoradas, juntamente com as variáveis ambientais. Várias espécies vulneráveis não foram registradas nas áreas afetadas pelo fogo, enquanto uma foi registrada apenas em áreas queimadas. Algumas das causas podem ser atribuídas à dinâmica de disponibilidade de alimentos, umidade e grau de cobertura do solo pela vegetação. Estas espécies começaram a frequentar as áreas queimadas em recuperação, aproveitando-se de gramíneas novas que produziam sementes e da presença de flores ao longo da estação seca. As aves migratórias estiveram presentes apenas no período chuvoso, partindo em diferentes tempos no início do período seco e retornando apenas no final. A detecção de aves campestres foi bastante dificultada no final do verão e início da estação seca. Isto se deveu ao comportamento mais discreto após o período reprodutivo e porque a vegetação se tornou muito alta, dificultando também os registros visuais. Os dados sobre a espécie foco deste trabalho, *Alectrurus tricolor* (Vieillot, 1816), corroboram relatos e uma simulação que lhe atribuem o status de residente. Evidências sugerem que pelo menos alguns pares permanecem juntos durante todo o inverno. Os machos foram registrados exibindo suas caudas exóticas em todos os meses. Como para as outras aves, esta espécie também adotou comportamento recluso, e a detecção de fêmeas exigiu esforço extra. Este trabalho sugere a necessidade de estudos mais aprofundados sobre a dinâmica ecológica dos campos hidromórficos do Cerrado. Também aponta para a necessidade urgente de preservar esses ambientes vitais, preferencialmente criando áreas protegidas, altamente escassas. O uso de áreas agrícolas por várias espécies atesta a importância do planejamento de manejo para toda a matriz.

Palavras chave: biologia da conservação, ecologia do fogo, comunidade de aves, diversidade, savana tropical, *Alectrurus tricolor*, status residente ou migratória.

ABSTRACT

Fire is a structuring agent of the Cerrado biome, provided it is not too frequent, the largest savannah in South America. Its grasslands are home to several vulnerable species of birds and are among the most threatened types of habitat in Brazil. Six areas of wet grasslands were studied in central Brazil, three that had been burned one month earlier and three untouched by fire for at least three years. In each area, five 200 m long transects with one watch point at the end were chosen, totaling thirty points. They were surveyed for a period of twelve months, starting in October, 2015. The ecological succession of grassland birds was monitored and the True Diversity index compared using an ANOVA test. The differences between burnt and unburned treatments, between rainy and dry seasons and for their interaction were significant ($f = 5.542$, $p = 0.022$; $f = 5.909$, $p = 0.0183$; $f = 5.699$, $p = 0.021$; respectively). The life histories of the bird species were observed, along with the environment variables. Several vulnerable species were not recorded in areas recently burned, while one was recorded only in burnt areas. Some causes could be attributed to the dynamics of food availability, humidity and degree of soil cover by the vegetation. These species began to frequent recovering burnt areas, taking advantage of seed producing grasses and flowering throughout the dry season. Migratory birds were present only in the wet summer, departing with different timings at the beginning of the dry period and returning only at the end. Detection of grassland birds was greatly reduced in late summer and early dry season. This was due to the more discrete behaviour after the reproductive period and because the vegetation had become very high, also hindering visual records. The data on the species focus of this , *Alectrurus tricolor* (Vieillot, 1816), corroborate reports and a simulation that attribute to it the status of resident. Evidence suggests that at least some pairs stay together throughout the winter. Males were recorded exhibiting their exotic tails in every month. Like other species, the birds adopted reclusive behaviour and the detection of females required extra effort. This study suggests the need for more in-depth studies on the ecological dynamics of the wet grasslands of the Cerrado. It also points to the urgent need to preserve these vital environments, preferably by creating protected areas, highly scarce. The use of agricultural areas by various species attests to the importance of management planning for the entire matrix.

Key words: tropical grassland birds, migratory or resident status, fire ecology, endangered species, bird community, conservation biology, Brazilian savannah, Cerrado grasslands.

INTRODUÇÃO GERAL

Savanas tropicais têm uma longa história evolutiva atrelada à evolução de plantas C_4 e foram produzidas e estruturadas por ação de vários fatores: clima, concentração de carbono na atmosfera, solos e pelos seus grandes consumidores, os herbívoros e o fogo. Hoje em dia suas formações prestam serviços diretos a aproximadamente um quinto da população mundial, compreendem biomas que são *hotspots* de biodiversidade e seus regimes de queimadas têm papel vital no ciclo de carbono do planeta. Apesar de sua relevância, as formações savânicas têm recebido uma pequena fração da atenção das pesquisas quando comparadas a formações florestais (Bond, 2016; Veldman *et al*., 2015; Parr *et al*., 2014; Lehman *et al*., 2014, Bond, 2005). As principais ameaças a esses sistemas são o avanço da agricultura mecanizada e a agropecuária (Marçal Junior, 2008; Foley *et al*., 2005; Benton *et al*., 2003, Klink *et al*., 1993).

O fogo é um agente fundamental na história natural das savanas tropicais no mundo todo e responsável pela maioria das áreas queimadas em diversos países e regiões (Bond, 2016; Parr *et al*., 2014; Woinarski and Legge, 2013). Há um grande número de estudos sobre aves dessas savanas a influência do fogo sobre as espécies savânicas – flora e fauna (Frizzo *et al*., 2011), muitos deles sobre aves (Woinarski & Legge, 2013; Valentine, 2007). O consenso é que o distúrbio inicialmente favorece algumas espécies e elimina ou diminui a abundância de outras (Woinarski & Legge, 2013; Franchin *et al*., 2009; Valentine, *et al*., 2007). O grau em que isso ocorre e que direção tomam os índices de diversidade das áreas afetadas são dependentes de um grande número de fatores tais como, e principalmente, os requisitos ecológicos das espécies e a intensidade e a frequência das queimadas (Frizzo *et al*. 2011; Frsanchin *et al*., 2009; Yang *et al*. 2008), Em uma situação intermediária ideal, a diversidade aumenta (Connell, 1979).

A situação do Cerrado brasileiro, a maior savana tropical da América do Sul, não é diferente. O fogo é também um importante agente na gênese e estruturaçãoo do Cerrado brasileiro (Gomes *et al*., 2016; Miranda *et al*., 2009; Klink & Machado, 2005). O Cerrado se caracteriza como um "*hot spot*" de biodiversidade, apresenta alto grau de endemismo e é um dos ecossistemas mais ricos e ameaçados do mundo (Junior *et al*., 2014; Marini & Garcia, 2005; Klink & Machado, 2005; Silva & Bates, 2002; Myers *et al*., 2000; Silva, 1997). As estimativas de perda da sua área original variam de 50% (ICS 2011, Figura 1) a mais de 70% (Scariot *et al.* 2005). Seus problemas de conservação parecem repetir o ciclo que se passou na Mata Atlântica: é o bioma mais devastado em décadas recentes e o que abriga o segundo maior número de espécies animais ameaçadas, incluindo muitas aves (Machado *et al.* 2008; Scariot *et al.* 2005).

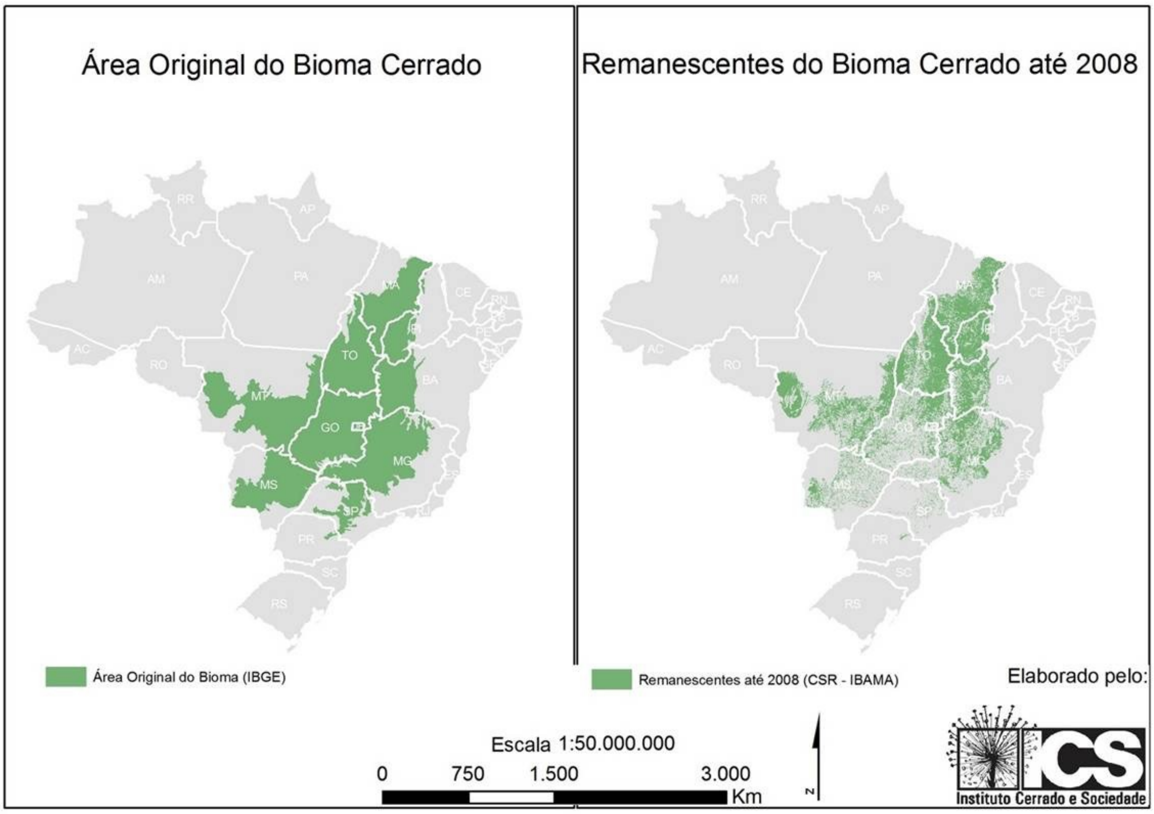

Figura 1. Perda do bioma cerrado. Adaptado de ICS, 2011.

Dentro do Cerrado, como em outros biomas, um dos ambientes mais negligenciados é o de campos. Sem o apelo do status de "floresta", a biodiversidade dessas formações está entre as mais ameaçadas, incluindo muitas aves (Junior *et al*., 2014; Frizzo *et al*., 2011; Franchin *et al*., 2009; Klink & Machado, 2005). Os remanescentes são agudamente escassos, a maioria restando apenas em unidades de conservação (Tubelis, 2000); e fora delas a destruição é iminente (Stotz *et al.* 1996). Segundo Collar *et al*. (1992), a destruição quase total de ambientes campestres no Brasil é uma das maiores catástrofes ecológicas da América do Sul. O principal motivo é a expansão da agricultura mecanizada e da pecuária. Uma grande gama de trabalhos correlaciona a ocupação humana – e em grande parte a agricultura – com a destruição e a fragmentação de habitats naturais de Cerrado na região (Angá, 2015; Marini & Garcia, 2005; Klink & Machado, 2005).

No Triangulo Mineiro, já em 1993, estudos mostravam o alto grau de conversão das áreas naturais para uso econômico: a distribuição do uso da terra apontava pastagens com 28,4%, culturas temporárias com 24,6% e a vegetação de Cerrado com apenas 13,8% (Lima e Lima, 1993). Um levantamento semelhante, realizado para o município de Uberlândia, em 2005, é coerente com esse diagnóstico, mas mostra o avanço da ocupação: pastagens com 40,56%, culturas temporárias com 27,48% e o Cerrado com apenas 7,65% da área do município (Brito e Prudente, 2005).

Estudos a respeito da influência do fogo sobre a fauna do Cerrado chegam às mesmas conclusões que os trabalhos em outras partes do mundo; ou seja, que ele é necessário para a manutenção de paisagens abertas, desde que não ocorra com muita frequência (Reis, Fieker & Dias, 2016; Frizzo *et al*., 2011; Sendoda, 2009; Cintra & Sanaiotti, 2005). O intervalo ideal ainda é alvo de debates.

Atualmente, o uso de aves como bioindicadores é bastante amplo e a utilização de dados sobre o grupo podem ser empregados como indicadores da biodiversidade regional, nacional e/ou global. Assim, a medida de como as aves são conservadas é uma forma de avaliar quão bem sucedida é a manutenção das funções dos ecossistemas e da biodiversidade como um todo. Isso se deve ao fato delas estarem no topo da cadeia trófica e, portanto, integrando alterações de outros níveis. Aves também ocupam uma ampla variedade de ecossistemas e têm variadas histórias naturais. De fato, aves são um dos grupos de seres vivos mais bem estudados em todo o mundo. Nesse contexto, dados, tendências de populações e estado de conservação do grupo são geralmente melhor compreendidos do que os de outros táxons, sendo significativos não apenas para a Ciência, mas também para uma audiência ampla, incluindo o público leigo (Ladin *et al*., 2016; Gregory, 2010; Heath & Rayment, 2003).

OBJETIVOS

Objetivo Geral

Monitorar uma comunidade de aves de formações campestres hidromórficas do Cerrado, com especial atenção àquelas ameaçadas ou com insuficiência de dados, buscando avaliar a influência do fogo sobre elas.

Objetivos Específicos

Acompanhar a sucessão da comunidade de aves em áreas de campos hidromórficos recentemente queimados e compará-la àquela de locais que não sofreram a influência recente do fogo;

Avaliar as variações estacionais de uma população de *Alectrurus tricolor* (Vieillot, 1816) no Triângulo Mineiro, visando corroborar ou refutar relatos de que a espécie é migratória, nômade ou residente, e um trabalho de modelagem que a aponta como sendo uma espécie residente.

HIPÓTESES E PREDIÇÕES

a. O fogo afeta negativamente a diversidade de espécies de aves.
b. Dados de diversidade e abundância coletados em áreas queimadas serão mais pobres do que aqueles coletados de áreas não afetadas por fogo por vários anos.

a. A população de *Alectrurus tricolor* é migratória no Triângulo Mineiro;
b. Os censos detectarão a espécie em algumas estações do ano, mas não em outras, ou a abundância variará grandemente entre as estações.

MATERIAL E MÉTODOS

Área de estudo

As áreas pesquisadas foram escolhidas procurando representar a fisionomia de campos hidromórficos (de murundus) do Cerrado, no Triângulo Mineiro (DiMauro *et al.*, 2011; MIDGLEY (2010); SILVA *et al.*, 2015; Angá *et al.*, 2015; Lopes *et al.*, 2009; observações pessoais e discussões com alguns desses autores) e estão em uma região chave para a conservação: nelas as partes das nascentes dos rios Uberabinha (Uberaba-MG) e Mandaguari (Indianópolis-MG), que abastecem cerca de 600,000 pessoas e uma importante porção das atividades agropecuárias no Triângulo Mineiro (Figuras 2 e 3). Seus campos também são habitat fundamental para a conservação de várias espécies de aves campestres endêmicas e ameaçadas do Cerrado (Angá *et al.*, 2015; Silva, 1997) nos níveis estadual (SEMAD, 2010), nacional (Machado *et al.*, 2014) e internacional (BirdLife International, 2015). Entre essas aves estão incluídas espécies residentes e várias outras migratórias, que se reproduzem no sul do Brasil (Repenning & Fontana, 2016; Lopes *et al.*, 2009; Drummond *et al.*, 2005). As aves migratórias fazem parada aqui no período seco para efetuarem a muda e se reabastecerem para a viagem de volta ao sul. Das seis áreas selecionadas, três haviam sido queimadas um mês antes do início das campanhas e ainda apresentavam o solo nu. As outras três não haviam sido alvo de fogo por pelo menos três anos, provavelmente mais, segundo informações de moradores da região e de Gustavo B. Malacco da Silva. Com o auxílio de imagens de satélite, cinco pontos foram escolhidos em cada uma dessas áreas pelo método de randomização sistemática (Hulbert, 1984), procurando representar o maior número possível de condições.

Figura 2 – Campos hidromórficos (de murundus) do Cerrado no Triângulo Mineiro (**Google, 2021**).

Figura 3 – Localização da área de estudo em Uberaba, Minas Gerais.

O clima da região é classificado como Aw (Köppen, 1918), com apenas duas estações bem definidas, um verão quente e úmido de outubro a março e um inverno seco de abril a setembro. A precipitação média é em torno de 60 mm na estação chuvosa e 1.500 - 1.600 mm na estação seca (de Melo Prado et al., 2016; Klink & Machado, 2005).

Espécie foco

Alectrurus tricolor (Vieillot, 1816) é uma espécies da família Tyrannidae, o macho mede 18 cm e a fêmea 12 cm. O Macho é predominantemente negro por cima e branco por baixo, com uropígio cinza, barras brancas nas coberteiras das asas e uma faixa negra no peito. Ele exibe uma cauda negra em forma de "V". A fêmea tem as partes negras substituídas por marrom e bege e não apresenta cauda peculiar (Fig. 4).

Figure 4. Macho (superior) e fêmea (inferior) de *Alectrurus tricolor.* Fotos: Dimas Pioli.

A ecologia de *Alectrurus tricolor* é pouco conhecida, mas seu habitat típico é campos secos e úmidos, com vegetação densa e alta (0.3 – 1.0 m) e é essencialmente insetívoro. A espécie é considerada parcialmente nômade (Del Hoyo *et al*., 2004; BirdLife International, 2016), migratória (Silveira, 1998) ou residente (Birdlife International, 2016; Machado, Drummond & Paglia, 2008). No Brasil o período reprodutivo começa no início da estação seca (setembro/outubro). Sua área de ocorrência no Brasil se espalha pelos estados de Mato Grosso, Goiás, Minas Gerais, Rio de Janeiro, São Paulo, Mato Grosso do Sul e Paraná. A espécie também ocorre no Paraguai (muito raro), leste da Bolívia (local) e está provavelmente extinto na Argentina (BirdLife International, 2016). Ela é endêmica dos campos do Cerrado e classificada como vulnerável em nível nacional (Machado *et al*., 2014; MMA, 2014) e internacional (BirdLife International, 2015; IUCN, 2017), e ameaçada em nível estadual em Minas Gerais (Biodiversitas, 2007; SEMAD, 2010). De acordo com o relatório da BirdLife International

(2015), *A. tricolor* é uma espécie considerada de escassa a rara, local, em declínio em toda a sua área de ocorrência, e que tem ecologia pouco conhecida, com informações insuficientes sobre suas populações, hábitos migratórios e ocorrência fora de áreas protegidas. Por esses motivos, a BirdLife International recomenda que estudos adicionais sobre essa espécie sejam levados a cabo para completar as lacunas sobre o seu conhecimento e oferecer elementos para a sua conservação.

Procedimentos

As seis áreas de campos hidromórficos amostradas (Figura 2) foram selecionadas considerando-se a experiência do autor e de outros pesquisadores em estudos com aves nas áreas naturais da região (Lopes *et al.* 2009, di Mauro *et al*., 2011).

Foram realizados levantamentos mensais da avifauna nas áreas pesquisadas. As visitas se iniciaram pelo menos 30 minutos antes do alvorecer. Foram amostrados cinco transectos com seus respectivos pontos terminais, de acordo com os seguintes critérios: transectos com pelo menos 200 m de comprimento; espaçados a pelo menos 400 m de qualquer outro. Cada transecto com seu ponto foi visitado todos os meses, por doze meses consecutivos, conforme Franchin *et al*.(2010). A primeira visita ocorreu em outubro de 2015. Cada par transecto-ponto foi visitado em ordem alternada, de modo que cada um foi recenseado pelo menos uma vez nas primeiras horas da manhã e em cada estação. Após percorrer o transecto, o único ponto ao final foi escrutinado por 20 minutos (Vielliard *et al*. 2010, 2011; Bibby *et al*., 2000).

As seguintes variáveis ambientais foram registradas: nível aproximado da água, presença de arbustos ou árvores, estágio de regeneração da vegetação, paisagem da matriz do entorno, altura da vegetação e distância do ponto antropizado mais próximo.

A classificação e a nomenclatura das espécies de aves seguiram Piacentini *et. al*. (2015). Para confirmação das identificações foi utilizada a seguinte literatura de apoio: Cleere & Nurney (1998), Del Hoyo *et al*. (1992 - 2013), Grantsau (1988), König, Weick & Becking (1999), Ridgely *et al*. (2010), Ridgely & Tudor (1989, 1994) e Sigrist (2007).

Análise de dados

Entre os vários índices de diversidade consagrados, foi escolhido o de Diversidade Efetiva ^1D (Morris *et al*. 2014; Jost, 2006) por ser baseado no índice de Shannon-Wiever H' e por permitir uma melhor visualização e comparação direta das diferenças. Os resultados foram considerados significativos para erros menores que 5% ($p \leq 0,05$).

As análises estatísticas foram realizadas com o auxílio dos programas R (R Core Team, 2017), usando o modulo Circular Statistics (Agostinelli and Lund, 2013.); STATISTICA (StatSoft, Inc., 2004); EstimateS (Colwell, 2006) e Oriana (Kovach, 2011).

Equipamentos

Foi usado um GPS (Garmin GPSmap 76CSx) para a marcação precisa e a visitação dos locais escolhidos em cada área. Os registros visuais e acústicos das espécies presentes foram realizados por meio de observações diretas, à vista desarmada, com auxílio de binóculos (Celestron Granite 8x42) e com uma luneta (Kowa TSN-821).

As ocorrências foram documentadas por meio de gravações de vocalizações com o gravador digital portátil Sony PCM-M10 de um microfone Sennheiser ME-66 e por meio de fotografias pela técnica de digiscoping com a referida luneta e um smartphone Samsung S4. Este último também foi utilizado para fazer "playback" de cantos e anotação dos dados de campo

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CAPÍTULO 1

Birds and fire in the Cerrado native wet grasslands: seasonal population dynamics, ecological succession in burnt areas and comparison to preserved grasslands.

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ABSTRACT

Fire is a determinant component in the genesis and structure of tropical grasslands, a fast disappearing ecosystem worldwide. The Brazilian Cerrado, the largest savannah biome in South America, is one of the richest and most threatened biodiversity "hot spots" of the world. Using birds as a biodiversity indicator, the object of this study was to compare the bird communities of burnt and unburned Cerrado grasslands in central Brazil. The community succession was monitored for 12 consecutive months. Fifteen points were sampled in each case scenario. Burning opened the system to generalist species, in a way that the True Diversity indexes were very similar between burnt and preserved areas during the wet season. However, the diversity turns significantly higher for the burnt sites in the dry season. The succession process could be seen in burnt grasslands: specialist - vulnerable species stayed out of recently burnt areas, but many attended them in the dry season. One species was recorded only in recovered, dense, mid-size grasses in burnt sites. In the wet (breeding) season, birds found resources and protection in taller vegetation in mature grasslands, but in the dry season the resources had already been depleted there. In the dry season the recovering flora in burnt areas had an abundance of young grasses producing seeds and flowering for most of the period. This was due to water, vegetation and food availability dynamics. The water levels, the vegetation cover and height were almost constant for unburned grasslands, but varied greatly for burnt areas. They were very low into a few months after the fire, increased in the wet season, but started desiccating much faster in the dry season, with implications on the conservation of this type of natural physiognomy.

Keywords: bird community, diversity, tropical grasslands, conservation biology, Brazilian savannah.

INTRODUCTION

The tropical savannahs have a complex and ancient history (Bond, 2016) and fire is one of the major determinant components in their genesis and structure (Lehmann *et al*., 2014; Parr *et al*., 2014; Bond, Woodward and Midgley, 2005; Bond, 2008; ANGÁ / SEDESE, 2015). Fire is, accordingly, an import factor in shaping the Brazilian Savannah, also known as Cerrado (Gomes *et al*., 2016; Miranda *et al*., 2009; Klink & Machado, 2005).

The destruction of the tropical grasslands is one of the greatest ecological catastrophes in South America (Collar *et al*., 1992; Lopes *et al*., 2009). The remnants are scarce and mostly in conservation units (CU's), which are far from being sufficient (Tubelis, 2000). Outside the CU's, the doom is imminent (Stotz *et al.,* 1996).

The Brazilian Cerrado is the largest savannah biome in South America, the second largest biome (second only to the Amazon). Considered one of the richest and most threatened biodiversity "*hot spots*" of the world and a priority for conservation (Silva and Bates, 2002; Myers *et al*., 2000), it also exhibits great degree of endemism (Stattersfield *et al*. 1998). Much of its original cover has been lost, with estimates ranging from 50% (ICS, 2011) to more than 70% (Scariot *et al.* 2005). The current setting of the Cerrado seems to repeat what befell on the Brazilian Atlantic Rainforest, an almost totally degraded biome that harbours the second largest number of threatened animal species in Brazil, including many birds (MMA, 2014; Scariot *et al.* 2005).

The several Cerrado physiognomies have been the object of many studies. But without the appeal of being a "forest", the grasslands are among those ignored most and its biodiversity is among the most highly threatened (Lopes *et al*., 2009). The cause: the expansion of modern mechanized agriculture and cattle raising (Junior *et al*., 2014; Franchin *et al*., 2009, Tubelis, 2000). Besides converting land, the human occupation has altered the fire regimen, which has become accelerated, with shorter intervals (Junior *et al*., 2014; Klink & Machado, 2005). Furthermore, this scenario increases greenhouse gas emissions and causes soil degradation.

Birds conform to many attributes necessary to be a good indicator of the biodiversity and the health of an ecosystem. Some species are very sensitive to disturbance, requiring well preserved environment and therefore are direct pointers to conservation needs and measures (Ladin *et al*., 2016; Gregory & van Strien, 2010). The extent to which birds are being preserved is a measure of how well are preserved the ecosystem functions and the biodiversity as a whole. This is owing to birds being at the top of the trophic chain, integrating changes from lower levels, and for occupying a wide variety of ecosystems and with highly varied natural histories. The data, population trends and the conservation status of this group are generally better understood than other taxa. They are also well known to a large audience, including the general public (Heath & Rayment, 2003).

This study aimed to monitor recently burnt grasslands, following the bird component succession along the seasons and comparing the results to those from areas that had not been burned for more than three years. This study was conceived to test hypothesis H_1 that the diversity in burnt grasslands differs and is smaller than that of unburned areas. The was carried out for 12 consecutive months in areas of Cerrado grasslands in central Brazil.

METHODS

Study area

Based on data from personal observations and previous studies in the region (Angá, 2015; Di Mauro *et al*., 2011; Lopes *et al*., 2009), six areas were selected for this study (Fig. 1). They typify well the Cerrado wet grasslands in a key region for conservation: the head springs of the rivers Uberabinha (Uberaba-MG) and Mandaguari (Indianópolis-MG) in the "Triângulo Mineiro". These water sources provision about 600,000 people and the agriculture in the region (Di Mauro *et al*., 2011). Additionally, the native grasses in these areas are key to preserve habitat for several birds considered threatened at the state (SEMAD, 2010), national (MMA, 2014) and international levels (IUCN, 2017). Besides the resident species, many of these birds are migrants from the South that make these grasslands their wintering quarters. Here they moult and replenish their energies preceding spring migration (Repenning & Fontana, 2016; Lopes *et al*., 2009; Drummond *et al*., 2005). As for the Cerrado as a whole, these are also areas under great anthropic pressure (Junior *et al*., 2014; Lopes *et al*., 2009; Franchin *et al*., 2009).

The climate in the region is classified as Aw (Köppen, 1918), with only two defined seasons, a wet and hot summer from October to March and a dry winter from April to September. The average precipitation is around 60 mm in the rainy season and 1.500 - 1.600 mm in the dry season (de Melo Prado *et al*., 2016; Klink & Machado, 2005).

Procedures

The survey transects (with one observation point at the end of each) were chosen by systematic randomization (Hulbert, 1984), in order to sample a large variety of habitat conditions: soils, water proximity, bush or tree cover, area size, invasive trees. Satellite imagery (Figure 1) was used to select land with preserved native grasses.

Figure 1. In the satellite image, pink areas are burnt e green ones are unburned. The codes correspond to the transect-point pairs in native grasslands: UP-a-1 = unburned point, area a, number one; BP-b-3 = burnt point, area b, number 3, etc. The red lines are the transects. Modified from Ribeiro, 2011 and Google Earth, 2017, respectively.

The burnt areas were found by surveying the region by car and talking to local residents, who informed that the chosen lands were burned in a large fire in the region early in October/2015, month when the surveys started immediately. Only native wet grasslands were considered. Fifteen transect-point pairs were marked in recently burnt areas and fifteen in grasslands that had not seen fire for at least three years, probably more (information from area residents and from Gustavo B. Malacco da Silva). The following criteria were observed: the transects were 200 m long and at least 400 m from each other (Vielliard *et al*., 2010; Accordi & Cândido JR, 2010; Bibby *et al*., 2000). They were visited every month for 12 successive months, alternating the order every trip, in a way that they were surveyed at least once in the first hours of the morning and in each quarter of the calendar year. At the end of the transect, the observer spent 20 minutes at the point, logging all birds (Vielliard *et al*., 2010). During this time, playback was used, alternating three times for each of the following strictly grassland species of particular concern: *Micropygia schomburgki, Culicivora caudacuta, Coryphaspiza melanotis* and

Cistothorus platensis. Special attention was paid to the presence of *Alectrurus tricolor*, also of greater concern, but chiefly silent. The genus *Sporophila* was also watched carefully, since several of the species are considered threatened to various degrees and many are migratory. It's usually difficult to identify species of the genus *Sporophila* in eclipse plumage. However, with practice, the observer can feel confident to identify groups of species or a species that is different from the usual ones in an area (personal experience).

Appropriate variables were observed and annotated in order to correlate the data found with characteristics of the matrix (Anderson, 1981). For each transect, the following parameters were recorded: a) habitat: dry or wet grassland, bush and or tree cover, regeneration stage of the vegetation – for burnt areas; b) matrix: other natural formations, pasture, agricultural land, exotic vegetation, bare soil; c) height of the vegetation; d) shortest distance to the closest anthropized area; e) level of the water (if any).

Several species were excluded from the analyses for not being directly associated to or not inhabiting grasslands. What determined if one of these species was present was the proximity of its required (other) habitat, whether the grasslands studied were burned or not. These were woodland birds heard or seen in nearby woods and chiefly aquatic and aerial animals (Anseridae, Ardeidae, Psittacidae, Apodidae). Some genera and species were not considered for the same reasons: *Certhiaxis, Cantorchilus, Arundinicola, Turdus, Todirostrum, Anthus, Tangara palmarum, Tangara sayaca,* and *Patagioenas cayanensis*. Aerial birds associated to the local land were included (grassland swallows, *Eupsittula aurea* and others). Special care was taken when going from area to area not to count twice animals of species that are highly mobile (raptors, *Cypsnagra hirundinacea*, *Colaptes campestris*, *Melanerpes candidus* and *Cyanocorax cristatellus*).

Animals identified only to the genus level were included separately in the analyses only when no species of the same genus was identified in that sample. Grassland birds exploiting the border between native areas and other physiognomies of the matrix, especially agricultural areas, were taken into account: these species always used the matrix regardless if the adjacent native areas were burned or not.

There were sparsely distributed trees and small groves in almost all areas: these were invasive species, generally *Pinus sp*., but they were in both burnt and preserved areas.

Weather affects the counts (Vielliard *at al*., 2010), but it influences them randomly at all the sites. Furthermore, with a 12 month times 15 points to study each case, the weather was regarded as negligible after a thorough review of the data.

In an attempt to help understand the results of this study, relevant aspects of the life history of the species were noted (Franchin *et al*., 2010): display/courtship, nesting, movements, foraging, evasion from predators, antagonism and territory defense. In certain cases, when an important characteristic was observed, extra effort was employed to try to understand it. In these cases, the transect and point procedure was abandoned for a while, for this purpose only.

Among the several recognized diversity indexes, the True Diversity ^{1}D was chosen. It is correlated to the Shannon-Wiever index H', but allows a better and direct comparison of the differences (Morris *et al*. 2014; Jost, 2006).

The classification and nomenclature of birds followed Piacentini *et al*. (2015).

Statistical Analysis

The results were considered significant for errors smaller than 5% ($p \leq 0,05$). All statistics theory and related calculi were taken from Zar (2010), except when indicated differently.

In order to evaluate the sampling efficiency, rarefaction curves (collector curves) were calculated considering the samples for the burnt and unburned areas, using the program EstimateS 8.2 (Cowell, 2006). In addition to the number of species detected in the field, an estimation of species that can occur in the areas (estimated richness) was calculated using the Jackknife 1 estimator, considered efficient (Magurran, 2003).

ANOVA of two factors was used to evaluate the existence of differences in bird species diversity between the two seasons (dry and rainy), the treatments (burned and unburned) and their interaction.

Analyzes of hierarchical clusters of similarity among the samples of burnt and unburned areas were performed, based on composition and abundance data of the species (Shepherd, 2010). A cluster was built for each season (rainy and dry). The grouping method was the group average, UPGMA (Unweighted Pair Group Method with Arithmetic). The index used was the dissimilarity of Bray-Curtis. In the UPGMA, the co-phenetic correlation coefficient was calculated in order to evaluate the degree of distortion of the dendrogram relative to the original similarity matrix. In general, the closer to 1 the value is, the better the representation by the dendrogram of the original data provided. The graph of the values of the original coefficient matrix was also inspected against the co-phenetic values of the dendrogram with the same purpose. Fitopac 2.1 software (Shepherd, 2010) was used for this analysis.

A chi-square test was performed to determine if there was difference in frequency of records between burnt and unburned areas. This analysis was done separately for each season. These analyzes were carried out with the program STATISTICA (StatSoft, Inc., 2004)

Vegetation cover was compared between dry and rainy season for burnt and unburned areas separately using the Mann-Whitney non-parametric test, due to the lack of homoscedasticity and normality of this variable. An ANOVA analysis was also used to test if there were significant differences in the height of the vegetation between the dry and rainy seasons, the burned and unburned treatments and their interaction.

Equipment

The species were sought with the help of a telescope Kowa TSN-821 and a pair of binoculars Celestron Granite 8x42. All points and tracks were marked and followed with a GPS Garmin GPSmap 76CSx. Songs and calls were documented with a Sony digital sound recorder PCM-M10 and a Sennheiser ME-66 Microfone. Photos were taken with the digiscoping technique, using the telescope and a Samsung S4 Smartphone. The device was also used for data recording and bird song playback. Data in the field was logged using an application in the smartphone. The data was then backed-up to a MacBookPro computer after each visit.

RESULTS

The accumulation curves demonstrate that the sampling was sufficient (Fig. 4) for both treatments, “burnt” and “unburnt” grasslands, although the rarefaction curve for the unburned area did not reach the asymptote. The accumulation curves of species produced by non-parametric estimator of richness, although stabilized, show that there is still a tendency to increase species richness, especially for the unburned areas (Fig. 2). The richness found in the field in burnt (n = 100) and unburned areas (n = 102) represented respectively 91.6% and 86.7% of the richness estimated by Jackknife 1 (highest estimated values).

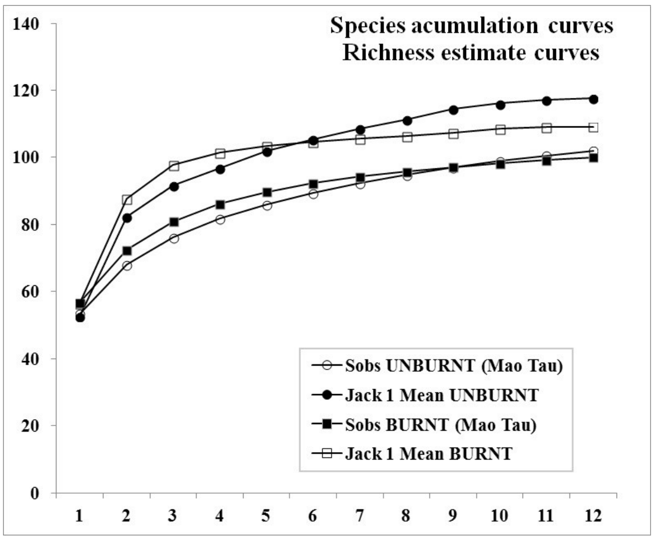


Fig. 2 – Accumulation Curves and Jack1 richness estimates for burnt and unburned grasslands.

ANOVA with the True Diversity indexes (Fig. 3a) showed significant difference for the wet/dry seasons, for the treatments and for their interaction (f = 5.542, p = 0.022; f = 5.909, p = 0.0183; f = 5.699, p = 0.021; respectively). Another analysis trying to find variation among the calendar year quarters showed significance only for the treatment (f = 5.345, p = 0.022) but not for seasons or the interaction (f = 2.454, p = 0.067; f = 2.081, p = 0.107; respectively), Fig. 3b.

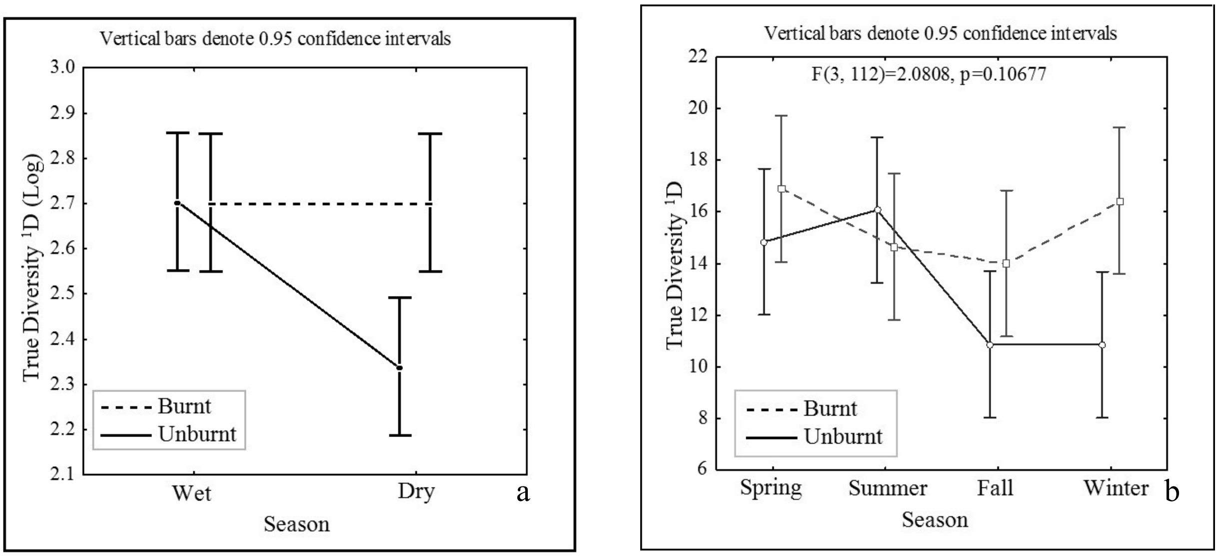


Figure 3 – Two-way ANOVA's for the diversity as a function of the treatment and the wet and dry seasons (a) and the four calendar year quarters (b).

A Bray Curtis species composition similarity analysis clearly showed aggregation of the sampling points according to burnt and unburned points in the wet season. Such aggregation was not visible for the dry season (Fig. 4). The co-phenetic correlation was 0.86 for the dry season and 0.72 for the rainy season, corresponding to 86% and 72% of the similarity information were faithfully reproduced in the dendrograms, indicating a low distortion between the calculated and the original matrix. The two groups formed in the dry season were fused to approximately 0.6 on the Bray-Curtis scale, and the group formed by the burnt areas was 0.5 on the scale.

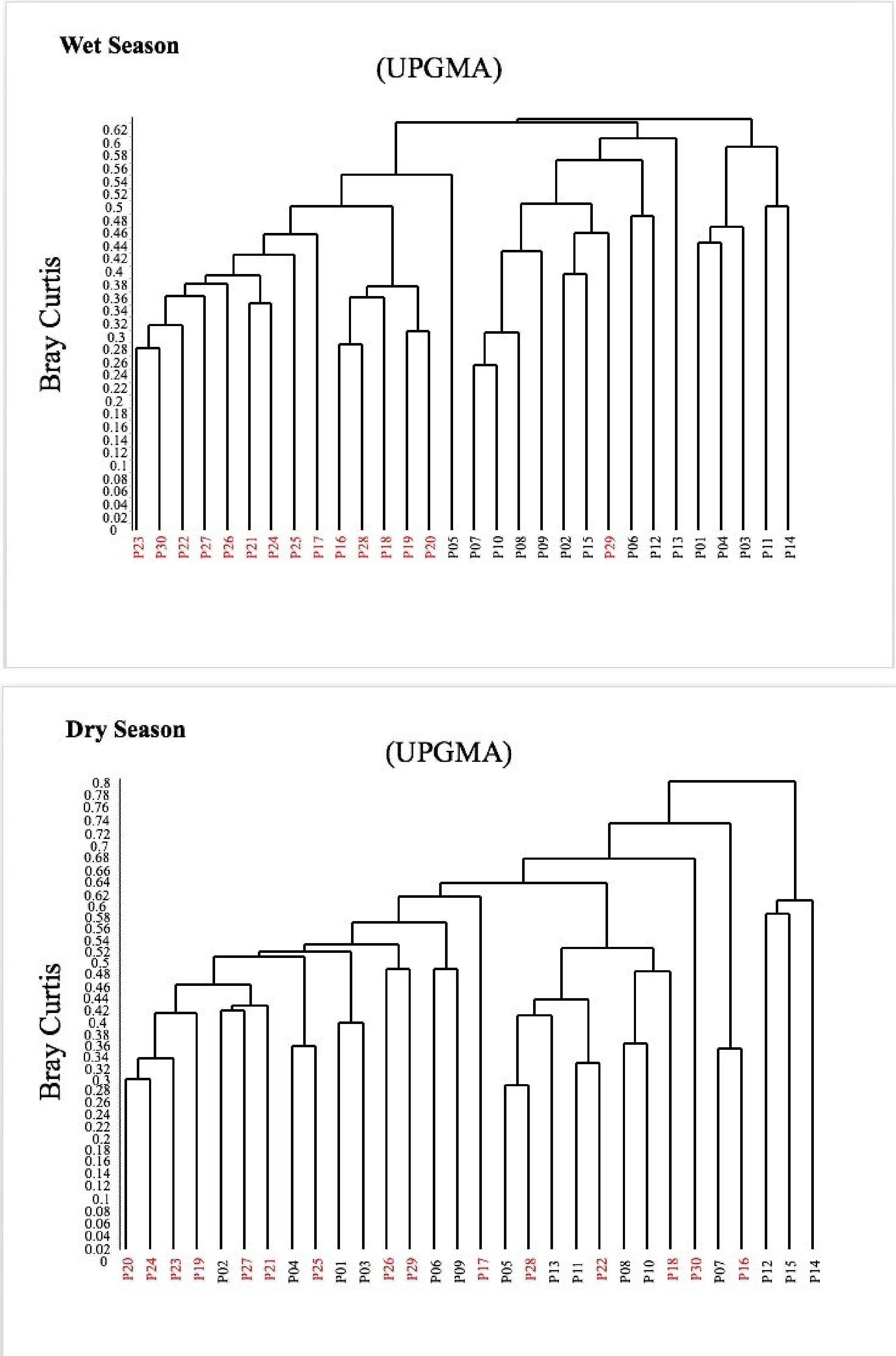
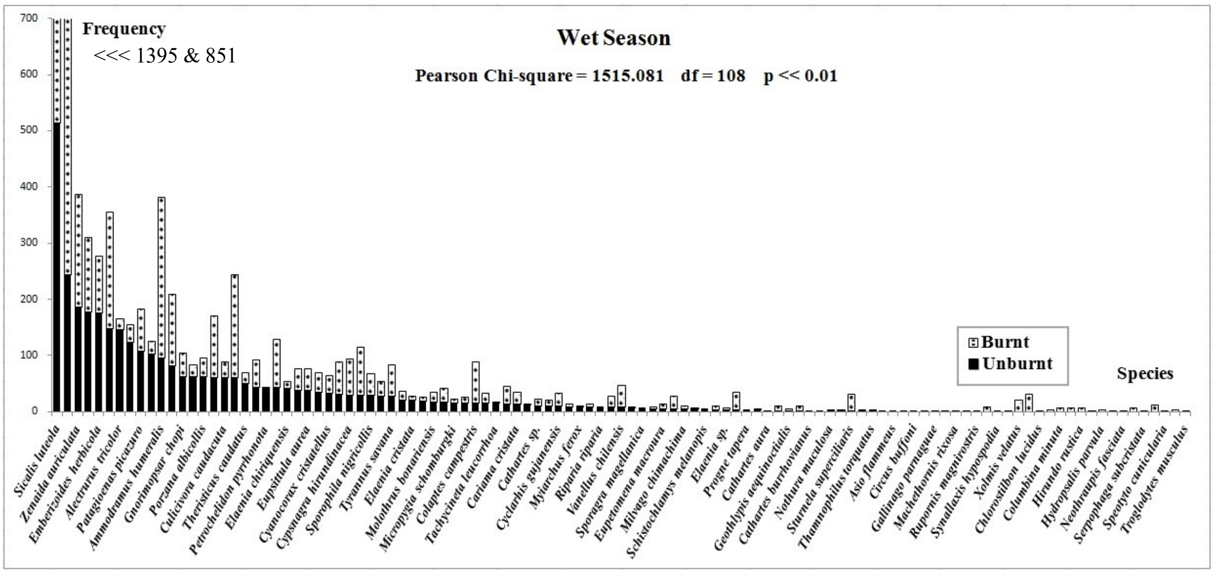


Figure 4 – Bray Curtis species composition dissimilarity analysis according to burnt / unburned treatments, for the wet and dry seasons.

A Chi-square test with the frequency data of the species indicated significant differences between the treatments for both the wet and the dry seasons, Pearson's $\chi^2 = 1515$, df = 108, p << 0.01 and $\chi^2 = 768$, df = 99, p << 0.01, respectively (Fig. 5). In both cases the frequencies were higher for burnt areas, but the difference diminished going into the dry season.



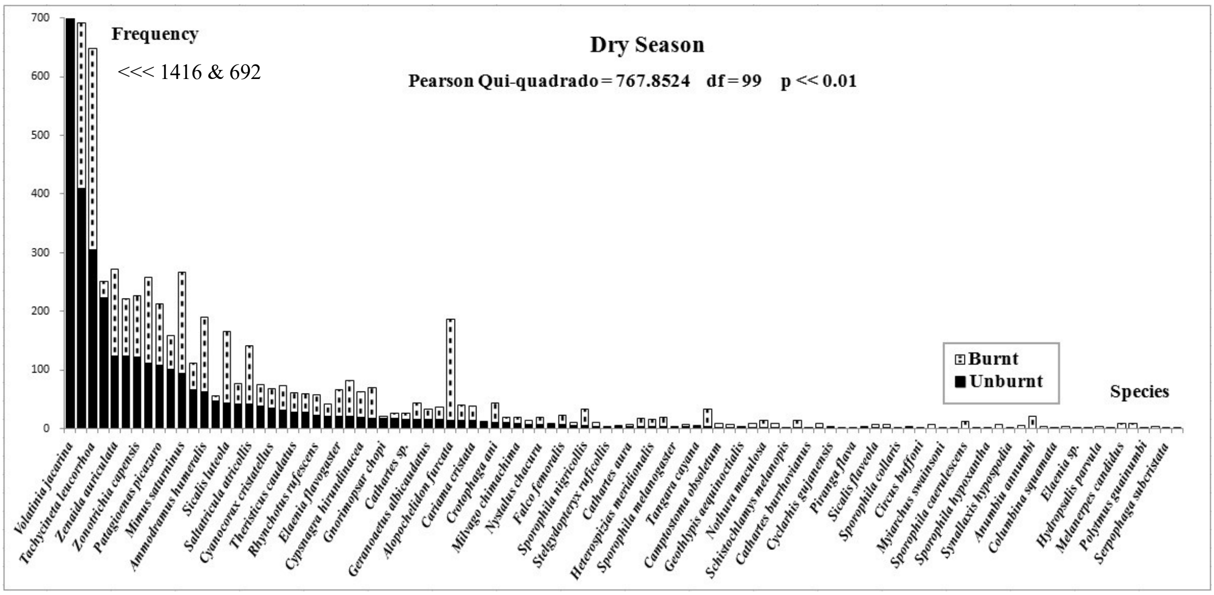


Fig. 5 - Frequency of the species for both wet and dry seasons and for burnt and unburned grasslands.

The water cycle and the vegetation conditions varied drastically between treatments and seasons. In unburned areas, the water level, the vegetation cover and height varied little. The water levels in the burnt areas varied from zero at the end of the dry season, to many centimetres accumulated at the peak of the rainy season, to zero again at the beginning of the dry season. The vegetation cover varied from zero to around 70 - 90% and the height from zero to about 70 – 100 cm. In unburned areas, a Mann-Whitney test showed that the vegetation cover did not differ between seasons ($U=105$, $n_1=15$, $n_2=15$ $p=0,75$). For burnt areas, it was much greater greater in the dry season ($U=5.0$, $n_1=15$, $n_2=15$, $p<<0,001$). The areas never reached full recovery in one annual cycle and dried much faster at the end of the rainy season than the ones that had not been affected by fire. An ANOVA test found statistically significant vegetation height differences for season, treatment and the interaction: $f(1, 56) = 58.88$, $p << 0.01$; $f(1, 56) = 157.38$, $p << 0.01$ and $f(1, 56) = 6.29$, $p = 0.015$, respectively (Fig. 5).

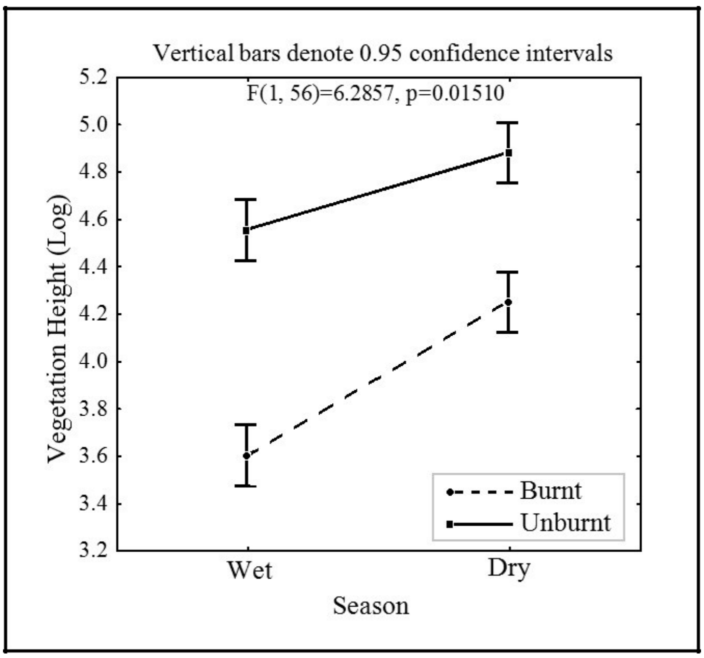


Figure 5 – Vegetation height for wet / dry seasons, comparing burnt and unburned grasslands.

The records for many species, common (*Ammodramus humeralis, Colibri serrirostris, Elaenia sp., Emberizoides herbicola, Porzana albicollis, Rhynchotus rufescens, Sicalis luteola, Synallaxis albescens, Zonotrichia capensis*) or more rare (*Alectrurus tricolor, Coryphaspiza melanotis*), fell significantly in the middle of the dry season.

Tyrannus savana was not recorded from February to July, returning in August, as it is well known for this highly seasonal species.

The migratory *Sporophila* did not stay in the area between the months of December and June: the jizz of all recorded animals were clearly from *S. pileata*, *S. nigricollis-caerulescens* and *S. plumbea*. *Sporophila*'s with different appearances started showing up in August and in September were already moulting confirming identification as *S. melanogaster*, *S. Cinnamomeus* and *S. hypoxantha*. Some of these species that are more dependent on preserved grasslands were never found in burnt areas. *Sporophila plumbea* continued being recorded at average numbers. *Sporophila pileata* was not recorded during the months of May through September.

Among the species of particular concern, *Alectrurus tricolor, Culicivora caudacuta and Micropygia schomburgki* were recorded every month and in both burnt and unburned areas. However, *A. tricolor* and *M. schomburgki* were found in burnt areas only after they were recovered, at the end of the wet season. *Coryphaspiza melanotis* was recorded between January and August, skipping April and June. All of its few records were in burnt areas, after they had recovered and had abundant, dense and tall grasses. *Cistothorus platensis* had very few records from February to September, both in burnt and unburned areas, also always in dense and tall grasses.

Grassland associated birds exploited the borders between native areas and other physiognomies of the matrix, including agricultural areas, regardless if the native areas were burned or not.

There were sparsely distributed trees and small groves in almost all areas: these were richer in species, but it they were found in both burnt and preserved areas.

About seventy five per cent of all species were documented photographically or via song and call recordings. All species under some lever of threat were documented, in most of the encounters.

DISCUSSION

The fact that the accumulation curves did not reach the asymptote, suggesting that a higher number of species might be present in both burnt and unburned areas, may be explained by the elimination of several species from the analyses, so to take into account only birds associated to the grasslands. Actually, the same analysis including such species presented a much better saturated curve. In other words, **there are more species there**, but they are not totally associated or dependent on the grasslands, rather being dwellers of the savannah as a whole.

Although the True Diversity index presented numerically significant differences for both seasons, graphically there was no difference in the wet season. This can be explained by the many possible outcomes from fires to life in the savannahs, reported in the literature (Reis, Fieker & Dias, 2016; Frizzo *et al*., 2011; Sendoda, 2009; Cintra & Sanaiotti, 2005). The disturbance initially favoured generalist species in detriment to specialists, the ones usually included in the lists of species under some level of threat (Woinarski & Legge, 2013; Franchin *et al*., 2009; Valentine, *et al*., 2007). These less common and more demanding species were not seen at all in the burnt lands within a few months following the fire. This is basically the depiction of the Intermediate Disturbance theory (Connel, 1979). At the end of the rainy / beginning of the dry seasons, the composition and abundance of species shifted and the diversity turned smaller in the unburned areas. This happened due to the movements of the species from unburned to burnt areas, to the variation of the vegetation and to the availability of food. Some specialist species recolonized the burnt areas after the vegetation had recovered to large degree. Many aspects of the natural history of the species and the Cerrado grassland dynamics also played their roles. First, the swing in resources between physiognomies of the Cerrado is well known. Although better documented for forest and "cerrado" as a whole (Macedo, 2002), it could also be seen for the "campos". When the dry season settled, the old grasslands may have had the resources depleted and the birds were observed roaming into other areas of the matrix, including the burnt areas and less optimum grasslands. The interpretation is that the birds used the preserved sites for protection and primary resources in the reproductive season, partially shifting to other resource rich areas subsequently. The vegetation in the burnt areas, although not fully recovered to its climax, had been producing abundant grasses, seeds, fruits and kept flowering throughout the dry season. The animals also opportunistically sought for food in other physiognomies, including temporarily abandoned overgrown crop fields or those with fruiting seed producing crops (*e.g. Soghum*).

Other indicators showed that there are significant differences in the bird community between preserved grasslands and those affected by fire, and between the wet and the dry seasons. The Bray Curtis community similarity analysis (Fig. 4) clearly grouped the sampled points into burnt and unburned for the wet season, but not for the dry season. This does not disagree with the ANOVA results for the True Diversity indexes. Although they were similar in the wet season between burnt and unburned areas, the species composition differed. In the dry season, the diversity indexes differed, while the species composition turned similar. The reasons are the same discussed before: in the wet season, there were more specialists in unburned sites and more generalists in the burnt ones. In the dry season, the bird species moving from preserved to burnt areas, recolonizations and mixing did not allow the clustering. These factors also caused the diversity in preserved areas to drop sharply in the dry season. The Bray-Curtis simililarity analysis takes into account the species composition of the community studied, while the True Diversity index ANOVA considers numbers only (richness and abundance). Furthermore, at the species level the processes must be much more complex, according to the specific facets of the life history of the species. A very large number of variables should be necessary to explain in detail the dynamics of the whole community.

The Chi-square test results for frequency of the species, exhibiting significant differences between burnt and unburned areas for both seasons, equally ads evidence to the generalist / specialist implications and their interaction with the treatments. The fact that the difference decreases for the dry season attests to the analysis about the shifting behaviour, movements and vegetation transformation.

Supporting the above arguments, is the high variation in the vegetation between seasons for burnt sites, but not for unburned ones. The Mann-Whitney and the ANOVA tests validated these observations of the natural history of the areas after the fire. In other words, the recovery process of the flora in burnt areas, and the consequent transformation of the food availability and protection cover conditions, caused the movements of the species, affecting community composition, frequencies and diversity.

The direct and clear consequences of the fire to the water levels and the partial recovery of the vegetation in the first year are strong evidence to the process by which the impoverishment of the soil, and of the diversity as whole, take place. If fires are frequent, the soil leaches out and become drier, the vegetation and other communities hurt and change, and the more specialist species do not find suitable habitat there. However, burning is essential to the maintenance of the grasslands and benefits some common and also threatened bird species (Frizzo *et al*., 2011). These current paradigms were illustrated in this study by the absence of some species under various levels of threat in the burnt grasslands, while others were present only in those areas, when the vegetation reached a reasonable degree of recovery.

One of the reasons why general numbers of grassland species fell greatly at the peak of the dry season is a familiar one: the birds are much more secluded and quieter outside the breeding season, so detection is much harder. Nevertheless, the phenomenon is the same for both burnt and unburned grasslands. Another key component was that the gasses grew much taller at the end of the wet season, reaching 2 m or more. So, it became much harder to detect the species visually too. This was much accentuated for the areas not affected by fire and has important conservation implications: the birds are better protected in well developed, denser and taller vegetation, which was not present in the burnt areas. Surely, their winter survival rate is higher there.

The characteristic two-season climate of the region was corroborated once again in the birds: the attempt to find variations along the calendar year quarters did not find any support (Fig. 3b).

The outcome from this study matches much of what is known about the fire or the Cerrado grassland birds. But, by following the whole community for one annual cycle, with much attention to the species under some level of threat, this study added more detailed information about what happens to the diversity of birds after a fire and throughout the seasons. This information also sheds some light on how the components of the community behave and why, based on their life histories and the succession of the vegetation and of the water levels in areas affected by fire. It shows that burnt areas take long to recover after the fire, the soil and the vegetation dry much faster than in preserved grasslands. This agrees with studies that report that frequent fires alter the composition of the community (Frizzo *et al*., 2011; Reis, Fieker & Dias, 2016; Souza *et al*., 2015; Vasconcelos *et al*., 2009). If burned more frequently, the humidity and the vegetation will never reach its climax and the composition of all life communities will change. On the other hand, some species of birds benefitted from the fire, especially those requiring open grasslands. It also became clear that it's vital to have preserved areas nearby to supply stock animals to recolonize the burnt areas. The importance of the management of the matrix by the farmers could be attested by species roaming for resources into abandoned or seed producing crop fields. Their understanding of this dynamics would certainly benefit conservation efforts, with slightly altered timings and proper fire avoidance controls. Ideally, preserving a large portion of all these very few remaining humid grasslands into a protected reserve would benefit wildlife, as well as the Man.

ACKNOLEDGEMENTS

The authors thank Carlos Henrique Nunes for fruitful discussions and suggestions, Gustavo Bernardino Malacco da Silva for presenting the study area, accompanying DP to the field and for valuable information. DP is also grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brazilian Department for Scientific and Technological Development) for financial support.

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CAPÍTULO 2

Population dynamics, reproductive biology and behavior of Cock-tailed Tyrant, *Alectrurus tricolor*) in a Cerrado grasslands.

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Abstract Understanding the migratory/resident status of a bird is essential for planning and carrying out any measures to preserve it. *Alectrurus tricolor* is a species classified as Vulnerable whose migratory/resident status is uncertain. This study sought to raise empirical data to help clarify this vital aspect of its life history. A local population of the species was monitored for 12 consecutive months in the course of one year in the Cerrado of central Brazil. This population was tracked in six adjoining areas of wet grasslands. In each area, five transects, with one observation point at the end, were surveyed every month in the course of a year. Circular statistics was used to analyze the data. The frequency of the records showed parameters pointing to a concentration in the breeding season, but also a tendency to uniformity. The resulting vector *r* was very small and there were significant numbers of sightings in every month. Morphological, behavioral and reproductive characteristics of its biology and ecology can be imputed for earlier misunderstandings about its population temporal dynamics and suggest that the species is resident throughout the year. Those include courtship behavior, camouflage, post-breeding behavior, movements and succession of the grasses in its habitat. They are responsible for the very low count or absence of the species in the dry season, reported in articles classifying it as migratory or resident. The data obtained also corroborate seasonal distribution of the species inferred from niche modeling and the status of resident.

Keywords: tropical grassland birds, migratory or resident status, fire ecology, endangered species.

INTRODUCTION

Alectrurus tricolor (Vieillot, 1816) (Fig. 2) is a bird categorized as "Vulnerable" at the national and international levels (SEMAD, 2010; MMA, 2014; IUCN, 2017) and "Threatened" in the state of Minas Gerais (Biodiversitas, 2007; SEMAD, 2010). This status is due to extensive habitat loss and consequent population decline (BirdLife International, 2016). The highly threatened and fast disappearing tropical grasslands (Marini and Garcia, 2005; Silva and Bates, 2002; Myers *et al*., 2000) are its obligatory habitat. This Tyrannidae bird is considered scarce to rare, local and declining in all its range. Its ecology is little known and the data about its populations, migratory habits and occurrence outside UC's is deficient (BirdLife International, 2016). Further studies focusing on this species are endorsed to fill voids in its knowledge and offer subsidies for its conservation (BirdLife International, 2016). Specific year round field studies on *Alectrurus tricolor* populations are recommended (Marini, 2013).

This species is a denizen mostly of the Cerrado, the largest savannah in South America and the second largest biome in Brazil (Collar *et al*. 1992; Gottsberger & Silberbauer-Gottsberger, 2006). It inhabits wet grasslands, probably the most threatened physiognomy of the biome (Collar *et al*. 1992). Without the appeal of the "forest" label, these grasslands are under studied and under protected (Lopes *et al*., 2009). The remnants are critically scarce and generally in conservation units (Tubelis, 2000). Outside those, the degradation is rampant (Stotz *et al*. 1996). Collar *et al*. (1992) suggests that the almost total obliteration of the "campos" in Brasil is among the greatest ecological catastrophes of South America. The main cause is the expansion of mechanized agriculture and cattle ranching.

Some authors consider *A. tricolor* as a migratory species, partially nomadic or resident (*sensu* Dingle & Drake, 2007; Dingle, H. 2006; Kennedy, 1985), depending on the region or the information source (Silveira, 1998; Del Hoyo *et al*., 2004; BirdLife International, 2016; Ten *et al*., 2001). Knowing the migratory/resident status of a species is key to the success of any conservation initiative (Cottee-Jones, Matthews and Whittaker, 2015; Runge *et al*., 2014; Bauer, 2014; Marini, 2013; Faaborg, 2010; Berthold, 2001). This is especially true about birds, the group of vertebrates with the largest percentage of migratory species (Bauer, 2014; Riede, 2001). Recently, Marini (2013) carried out a modeling study on the species geographic and seasonal distribution using niche modeling and concluded that it is resident. The camouflage, the very secretive and still behavior seen strongly suggest that the few winter records are due to difficulties to detect the birds.

In the beginning of the last century, natural history was the main stream of zoology, but recently scientists have shied away from being seen as naturalists (Bartholomew, 1986; Schulze-

Hagen and Birkhead, 2015). However, for decades many have attested to the importance of understanding a phenomenon in its full context, linking the several levels of its nature, so the research is not fooled by ignorance. And "natural history is the principal source of information about organisms living under natural conditions" (Bartholomew, 1986). It is also becoming ever clearer that studies of the biology and natural history of the species are indispensable for a better comprehension of elements key to conservation, from the most basic ecological studies to the most complex networks of interactions (Birkhead, 2015; Del-Claro *et al.*, 2013 and citations therein).

This study was designed to evaluate the population dynamics of *the* Cock-tailed Tyrant (*Alectrurus tricolor*) in the Cerrado grasslands, gathering empirical data to help understand the migratory, nomadic or resident status the this species in Central Brazil.

METHODS

Study area

The study area was selected based on data from previous studies in the region (Di Mauro *et al.*, 2011; Lopes *et al.*, 2010). It represents well the wet and dry grasslands of the Cerrado biome in the Triângulo Mineiro region. The phytophysiognomy is comprised mostly of Poaceae and Cyperaceae grasses, but also present many Cerrado non-Commelinid herbs, bushes and small trees. Encompassing areas of vital importance for conservation, the headwaters of the rivers Uberabinha (Uberaba-MG) and Mandaguari (Indianópolis-MG), the springs and aquifers supply the agriculture and about 600,000 people in the region (Di Mauro *et al.*, 2011). These grasslands have also proven to be key habitat for the preservation of several other birds, under various degrees of threat and in all levels: state, national and international (Biodiversitas, 2007; Machado, Drummond & Paglia, 2008; BirdLife International, 2015). The species include resident and migratory birds that use these areas as their wintering grounds, where they molt and refuel prior to spring migration (Repenning, 2012, Repenning & Fontana, 2013, 2016; Di Mauro *et al.*, 2011; Lopes *et al.* 2010). They are areas under huge anthropic pressure, mostly due to agricultural activities, and considered priority for conservation in the class of extremely high biological biodiversity (Di Mauro *et al.*, 2011; Drummond *et al.*, 2005).

The climate in the region is classified as Aw (Köppen, 1918), with just two well defined seasons, a hot and humid summer from October to March and a dry winter from April to September (de Melo Prado *et al.*, 2016; Klink & Machado, 2005).

Focus species

Alectrurus tricolor (Vieillot, 1816) is a small Tyrannidae flycatcher (male 18 cm, female 12 cm; Del Hoyo *et al*., 2004). The male is black above, white below, grey rump, white shoulder bars, black patches on the sides of the breast and a black V-shaped fan tail. The female has brown replacing black and buff replacing white, the tail is regular and short.Its ecology is little known, but it inhabits dry and wet/seasonally inundated grasslands, preferably tall (0.3 – 1.0 m). It is essentially insectivore and considered at least partially nomadic (Del Hoyo *et al*., 2004; BirdLife International, 2016). In Brazil, its reproductive season is believed to initiate at the beginning of the rainy season (September - October). Its range reaches areas in the states of Mato Grosso, Goiás, Minas Gerais, Rio de Janeiro, São Paulo, Mato Grosso do Sul and Paraná. It also occurs in Paraguay (very rare), Eastern Bolivia (local) and probably extinct in Argentina (BirdLife International, 2016 and citations therein).

Procedures

Six native grassland areas were selected by systematic randomization (Hulbert, 1984) using satellite imagery (Fig. 1). These included three areas burned one month immediately before the beginning of the study and three that had not been burned in at least three years. In each one, five points (Appendix 1) and related transects were selected (totaling 30 transect–point pairs), following these criteria (Bibby *et al*., 2000; Vielliard *et al*., 2010): at least 200 m long transects; at least 400 m from each other. In order to avoid recording the same individual twice only those within a radius of 150 m (visually estimated) were considered.

The records were collected with the naked eye and using specialized optical instruments. Each transect–point pair was visited every month, for 12 consecutive months. The final observations took place in September 2016 – so the months of October to December were surveyed back in 2015. The observations started at least 30 minutes before sunrise and the different areas, transects and points were visited in alternate order each trip, in a way that each one was visited in the first hours of the morning and in each season. After surveying the transect, the observer spent 20 minutes at the point. Special care was taken when moving from one transect to the other with the intent of avoiding duplicity in the records due to animal movements. Birds at the limit of the radius were recorded as belonging to only one point. No attempt was made to estimate the species population in the region.

The taxonomy of the species followed Piacentini *et al*. (2015).

Statistics

Statistical analyses were carried out in the R statistical environment (R Core Team, 2017) using the module Circular Statistics (Agostinelli and Lund, 2013.). The graphs were produced by the software Oriana (Kovach, 2011). These programs, better known to for their use to analyze plant phenology are also widely used in countless other contexts (Kato, 2010; Berens, 2009; Jammalamadaka and Sengupta, 2001). All records were attributed to the last day of the month, since these statistics take into account the 365 days of the year, and assigned to the next rounded angle according to the Julian date (q = JD*360/365). Results were considered significant for errors smaller than 5% ($p \leq 0{,}05$). Unless otherwise noted, all statistics theory and assumptions were taken from Zar (2010). The mean vector ($r, \bar{\theta}$) was determined, where $r = 0$ means uniform and $r = 1$ means concentrated distribution. To demonstrate if the distribution of the records is uniformly distributed or concentrated along the year it was compared to the von Mises distribution – the circular normal distribution. The Rayleigh test (z) was employed to test the significance of these resulting parameters. The z value was compared to tabled values according the confidence level. If $z < z_{table}$ then H_0 = uniform distribution is accepted; if z^{3} z_{table} H_0 is rejected and the distribution is directional or concentrated.

Natural History

It is essential to make notes of the appropriate variables to correlate the data found with characteristics of the matrix (Anderson, 1981). To that effect several parameters were recorded along the year for each transect and point. These were habitat (dry grassland, wet grassland, bush and tree cover); regeneration stage of any vegetation – documented photographically; matrix (other natural formations, pasture, crop species, exotic vegetation, nude soil); height of the vegetation; location of the animals (found in its habitat or roaming in other types of habitat - including anthropic) and size of the area.

In order to help understand any outcome of the results, relevant aspects of the life history of the species were recorded (Franchin *et al*., 2010), such as: display/courtship, foraging, antagonism, territory defense, evasion from predators, nesting and movements. When a noteworthy aspect was observed, some extra effort was put into trying to understand it better, abandoning for a while and only for this purpose, that transect - point.

Equipment

A Garmin GPSmap 76CSx GPS was used to find the transects and points chosen from satellite imagery and to record any other geographical information and localizations. A pair of Celestron Granite 8x42 binoculars and a Kowa TSN-821 telescope were used to visualize the birds from the transects and the points. No sound recording equipment was utilized to record the species, since its chiefly silent (del Hoyo *et al.*, 2004; Ridgely & Tudor, 1994). Most records were documented with the camera of a Samsung S4 smartphone placed against the telescope ocular. A text-editing tool in the smartphone was used for field data annotations and a music applicative for bird song playback. At the end of every visit, the data collected were backed-up to a MacBookPro computer. The statistics calculi were also performed in this machine.

RESULTS

Population dynamics

The species was present in all months of the year. The circular histogram shows the monthly records and the resulting vector angle and size (Fig. 3).

The resulting circular statistical analysis produced the parameters in Table 1.

Natural History

During the whole year it was possible to confirm and learn key aspects of the life history of the animal and its environment. In the reproductive (wet season), the birds remained in a few preferred areas, and presented lek-like behavior (*sensu* Höglund and Alatalo, 2014). Males performed their flight display endlessly, approaching females at the top of grass stalks and chasing other males. The females watched from their posts and frequently followed a male. It was not possible to observe copulations. These areas consisted of pristine native wet grasslands and the animals were not recorded in less optimal habitat, except when foraging for insects a few meters from its habitat into adjacent crop fields. No birds were found in the recently burned areas.

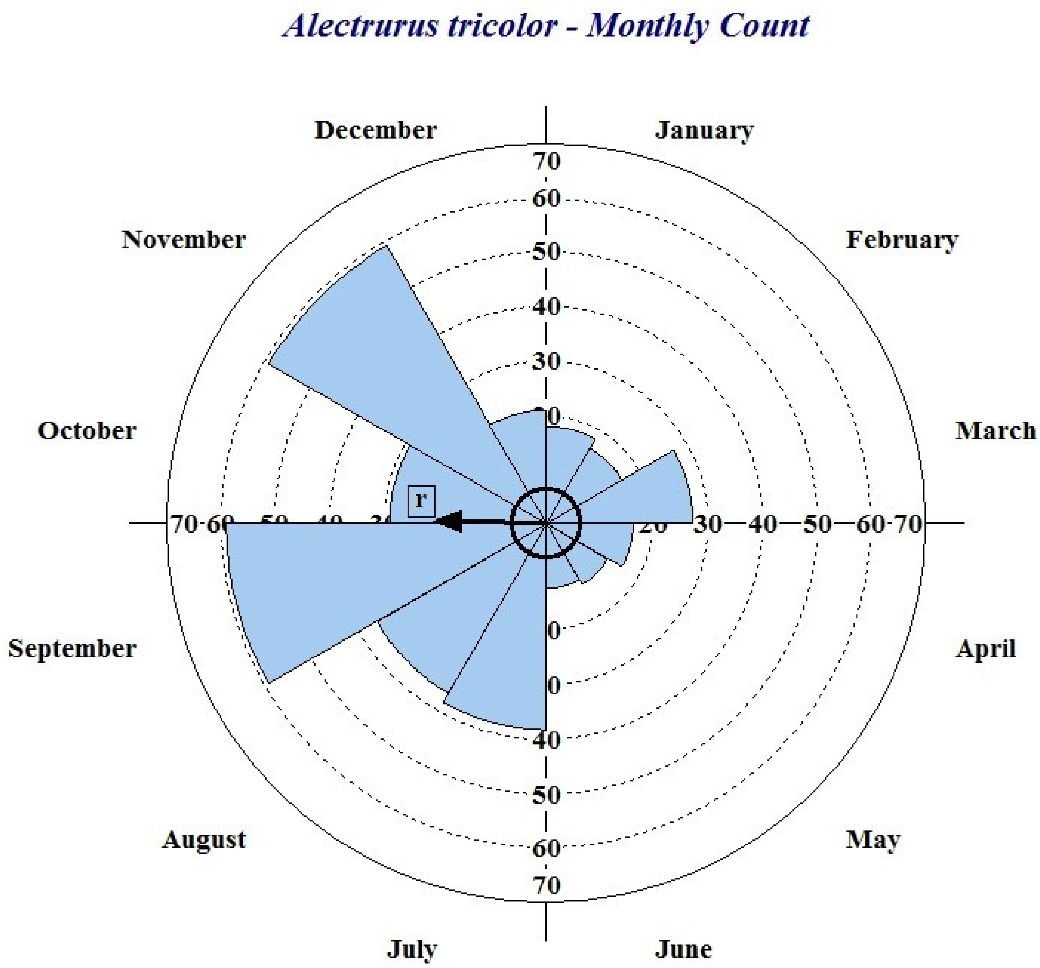

Fig. 3 Monthly distribution of the records and the resulting circular vector (r). The sizes of the bars (grid numbers) represent the actual numbers of individuals of the species counted in each month, in all areas

Table 1 Parameters from circular statistical analysis of frequency of *Alectrurus tricolor* records in the course of one year

Parameters	Values
Mean angle ($\bar{\theta}$)	271°
Mean vector size (r)	0.287
Rayleigh Test (z)	28.381
Rayleigh Test (p)	P << 0.001
Chi-Squared Test (X^2)	104.674
Chi-Squared Test (p)	P << 0.001

The breeding areas were dominated by two groups of grasses: a) shorter, more entangled and in lower ground with accumulated water, where they seemed to nest; b) taller, in higher in better drained ground, dominated by *Andropogon sp*. (Poaceae). A little latter into the reproductive season, the behavior started shifting. The males stopped displaying and turned to moving less and lower over the grasses. The females also stayed lower and pairs were documented nesting and feeding young (November - January). The nest consisted of a grass-lined cup low into a clump of grasses (Fig. 4).

At the end of the reproductive season the very discreet behavior increased resulting in no leks, no displays, birds moving much less and just above or in the grasses. Fewer-remove Males were found throughout the year sporting their long and odd tails, documented with photographic records, but always behaving as above. Females were very hard to detect, disappeared into the grasses and only seldom rose up. Once what was happening was realized, extra effort was put into trying to confirm the presence of females. In virtually every instance that a male was found, if sought hard enough, a female was detected close by. Meanwhile, the numbers thinned out, although several males and females still remained in the area. On the other hand they rose in neighboring areas and animals started being seen in adjacent native non-optimal grasslands, including areas burned a few months earlier and still not fully recovered, weedy fields and abandoned crop fields, all provided that there was abundant tall grasses of any kind. They abandoned the shorter grass areas where they nested and exploited the surrounding matrix, certainly to evade predation and to obtain enough resources to survive the dry season. Predatory birds, common in the breeding areas, could be avoided by moving into quieter spaces. These sightings shifted from place to place and from visit to visit. The animals were never seen in any areas with sparse or short grasses. No information was observed on its molting.

The characteristics of the vegetation changed strongly, according to the season. During the wet season the grasses grew, reaching their peak in April. In unburned areas they grew to a height of around 2.5 m. On the other hand, in the burnt areas the height reached 30 cm to 1.8 m, depending on the quality of the soil and the degree of drainage (the short measurement was for very sandy and dry soil). The grasses then started to deteriorate in May in all areas, but dried much faster in the burned grasslands. By July they were already decaying fast and were all broken down and much shorter, although still having a height of about 1.5 m in unburned places. Synced with this, the farmers abandoned the fields in the dry season and they were overgrown with native and exotic grasses – wherever tall grasses grew, they became new ranges that were exploited by the species in the dry season.

Fig. 4 *Alectrurus tricolor* nest, 30/11/2015. Top to bottom: two chicks in the nest, nest entrance and location in the grasses and landscape

DISCUSSION

The results match the status of resident, reported by authors from other regions (del Castillo, Clay and de Egea, 2005; Ten *et al*. 2001). The considerable number of records outside the breeding season dissents from several authors classifying *Alectrurus tricolor* as either nomadic (Birdlife International, 2016; Del Hoyo *et al*., 2004) or migratory (Birdlife International, 2016; Machado, Drummond & Paglia, 2008; Silveira, 1998).

The mean angle $\bar{\theta}$ points to the middle of the reproductive season, September to November, but by itself it does not indicate any concentration. Furthermore, the Rayleigh test parameter states that the distribution is directional ($z = 28.381$ and probability $p << 0.001$). Although this indicates that there is a concentration of sightings in the reproductive season, this parameter is considered more adequate for large values of r (Zar, 2010; Kovach, 2011). Also, the Chi-squared goodness of fit for circular data rejected H_0 that the distribution is uniform.

The high numbers around the reproductive season is expected. The lek behavior in the breeding season, reported in the literature (Ridgely and Tudor, 1994; Sick, 1977) helped detect both males and females very easily. They were very active, moving all the time, flying up high and chasing each other. Also, they were concentrated in a few preferred areas – the ones containing optimum breeding habitat.

These findings permit to infer that the nomadic or migratory status of the species was based on the difficulty to detect the animals in the dry season. Males were seen a little more easily due to the outstanding tail and black-an-white pattern, but the females camouflaged extremely well against the dry grasses and virtually disappeared. This difficulty in detecting and studying secretive females of a grassland bird when they are not attending leks, and therefore having imprecise information for conservation, has been reported by at least another study (Silva *et al*., 2014). Another aspect contributing to low number (or absence) of records is the very short-distance movements of the birds, when they moved into less optimal habitat and other areas in the matrix, including burned areas that had the grasses recovered to a tall height. In larger and well preserved ranges (including reserves), they would have sizeable expanses to move into and fade from the breeding lek areas. The yearly cycle of the native grasses and of the agricultural matrix also played a vital role in the problem of sighting the species. The very tall grasses hampered impossible to see grass birds, even more this primarily mute species. And the overgrown fields provided extra suitable areas for the birds to hide in.

We must also consider that reports in some papers may not have counted on enough or formal sampling of the species. The low numbers (or absence) of *Alectrurus tricolor* in the dry season are due to its shifted behavior, cryptic plumage of the females, their wandering into the areas outside the lek and breeding areas and across the matrix. In the winter, it exploits non-standard open habitats, including nearby weedy fields (resting cultivated areas) and burned areas, provided that there are native tall grasses (including exotic and crop Poaceae) in the vicinity for roosting and protection. The birds maintained several pairs throughout the dry season, another phenomenon worth further investigation and that supports the conclusion that the birds remained in the region and just became harder to detect. Apparently, the population did not vary visibly in this study (comparing highest counts in the two years). Deceased, old and young males supposedly replace each other by means of the lek behavior. This study, along with others, corroborates the studies and brings more evidence that the species is, in fact, resident throughout its range. Indeed, our empirical data corroborate the findings from niche modeling by Marini (2013).

The fact that the final observations were in September/2016, and that the months of October to December were surveyed in 2015, suggests that the two proximate peaks in November/2016 and September/2015 may be close to the highest count for the population in the site, with its detection only out of phase from one year to another.

Replications of this study in other regions and long term studies marking individual birds will probably corroborate these findings, allow a more fine understanding of any fluctuations of the local populations and are highly advisable. Other approaches are also recommended in face of the new information, for example, extensive search concentrated on the species instead of transect and point censuses.

ACKNOWLEDGEMENTS

The authors thank Carlos Henrique Nunes and Liliane Martins Oliveira for fruitful discussions and suggestions, Gustavo Bernardino Malacco da Silva for presenting the study area, accompanying DP to the field and for valuable information. We are also grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for financial support.

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CONSIDERAÇÕES FINAIS

O acompanhamento da sucessão ecológica nos ambientes queimados em todo o primeiro ano após o fogo permitiram detectar variação no índice de Diversidade Efetiva entre campos hidromórficos queimados e não queimados, bem como entre as estações chuvosa e seca. Os resultados permitiram observar os efeitos dessas condições ambientais sobre a comunidade de aves, mostrando como elas se comportam e o porquê, considerando suas histórias de vida, características da flora e níveis de umidade. Várias espécies de aves não foram registradas em áreas recentemente afetadas pelo fogo. Uma espécie foi registrada apenas em uma área queimada, na qual a vegetação se encontrava em estágio razoável de recuperação, caracterizada pela ocorrência de capinzais densos e de média altura. Nos campos preservados houve pequena variação na disponibilidade de alimento e no grau de umidade, bem como na altura e grau de cobertura do solo. Já nas áreas queimadas, esses parâmetros tiveram uma larga amplitude. As áreas queimadas se recuperaram lentamente e o solo e a vegetação secaram muito mais rápido do que nas áreas preservadas. Nessas condições, as espécies de aves menos comuns ou sob algum nível de ameaça permaneceram principalmente em áreas não queimadas durante a estação chuvosa. Presume-se que alí havia recursos e proteção da vegetação mais alta. Tais espécies passaram a frequentar também áreas queimadas em recuperação com o início da estação seca, aproveitando a disponibilidade de gramíneas jovens que passavam por vários estágios de floração e produção abundante de sementes.

Aves migratórias estiveram presentes principalmente no verão chuvoso, cada espécie partindo em diferentes tempos no início do período seco e só retornando no final. Mudas de penas puderam ser observadas em algumas espécies, em setembro. A detecção de aves campestres foi sensivelmente diminuída no final do verão e início da estação seca. Isso parece estar associado ao comportamento mais discreto das referidas aves, após o período reprodutivo, e ao fato de a vegetação ter se tornado muito alta, dificultando o registro visual. A maioria das espécies foi documentada diversas vezes, em vários meses, por meio de gravações de cantos e fotografias. A sucessão nos ambientes queimados também foi documentada.

Os dados sobre a espécie foco do trabalho, *Alectrurus tricolor*, corroboram observações de outros autores, bem como uma simulação que lhe atribui o status de residente. Evidências sugerem que pelo menos alguns casais se mantém durante todo o inverno. Talvez a mais forte dessas evidências tenha sido o registro de caudas exóticas de machos da espécie em todos os meses de realização da pesquisa. Como ocorre com outras espécies, as aves adotaram comportamento recluso e a detecção de fêmeas exigiu esforço extra.

Este trabalho aponta a necessidade de estudos mais aprofundados em todos os aspectos da dinâmica ecológica dos campos hidromórficos do Cerrado, um vasto campo ainda desconhecido e carente de pesquisas. A conservação desses ambientes se mostra vital e urgente, especialmente no que tange à criação de áreas protegidas, agudamente escassas. O uso de áreas agrícolas temporariamente abandonadas e de outras que produzem sementes de várias espécies indica a importância do manejo em toda a matriz. A necessidade de entendimento por parte dos fazendeiros sobre essa dinâmica exige também o desenvolvimento de estudos integrados com outras áreas do conhecimento, como a Sociologia. Assim, esforços de conservação dos campos hidromórficos certamente beneficiarão tanto a vida silvestre quanto o homem.

SUPPLEMENTAL INFORMATION

Appendix 1. Coordinates of the study points.

Points	Geographical Coordinates
UP-a-1	23 K 191096 E 7855602 S
UP-a-2	23 K 190393 E 7855166 S
UP-a-3	23 K 190893 E 7855194 S
UP-a-4	23 K 191033 E 7854808 S
UP-a-5	23 K 191224 E 7854431 S
BP-a-1	23 K 192862 E 7854371 S
BP-a-2	23 K 193881 E 7854601 S
BP-a-3	23 K 193589 E 7855177 S
BP-a-4	23 K 193507 E 7855961 S
BP-a-5	23 K 193841 E 7856423 S
UP-b-1	23 K 197401 E 7854217 S
UP-b-2	23 K 197352 E 7853807 S
UP-b-3	23 K 196863 E 7854030 S
UP-b-4	23 K 196319 E 7854143 S
UP-b-5	23 K 195429 E 7854069 S
BP-b-1	23 K 192940 E 7857104 S
BP-b-2	23 K 193345 E 7857180 S
BP-b-3	23 K 193529 E 7857526 S
BP-b-4	23 K 193426 E 7858024 S
BP-b-5	23 K 193842 E 7858061 S
UP-c-1	23 K 195016 E 7855540 S
UP-c-2	23 K 195307 E 7855195 S
UP-c-3	23 K 195977 E 7855476 S
UP-c-4	23 K 196378 E 7855556 S
UP-c-5	23 K 197299 E 7855587 S

BP-c-1	23 K 194087 E 7857712 S
BP-c-2	23 K 193927 E 7857330 S
BP-c-3	23 K 194166 E 7856795 S
BP-c-4	23 K 194496 E 7857019 S
BP-c-5	23 K 194443 E 7857425 S

Appendix 2 – Grassland associated species recorded and considered for the calculi.

	Famílias e nomes científicos	**Nome em Português**	**English Name**
	Rheidae Bonaparte, 1849		
1	*Rhea americana* (Linnaeus, 1758)	ema	Greater Rhea
	Tinamidae Gray, 1840		
2	*Crypturellus parvirostris* (Wagler, 1827)	inambu-chororó	Small-billed Tinamou
3	*Rhynchotus rufescens* (Temminck, 1815)	perdiz	Red-winged Tinamou
4	*Nothura maculosa* (Temminck, 1815)	codorna-amarela	Spotted Nothura
	Ardeidae Leach, 1820		
5	*Syrigma sibilatrix* (Temminck, 1824)	maria-faceira	Whistling Heron
	Threskiornithidae Poche, 1904		
6	*Theristicus caudatus* (Boddaert, 1783)	curicaca	Buff-necked Ibis
	Cathartidae Lafresnaye, 1839		
7	*Cathartes aura* (Linnaeus, 1758)	urubu-de-cabeça-vermelha	Turkey Vulture
8	*Cathartes burrovianus* Cassin, 1845	urubu-de-cabeça-amarela	Lesser Yellow-headed Vulture
9	*Coragyps atratus* (Bechstein, 1793)	urubu	Black Vulture
	Accipitridae Vigors, 1824		
10	*Circus buffoni* (Gmelin, 1788)	gavião-do-banhado	Long-winged Harrier
11	*Heterospizias meridionalis* (Latham, 1790)	gavião-caboclo	Savanna Hawk
12	*Urubitinga coronata* (Vieillot, 1817)	águia-cinzenta	Crowned Eagle
13	*Rupornis magnirostris* (Gmelin, 1788)	gavião-carijó	Roadside Hawk
14	*Geranoaetus albicaudatus* (Vieillot, 1816)	gavião-de-rabo-branco	White-tailed Hawk
	Rallidae Rafinesque, 1815		
15	*Micropygia schomburgkii* (Schomburgk, 1848)	maxalalagá	Ocellated Crake
16	*Mustelirallus albicollis* (Vieillot, 1819)	sanã-carijó	Ash-throated Crake
	Charadriidae Leach, 1820		
17	*Vanellus chilensis* (Molina, 1782)	quero-quero	Southern Lapwing
	Scolopacidae Rafinesque, 1815		
18	*Gallinago paraguaiae* (Vieillot, 1816)	narceja	South American Snipe
	Columbidae Leach, 1820		

19	*Columbina minuta* (Linnaeus, 1766)	rolinha-de-asa-canela	Plain-breasted Ground-Dove
20	*Columbina talpacoti* (Temminck, 1810)	rolinha	Ruddy Ground-Dove
21	*Columbina squammata* (Lesson, 1831)	fogo-apagou	Scaled Dove
22	*Patagioenas picazuro* (Temminck, 1813)	asa-branca	Picazuro Pigeon
23	*Zenaida auriculata* (Des Murs, 1847)	avoante	Eared Dove
24	*Leptotila verreauxi* Bonaparte, 1855	juriti-pupu	White-tipped Dove
	Cuculidae Leach, 1820		
25	*Crotophaga ani* Linnaeus, 1758	anu-preto	Smooth-billed Ani
26	*Guira guira* (Gmelin, 1788)	anu-branco	Guira Cuckoo
27	*Tapera naevia* (Linnaeus, 1766)	saci	Striped Cuckoo
	Strigidae Leach, 1820		
28	*Athene cunicularia* (Molina, 1782)	coruja-buraqueira	Burrowing Owl
29	*Asio flammeus* (Pontoppidan, 1763)	mocho-dos-banhados	Short-eared Owl
	Caprimulgidae Vigors, 1825		
30	*Antrostomus rufus* (Boddaert, 1783)	joão-corta-pau	Rufous Nightjar
31	*Nyctidromus albicollis* (Gmelin, 1789)	bacurau	Common Pauraque
32	*Hydropsalis parvula* (Gould, 1837)	bacurau-chintã	Little Nightjar
33	*Hydropsalis anomala* (Gould, 1838)	curiango-do-banhado	Sickle-winged Nightjar
34	*Nannochordeiles pusillus* (Gould, 1861)	bacurauzinho	Least Nighthawk
	Trochilidae Vigors, 1825		
35	*Eupetomena macroura* (Gmelin, 1788)	beija-flor-tesoura	Swallow-tailed Hummingbird
36	*Colibri serrirostris* (Vieillot, 1816)	beija-flor-de-orelha-violeta	White-vented Violetear
37	*Chlorostilbon lucidus* (Shaw, 1812)	besourinho-de-bico-vermelho	Glittering-bellied Emerald
38	*Hylocharis chrysura* (Shaw, 1812)	beija-flor-dourado	Gilded Hummingbird
39	*Polytmus guainumbi* (Pallas, 1764)	beija-flor-de-bico-curvo	White-tailed Goldenthroat
	Bucconidae Horsfield, 1821		
40	*Nystalus chacuru* (Vieillot, 1816)	joão-bobo	White-eared Puffbird
	Ramphastidae Vigors, 1825		
41	*Ramphastos toco* Statius Muller, 1776	tucanuçu	Toco Toucan
	Picidae Leach, 1820		
42	*Melanerpes candidus* (Otto, 1796)	pica-pau-branco	White Woodpecker
43	*Colaptes campestris* (Vieillot, 1818)	pica-pau-do-campo	Campo Flicker

	Cariamidae Bonaparte, 1850		
44	*Cariama cristata* (Linnaeus, 1766)	seriema	Red-legged Seriema
	Falconidae Leach, 1820		
45	*Caracara plancus* (Miller, 1777)	carcará	Southern Caracara
46	*Milvago chimachima* (Vieillot, 1816)	carrapateiro	Yellow-headed Caracara
47	*Herpetotheres cachinnans* (Linnaeus, 1758)	acauã	Laughing Falcon
48	*Falco sparverius* Linnaeus, 1758	quiriquiri	American Kestrel
49	*Falco femoralis* Temminck, 1822	falcão-de-coleira	Aplomado Falcon
	Psittacidae Rafinesque, 1815		
50	*Eupsittula aurea* (Gmelin, 1788)	periquito-rei	Peach-fronted Parakeet
	Thamnophilidae Swainson, 1824		
51	*Thamnophilus torquatus* Swainson, 1825	choca-de-asa-vermelha	Rufous-winged Antshrike
	Furnariidae Gray, 1840		
52	*Furnarius rufus* (Gmelin, 1788)	joão-de-barro	Rufous Hornero
53	*Phacellodomus ruber* (Vieillot, 1817)	graveteiro	Greater Thornbird
54	*Anumbius annumbi* (Vieillot, 1817)	cochicho	Firewood-Gatherer
55	*Certhiaxis cinnamomeus* (Gmelin, 1788)	curutié	Yellow-chinned Spinetail
56	*Synallaxis albescens* Temminck, 1823	uí-pi	Pale-breasted Spinetail
57	*Synallaxis hypospodia* Sclater, 1874	joão-grilo	Cinereous-breasted Spinetail
	Tyrannidae Vigors, 1825		
58	*Camptostoma obsoletum* (Temminck, 1824)	risadinha	Southern Beardless-Tyrannulet
59	*Elaenia flavogaster* (Thunberg, 1822)	guaracava-de-barriga-amarela	Yellow-bellied Elaenia
60	*Elaenia cristata* Pelzeln, 1868	guaracava-de-topete-uniforme	Plain-crested Elaenia
61	*Myiarchus swainsoni* Cabanis & Heine, 1859	irré	Swainson's Flycatcher
62	*Myiarchus ferox* (Gmelin, 1789)	maria-cavaleira	Short-crested Flycatcher
63	*Myiarchus tyrannulus* (Statius Muller, 1776)	maria-cavaleira-de-rabo-enferrujado	Brown-crested Flycatcher
64	*Pitangus sulphuratus* (Linnaeus, 1766)	bem-te-vi	Great Kiskadee
65	*Machetornis rixosa* (Vieillot, 1819)	suiriri-cavaleiro	Cattle Tyrant
66	*Tyrannus melancholicus* Vieillot, 1819	suiriri	Tropical Kingbird
67	*Tyrannus savana* Daudin, 1802	tesourinha	Fork-tailed Flycatcher

68	*Myiophobus fasciatus* (Statius Muller, 1776)	filipe	Bran-colored Flycatcher
69	*Gubernetes yetapa* (Vieillot, 1818)	tesoura-do-brejo	Streamer-tailed Tyrant
70	*Alectrurus tricolor* (Vieillot, 1816)	galito	Cock-tailed Tyrant
71	*Xolmis cinereus* (Vieillot, 1816)	primavera	Gray Monjita
72	*Xolmis velatus* (Lichtenstein, 1823)	noivinha-branca	White-rumped Monjita
73	*Cyclarhis gujanensis* (Gmelin, 1789)	pitiguari	Rufous-browed Peppershrike
	Corvidae Leach, 1820		
74	*Cyanocorax cristatellus* (Temminck, 1823)	gralha-do-campo	Curl-crested Jay
	Hirundinidae Rafinesque, 1815		
75	*Alopochelidon fucata* (Temminck, 1822)	andorinha-morena	Tawny-headed Swallow
76	*Stelgidopteryx ruficollis* (Vieillot, 1817)	andorinha-serradora	Southern Rough-winged Swallow
77	*Progne tapera* (Vieillot, 1817)	andorinha-do-campo	Brown-chested Martin
78	*Tachycineta leucorrhoa* (Vieillot, 1817)	andorinha-de-sobre-branco	White-rumped Swallow
79	*Riparia riparia* (Linnaeus, 1758)	andorinha-do-barranco	Bank Swallow
80	*Hirundo rustica* Linnaeus, 1758	andorinha-de-bando	Barn Swallow
81	*Petrochelidon pyrrhonota* (Vieillot, 1817)	andorinha-de-dorso-acanelado	Cliff Swallow
	Troglodytidae Swainson, 1831		
82	*Troglodytes musculus* Naumann, 1823	corruíra	Southern House Wren
83	*Cistothorus platensis* (Latham, 1790)	corruíra-do-campo	Sedge Wren
	Mimidae Bonaparte, 1853		
84	*Mimus saturninus* (Lichtenstein, 1823)	sabiá-do-campo	Chalk-browed Mockingbird
	Motacillidae Horsfield, 1821		
85	*Anthus lutescens* Pucheran, 1855	caminheiro-zumbidor	Yellowish Pipit
	Passerellidae Cabanis & Heine, 1850		
86	*Zonotrichia capensis (Statius Muller, 1776)*	tico-tico	Rufous-collared Sparrow
87	*Ammodramus humeralis* (Bosc, 1792)	tico-tico-do-campo	Grassland Sparrow
	Parulidae Wetmore, Friedmann et al. 1947		
88	*Geothlypis aequinoctialis* (Gmelin, 1789)	pia-cobra	Masked Yellowthroat
	Icteridae Vigors, 1825		

89	*Gnorimopsar chopi* (Vieillot, 1819)	pássaro-preto	Chopi Blackbird
90	*Chrysomus ruficapillus* (Vieillot, 1819)	garibaldi	Chestnut-capped Blackbird
91	*Pseudoleistes guirahuro* (Vieillot, 1819)	chopim-do-brejo	Yellow-rumped Marshbird
92	*Molothrus bonariensis* (Gmelin, 1789)	chupim	Shiny Cowbird
93	*Sturnella superciliaris* (Bonaparte, 1850)	polícia-inglesa-do-sul	White-browed Meadowlark
	Thraupidae Cabanis, 1847		
94	*Neothraupis fasciata* (Lichtenstein, 1823)	cigarra-do-campo	White-banded Tanager
95	*Schistochlamys melanopis* (Latham, 1790)	sanhaço-de-coleira	Black-faced Tanager
96	*Tangara cayana* (Linnaeus, 1766)	saíra-amarela	Burnished-buff Tanager
97	*Sicalis flaveola* (Linnaeus, 1766)	canário-da-terra	Saffron Finch
98	*Sicalis luteola* (Sparrman, 1789)	tipio	Grassland Yellow-Finch
99	*Volatinia jacarina* (Linnaeus, 1766)	tiziu	Blue-black Grassquit
100	*Sporophila plumbea* (Wied, 1830)	patativa	Plumbeous Seedeater
101	*Sporophila collaris* (Boddaert, 1783)	coleiro-do-brejo	Rusty-collared Seedeater
102	*Sporophila nigricollis* (Vieillot, 1823)	baiano	Yellow-bellied Seedeater
103	*Sporophila caerulescens* (Vieillot, 1823)	coleirinho	Double-collared Seedeater
104	*Sporophila leucoptera* (Sclater, 1865)	chorão	White-bellied Seedeater
105	*Sporophila pileata* (Sclater, 1865)	caboclinho-branco	Pearly-bellied Seedeater
106	*Sporophila hypoxantha* Cabanis, 1851	caboclinho-de-barriga-vermelha	Tawny-bellied Seedeater
107	*Sporophila cinnamomea* (Lafresnaye, 1839)	caboclinho-de-chapéu-cinzento	Chestnut Seedeater
108	*Sporophila melanogaster* (Pelzeln, 1870)	caboclinho-de-barriga-preta	Black-bellied Seedeater
109	*Coryphaspiza melanotis* (Temminck, 1822)	tico-tico-de-máscara-negra	Black-masked Finch
110	*Emberizoides herbicola* (Vieillot, 1817)	canário-do-campo	Wedge-tailed Grass-Finch
111	*Saltatricula atricollis* (Vieillot, 1817)	batuqueiro	Black-throated Saltator
112	*Cypsnagra hirundinacea* (Lesson, 1831)	bandoleta	White-rumped Tanager

113	*Piranga flava* (Vieillot, 1822)	sanhaço-de-fogo	Hepatic Tanager
	Fringillidae Leach, 1820		
114	*Spinus magellanicus* (Vieillot, 1805)	pintassilgo	Hooded Siskin

Appendix III

NATURAL HISTORY OF THE CERRADO GRASSLANDS IN PHOTOS
(All pictures Dimas Pioli)

I - Recovery Phases of the Flora in Burned Areas

Burned area a, 05/Oct/2015, parched.

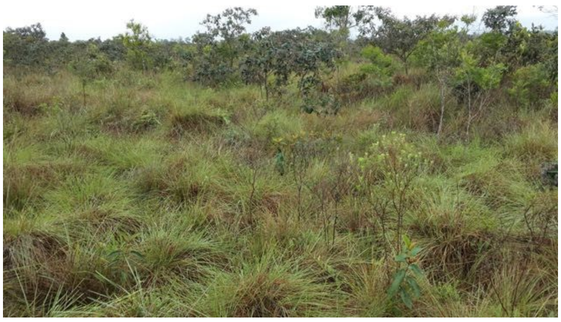
Burned area a, 22/Oct/2015, initial recovery.

Unburned area c, 28/Oct/2015, tall grasses.

Burned area c, 22/Oct/2015, soaking water.

Burned area a, 20/Nov/2015, faster recovery.

Burned area c, 20/Nov/2015, delayed recovery.



Unburned area a, 20/Nov/2015, very dense.

Burned are a, 14/Dec/2015, still much open

Burned area a, 23/Jan/2016, *Coryphaspiza melanotis*.

Unburned area c, 20/Feb/2016.

Burned area a, Mar/2016, advanced recovery.

Burned area c, Apr/2016, still wet.

Unburned area c, May/2016, tall vegetation.

Unburned area c, Apr/2016, invasive *Melinis sp*.

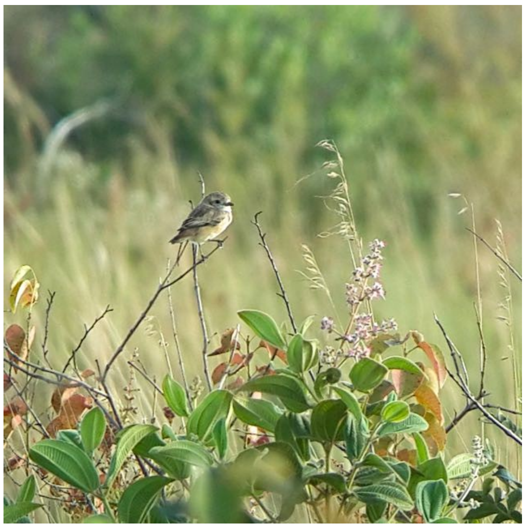
Burned area a, Jun/2016, very dry.

Burned area c, Jul/2016, completely dry.

II – The focus species: *Alectrurus tricolor*

Unburned: female attending a nest (Nov/2015)………… then a chick (Dec/2015)

Unburned. Males in tall grasses. Feb (left) / Apr (right).



Burned, male and female, May/.

Unburned, female hidden in the grasses (Jun). Burned, male in overgrown crop field (Jul).

Female, burnt (Aug).

Male, exposed, unburned (Sep). .

Female, exposed, unburned (Sep/2016).

III – Birds of the wet Cerrado grasslands

tico-tico-de-máscara
Black-masked Finch
Coryphaspiza melanotis
Vulnerable (IUCN., 2017; Global)
Endangered (MMA, 2014; National)

tico-tico-do-campo
Grassland Sparrow
Ammodramus humeralis
Very common bird.

cigarra-do-campo
White-banded Tanager
Neothraupis fasciata
Near Threatened (IUCN., 2017)

papa-moscas-do-campo
Sharp-tailed Tyrant
Culicivora caudacuta
Vulnerable (IUCN., 2017)

And nest.

patativa
Plumbeous Seedeater
Sporophila plumbea
Common

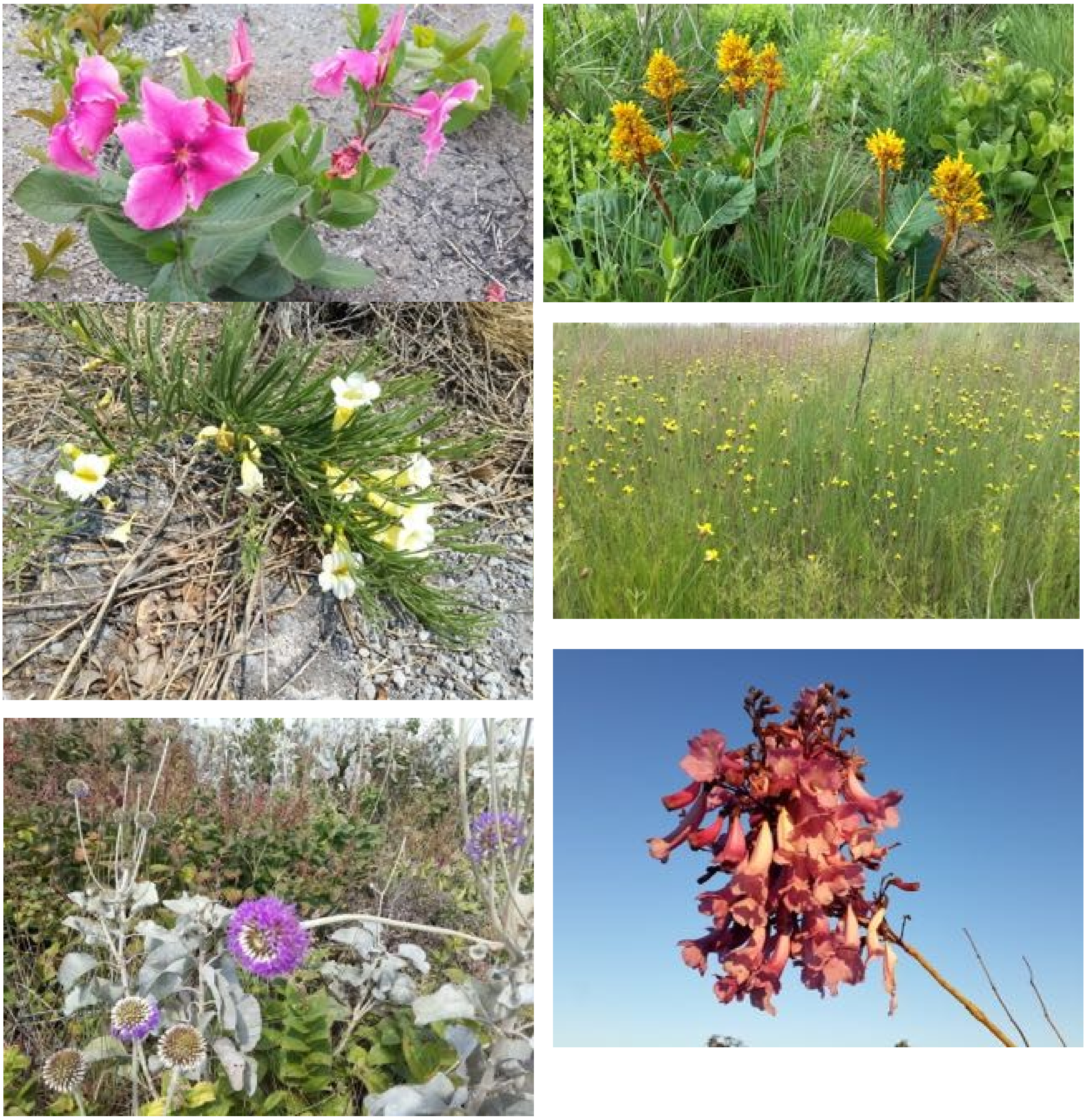
andorinha-morena
Tawny-headed Swallow
Alopochelidon furcata
Common

bandoleta
White-rumped Tanager
Cypsnagra hirundinacea
Fairly common

caboclinho-branco
Pearly-bellied Seedeater
Sporophila pileata
Common

corruíra-do-campo
Sedge Wren
Cistothorus platensis
Uncommon to rare

IV – Flowers in burnt grasslands throughout the year



Clockwise, from top to bottom: Nov, Dec, Jan, Feb, Jun, Jul, Sep