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DANTE ANDRES MELLER

ONDE MORAM AS ÁGUIAS: DISTRIBUIÇÃO E REPRODUÇÃO DE *HARPIA HARPYJA*, *MORPHNUS GUIANENSIS* E *SPIZAETUS* SPP. NO SUL DO BRASIL

São Gabriel, RS
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Tese apresentada ao programa de Pós-graduação Stricto Sensu em Ciências Biológicas da Universidade Federal do Pampa, como requisito parcial para obtenção do Título de Doutor em Ciências Biológicas.

Orientador: Carlos Benhur Kasper

Corientadora: Tânia Margarete Sanaiotti

São Gabriel, RS
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Dante Aliguieri, A Divina Comédia

RESUMO

Águias florestais são aves topo de cadeia com diversas exigências ecológicas à sua sobrevivência, tais como disponibilidade de presas, áreas de vida extensas, sítios reprodutivos preservados e baixa perturbação antrópica. Sem exceção, as cinco águias florestais que habitam o Rio Grande do Sul encontram-se ameaçadas de extinção regionalmente, além de no Brasil duas serem classificadas como vulneráveis e outra como quase ameaçada. Afim de contribuir com o conhecimento e conservação destas espécies, em especial para o limite sul de suas distribuições, foram realizadas pesquisas de campo no Parque Estadual do Turvo, Rio Grande do Sul, com metodologia de busca ativa percorrendo transectos (playback) e busca com uso de tecnologia remota (drone). Ao longo do estudo, realizou-se a descoberta dos primeiros ninhos de *Spizaetus melanoleucus* para o extremo sul de sua distribuição, assim como a descoberta dos primeiros ninhos de *S. ornatus* na região noroeste deste estado. Com base na distância observada entre ninhos, foi possível estimar o tamanho de territórios das espécies *S. melanoleucus* e *S. ornatus* neste ambiente, com áreas estimadas de 12,27 e 17,93 km² para cada casal. Também foi realizada uma avaliação populacional regional de *Harpia harpyja,* em que foi calculada a capacidade populacional suportada nas florestas protegidas na região do Corredor Verde. Nós estimamos uma variação de 10–77 casais (43 como média). E, por fim, divulgou-se a redescoberta de ocorrência estadual de *Morphnus guianensis*, que estava a cerca de cem anos sem registros no Rio Grande do Sul.

Palavras-chave: Águias florestais, biologia reprodutiva, densidade populacional, dieta, Parque Estadual do Turvo.

ABSTRACT

Forest eagles are top predators with many ecological requirements to survive, such as prey availability, wide home ranges, preserved breeding sites, and low anthropic disturbance. Without exception, the five forest eagles that inhabit Rio Grande do Sul are regionally threatened, additionally, two of the species are classified as vulnerable and another one as near-threatened in Brazil. In order to contribute to the knowledge and conservation of these species, especially in the southern limit of their distributions, we carried out field surveys with active search methodology covering transects (playback) and search using remote technology (drone). Throughout the study, we discovered the first nests of *Spizaetus melanoleucus* for the southern limit of its distribution. While we discovered the first nests of *S. ornatus* for the northwest region of this state. Based on the observed distance between nests, we estimated the size of territories of the species *S. melanoleucus* and *S. ornatus* in this environment. The estimated areas were of 12.27 and 17.93 km^2 for each pair. A regional population assessment of *Harpia harpyja* was also carried out, in which the population capacity supported in the protected forests in the region of the Green Corridor was calculated. We estimated a range of 10–77 pairs (43 as a mean). To conclude our findings, we reported the state rediscovery occurrence of *Morphnus guianensis*, which had been unrecorded in Rio Grande do Sul for about a hundred years.

Keywords: Breeding biology, diet, forest eagles, population density, Turvo State Park.

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LISTA DE ABREVIATURAS

n. – número

p. – página

f. – folha

cap. – capítulo

v. – volume

org. – organizador

coord. – coordenador

col. – colaborador

pers. comm. – *personal communication*

pers. obs. – *personal observation*

LISTA DE SIGLAS

AR – Argentina

BR – Brasil

HTML – *Hypertext Markup Language*

HTTP – *HyperText Transfer Protocol*

IBGE – Instituto Brasileiro de Geografia e Estatística

ICMBIO – Instituto Chico Mendes de Conservação da Biodiversidade

PET – Parque Estadual do Turvo

RS – Rio Grande do Sul

SC – Santa Catarina

PNI – Parque Nacional do Iguaçu

PR – Paraná

TIG – Terra Indígena do Guarita

UC – Unidade de Conservação

XML – *e**X**tensible **M**arkup **L**anguage*

Organização e apresentação da Tese

A organização dessa Tese é baseada no "Manual para elaboração e normalização de trabalhos acadêmicos: conforme normas da ABNT", que estabelece o padrão de apresentação de trabalhos acadêmicos da Universidade Federal do Pampa.

A Tese inicia com uma Introdução Geral, onde são apresentados os referenciais teóricos necessários à compreensão do tema, do local onde o estudo foi realizado e do grupo animal estudado. Nessa sessão é apresentada uma breve revisão da literatura sobre o tema geral abordado no trabalho e as referências bibliográficas citadas que aparecem neste item. De forma a não deixar a leitura da tese maçante e repetitiva em relação às sessões subsequentes, o referencial teórico apresentado é breve, já que as informações mais específicas são apresentadas nas introduções de cada capítulo.

Os capítulos centrais da Tese são organizados sob a forma de artigos, cada capítulo contando com seus respectivos Resumo, Introdução, Material e Métodos, Resultados, Discussão, Agradecimentos e Referências. Os capítulos são escritos em inglês. O artigo 4 já foi publicado sob a forma de nota científica na revista *Ornithology Research*.

O primeiro capítulo considera os objetivos referentes à busca ativa por ninhos no Parque Estadual do Turvo, incluindo os dados resultantes da sistemática aplicada. O segundo capítulo apresenta dados preliminares do monitoramento dos ninhos, incluindo biologia reprodutiva e dieta. O terceiro capítulo trata especificamente da avaliação da situação populacional de *Harpia harpyja* no sul da Mata Atlântica interior, incluindo a região do Corredor Verde de Misiones. O quarto capítulo trata da redescoberta de *Morphnus guianensis* no Rio Grande do Sul e das reflexões referentes à conservação da espécie no sul de sua distribuição. Por fim, são apresentadas as considerações finais a respeito desta Tese.

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1 – INTRODUÇÃO GERAL

A perda de biodiversidade é uma das consequências mais dramáticas que atualmente o planeta enfrenta em decorrência da degradação ambiental causada pela população humana. Diversos ecossistemas ao longo do globo têm sofrido impactos negativos, sendo a perda de hábitat a principal ameaça à flora e à fauna (Primack & Rodrigues 2001). No Brasil, não é diferente, com um elevado número de plantas e animais em ameaça de extinção, sobretudo nos biomas mais degradados, como a Mata Atlântica (Tabarelli et al. 2003). Entre as diversas espécies que sofrem com a degradação dos habitats em que ocorrem, destacam-se os predadores topo de cadeia, que em muitos casos dependem de habitats íntegros para sua sobrevivência.

Como predadores, rapinantes exercem importantes papéis ecológicos nas comunidades em que vivem, exercendo pressão seletiva que pode moldar desde as características de suas presas, como anatomia e coloração, ao uso de hábitat, padrões de atividade e comportamento social (Sarasola et al. 2018). São aves que geralmente ocorrem em baixas densidades e ocupam extensas áreas de vida, sendo muitas vezes sensíveis às alterações em seus hábitats, fazendo com que tais atributos contribuem para o interesse conservacionista em relação aos rapinantes (Del Hoyo et al. 1994). Ações que visam a conservação das aves de rapina podem beneficiar inúmeras outras espécies, uma vez que exercem papel “guarda-chuva” para outros animais com menores requerimentos ecológicos (Sergio et al. 2008, Donázar et al. 2016).

A despeito de sua importância, rapinantes encontram-se ameaçados ou próximos de categorias de ameaça ao longo de todos os continentes. Tal fato é ainda mais evidente para espécies de grande porte, sobretudo águias. Os fatores que levam tais espécies à ameaça de extinção são vários, com destaque para a redução e fragmentação do hábitat, e para a caça e abate por retaliação (ou sob o pretexto de evitar possíveis perdas de criações domésticas) (Del Hoyo et al. 1994). O efeito de tais fatores é sinérgico, com aves obrigadas a utilizar ambientes de borda pela fragmentação, onde ficam mais expostas à caça, por exemplo. Somado ao fato de que os rapinantes são naturalmente raros, os impactos da perda de indivíduos têm efeitos maximizados, sobretudo em espécies de baixa densidade populacional (Del Hoyo et al. 1994, Bierregaard 1998, Bencke et al. 2003).

Muitos rapinantes são pouco conhecidos, especialmente na região Neotropical, onde ocorrem algumas das assembleias mais diversas do planeta (Bierregard 1998, Whitacre 2012). Embora o conhecimento científico tenha avançado no que se refere a muitos rapinantes neotropicais, certas espécies ainda têm seus aspectos biológicos e ecológicos, como alimentação, reprodução e requerimentos de hábitat, pouco estudados (Ferguson-Lees & Christie 2001). Tal fato, em grande parte, se deve às dificuldades que ambientes tropicais impõem nas pesquisas ao grupo, tal como dificuldade de deslocamento em ambientes de floresta densa, pouca visibilidade do dossel e a dificuldade de encontro de ninhos (Granzinolli & Motta-Junior 2010).

Figura 1. Ninho de gavião-pato (*Spizaetus melanoleucus*), com filhote, encontrado no Parque Estadual do Turvo em 2021. Fonte: Este estudo.

Estes obstáculos aplicam-se não somente a espécies de pequeno porte, mas também às de porte avantajado, como as águias florestais. Águias são aves naturalmente raras, normalmente ocorrendo em densidades inferiores do que rapinantes menores (Newton 1979). Grandes águias também costumam estar distribuídas de maneira dispersa nos ambientes onde ocorrem, tornando-as de difícil detecção (Newton 1979, Del Hoyo et al. 1994). Não obstante, muitas espécies nidificam em áreas de difícil acesso, o que torna ainda mais complexo seu estudo (Granzinolli & Motta-Junior 2010).

Uma das maneiras mais eficientes para avaliar os requisitos ecológicos dos rapinantes é através do monitoramento de seus ninhos (Brown & Amadon 1968, Newton 1979). Embora sejam estruturas usualmente grandes, os ninhos de rapinantes costumam ser difíceis de localizar, mesmo aqueles que se destacam, como os das águias florestais (Figura 1). Com frequência, ninhos são localizados por leigos das comunidades locais que relatam aos pesquisadores sobre sua existência (Aguiar-Silva 2016, Miranda et al. 2021).

Até o momento, há poucos métodos sistematizados para busca de ninhos de rapinantes propostos formalmente, e estes incluem escalada em árvores, busca por árvores em territórios conhecidos, amostragem por transectos e entrevistas com moradores (Aguiar-Silva et al. 2012, Whitacre 2012, Sanaiotti et al. 2015, Miranda et al. 2021). Assim, um método de procura sistemático e bem definido, que ajude a localizar, quantificar e descrever a história natural dessas aves emblemáticas, é de grande valia.

1.1 – O PARQUE ESTADUAL DO TURVO

O bioma Mata Atlântica originalmente se distribuía desde o Rio Grande do Norte até os estados sulinos do Brasil, onde adentrava o continente até o sudeste do Paraguai e o nordeste da Argentina (Veloso et al. 1991). Com um histórico de mais de 500 anos de exploração, e tendo grande parte da população brasileira habitando seu território, não é de se surpreender que pouco mais de 10% da paisagem original tenha sido preservada até os dias atuais (Ribeiro et al. 2009). Atualmente, dois blocos florestais destacam-se quanto ao tamanho de área preservada, sendo que um deles fica em Misiones, Argentina, onde o Parque Estadual do Turvo, Rio Grande do Sul, é contíguo (Bencke et al. 2006).

O Parque Estadual do Turvo (PET) possui 17.500 ha de Floresta Estacional Decidual em excelente estado de conservação, sendo o último representante em estado primário da antes vasta mata do alto Uruguai (Silva et al. 2005). O parque encontra-se contíguo a uma extensa área florestal preservada da região de Misiones, Argentina (Bencke et al. 2006). Por tais atributos, o parque configura-se como uma excelente área para estudos com grandes rapinantes no sul do Brasil (Figura 2).

O Parque Estadual do Turvo foi criado em 1947 e representa a primeira UC do Rio Grande do Sul, situando-se no extremo noroeste do estado, no município de Derrubadas. Ao Norte, o parque é delimitado pelo rio Uruguai, fazendo fronteira com a Argentina e também fazendo divisa com o estado de Santa Catarina. O rio Parizinho é o limite Leste do parque, enquanto o rio Turvo, o Oeste. Ao Sul, sua área faz borda com propriedades privadas onde o uso da terra compreende em grande parte monoculturas de milho, trigo e soja (Silva et al. 2005).

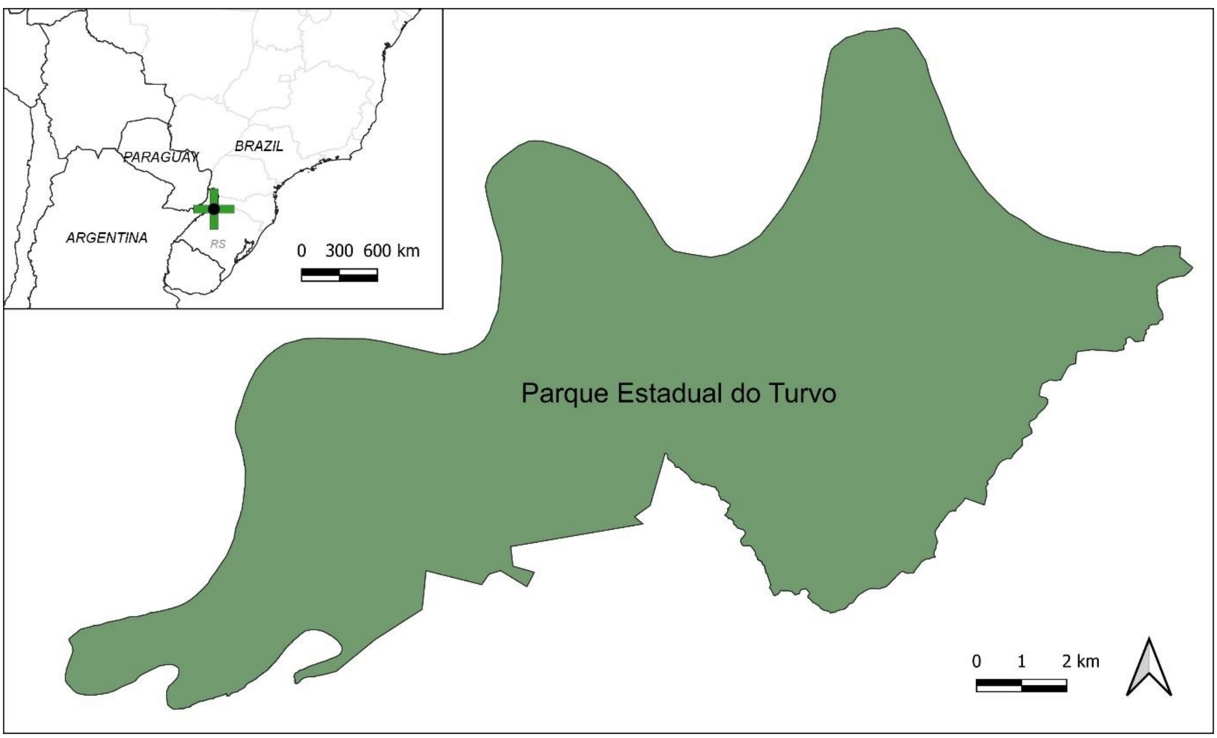

Figura 2. Parque Estadual do Turvo, Derrubadas, Rio Grande do Sul, Brasil.

Na classificação fitogeográfica de Cabrera & Willink (1973), a área da floresta do alto Uruguai está inserida no Domínio Amazônico, que possui um clima predominante quente e úmido, com chuvas oscilando entre 1.500 e 2.000 mm por ano na área. Segundo a classificação do IBGE (1986), essa floresta caracteriza-se como Estacional Decidual, com dois períodos térmicos diferenciados (média > 20°C em dezembro, janeiro e fevereiro, e média <15°C em junho, julho e agosto) e sem déficit hídrico.

A formação vegetal do PET insere-se no Distrito das Selvas, que possui matas com árvores de 20 a 30 m de altura, com estrato de árvores menores e sub-bosque denso, onde predominam bambus e samambaias arborescentes (Cabrera & Willink 1973). A grápia (*Apuleia leiocarpa*), a canafístula (*Peltophorum dubium*) e o angico-vermelho (*Parapiptadenia rigida*), ocorrentes no estrato emergente, são as principais responsáveis pela fisionomia decidual da floresta. Por serem elementos arbóreos de origem tropical, apresentam caducifolia no período de inverno, devido ao fenômeno de seca fisiológica, em que as baixas temperaturas determinam a perda da folhagem (IBGE 1986, Silva et al. 2005) (Figura 3).

Figura 3. Vista aérea do dossel florestal do Parque Estadual do Turvo a partir do setor centro-norte da Estrada do Salto do Yucumã no ano de 2021. Foto: Dante Andres Meller.

Em relação à fauna, o PET ganha destaque no Rio Grande do Sul por possuir uma grande diversidade de espécies, além de ser reduto de alguns animais que já desapareceram da maior parte do estado (Silva et al. 2005). Destacam-se neste grupo espécies como *Panthera onca*, *Tapirus terrestris*, *Mazama americana*, *Aburria jacutinga*, *Celeus galeatus*, *Tinamus solitarius*, *Bothrops jararacussu*, *Phyllomedusa tetraploidea* e *Brycon orbignyanus* (Fontana et al. 2003). Recentemente houve o primeiro registro do cachorro-do-mato-vinagre (*Speothos venaticus*) para o sul do Brasil no parque (Fick et al. 2021), o que reforça ainda mais a importância desta UC para diversos grupos ameaçados de extinção. Além das espécies citadas, o parque é área de ocorrência de diversos rapinantes, alguns dos quais possivelmente restritos ao parque no extremo sul do Brasil.

1.2 – RAPINANTES DA REGIÃO DO PARQUE ESTADUAL DO TURVO E MISIONES

As aves de rapina são muito representativas na área do PET, com registros de 48 espécies distribuídas nas quatro ordens tradicionalmente representadas pelo grupo, sendo 4 Cathartiformes, 25 Accipitriformes, 10 Strigiformes e 9 Falconiformes (Meller 2011, 2017, Meller et al. 2021). Duas espécies neste grupo carecem de documentação e também de registros recentes, sendo elas *Cathartes burrovianus* e *Spizaetus tyrannus* (Albuquerque 1981, Mähler 1996, Meller 2011). Dentre os Accipitriformes que ocorrem no parque, contam-se espécies raras, como *Accipiter poliogaster* e *A. superciliousus*, além das cinco águias florestais, que se destacam tanto por suas exigências ecológicas, como pela raridade e *status* de conservação.

Esse estudo focou na investigação da ocorrência e na busca de indícios de nidificação de cinco espécies, sendo três do gênero *Spizaetus*, uma do gênero *Harpia* e outra do gênero *Morphnus.* Todas estas espécies são florestais, ameaçadas a nível regional e apresentam distribuição neotropical (Del Hoyo et al. 1994, Rio Grande do Sul 2014). A seguir são apresentadas informações básicas referentes a cada uma destas espécies, acompanhadas de imagens ilustrativas.

***Spizaetus melanoleucus* – gavião-pato**

O gavião-pato é a menor das águias florestais ocorrentes na América do Sul, ainda assim sendo uma espécie imponente, em que as fêmeas chegam a 61 cm de altura e peso de 1,1 kg (Pallinger & Menq 2021). A principal característica de sua plumagem é o branco-puro do ventre, contrastado pelo dorso preto (Figura 4). Na face apresenta manchas negras ao redor dos olhos, base do bico alaranjada e íris amarela (Ferguson-Lees & Christie 2001). As asas têm proporção mais longa e a cauda mais curta que nos outros *Spizaetus*, o que o torna mais apto a planar, elevando-se com frequência em termais, muitas vezes sobre áreas abertas (Pallinger & Menq 2021). O jovem é parecido com o adulto, porém tem mais barras nas retrizes e rêmiges. É o mais comum dos *Spizaetus* no Rio Grande do Sul, porém na região nunca teve estudado aspectos relativos à sua reprodução, alimentação e área de vida. No noroeste do estado, a espécie é encontrada com alguma frequência no PET, tornando-se mais rara na TI do Guarita, além de possuir registros ocasionais em outras áreas (Meller 2021). É ameaçada de extinção a nível estadual, na categoria Em Perigo (Rio Grande do Sul 2014).

Figura 4. Gavião-pato (*Spizaetus melanoleucus*) adulto, com presa nas garras, fotografado nos arredores do Parque Estadual do Turvo em 2013. Fonte: Meller (2021).

***Spizaetus tyrannus* – gavião-pega-macaco**

O gavião-pega-macaco é o maior representante do gênero *Spizaetus* no Brasil, embora não seja o mais pesado. As fêmeas atingem tamanho de 71 cm e peso de pouco mais de 1,1 kg (Pallinger & Menq 2021). O adulto é caracterizado pelo negro de sua plumagem, com um pequeno penacho esbranquiçado em forma de coroa e finas barras claras nas penas de voo

(Figura 5). O jovem tem um padrão negro-acinzentado, com manchas claras na face e garganta (Ferguson-Lees & Christie 20021). É uma espécie bastante ativa vocalmente, emitindo um chamado agudo descrito como: "whit, whit-whit whiiiir" (Ferguson-Lees e Christie 2001). O gavião-pega-macaco é a mais rara das águias do gênero *Spizaetus* na região noroeste do RS, com poucos registros ao longo do tempo (Meller 2021). Essa espécie é classificada como Em Perigo de extinção no RS (Rio Grande do Sul 2014).

Figura 5. Gavião-pega-macaco (*Spizaetus tyrannus*) adulto, fotografado no município de Santo Ângelo, RS, em 2021. Fonte: Meller (2021).

***Spizaetus ornatus* – gavião-de-penacho**

O gavião-de-penacho é uma das mais belas águias florestais do mundo, sendo frequentemente mencionado como um fiel indicador de conservação de uma floresta, onde costuma ser a águia mais tipicamente encontrada na mata primária (Chebez 2008). Este é o mais poderoso dos *Spizaetus* brasileiros, chegando as fêmeas a 67 cm de altura e peso de 1,7 kg (Pallinger & Menq 2021). Esta espécie possui várias características que a representam, como o longo penacho preto, os lados do pescoço avermelhados e o ventre branco, incluindo a garganta, que tem estrias malares escuras (Figura 6). Os tarsos são emplumados, assim como nos outros representantes do gênero, mas nesta espécie são maiores (Ferguson-Lees & Christie 2001). Os flancos são barrados, inclusive no jovem, que tem padrão mais claro, sem o avermelhado nos lados da face e, por vezes, sem as estrias malares. Emite um canto territorial que se assemelha em timbre ao da espécie anterior, embora com outra sequência de notas: "whit, wheée-euu, whep whep, whep whep" (Ferguson-Lees & Christie 2001). Os registros desta espécie no noroeste do RS são atualmente restritos ao PET, onde é uma das águias mais frequentes (Meller 2021). No Rio Grande do Sul, o gavião-de-penacho chegou a ser considerado extinto no passado, mas foi redescoberto e atualmente é classificado como Criticamente em Perigo (Rio Grande do Sul 2014). No Brasil e a nível mundial a espécie é considerada Quase Ameaçada (BirdLife International 2016, ICMBIO 2018).

Figura 6. Gavião-de-penacho (*Spizaetus ornatus*) adulto com cutia (*Dasyprocta azarae*) nas garras, fotografado no Parque Estadual do Turvo em 2015. Fonte: Meller (2021).

***Harpia harpyja* – gavião-real ou harpia**

A harpia é conhecida como a mais poderosa ave de rapina do planeta, sendo também uma das maiores, com fêmeas chegando a mais de um metro de altura e pesando até 9 kg (Ferguson-Lees & Christie 2001). Caracteriza-se por possuir cabeça cinza, com longo penacho bipartido e um colar negro no peito, enquanto o ventre é claro e o dorso é escuro (Figura 7). Os tarsos são desprovidos de penas e, junto com as garras, são os maiores entre qualquer ave de rapina (Del Hoyo et al. 1994). O jovem tem a plumagem mais clara, sem o colar negro no peito. Costuma ficar longos períodos empoleirada espreitando suas presas. Dificilmente se eleva em termais, como fazem outros rapinantes, preferindo patrulhar a floresta pelas copas das árvores emergentes (Pallinger & Menq 2021). Sua voz mais característica é um forte assobio agudo: "whiiiioooo" (Ferguson-Lees & Christie 2001). Foi considerada extinta por longos anos no Rio Grande do Sul, até ter sido redescoberta no PET, de onde provêm os únicos registros recentes do estado (Meller & Guadagnin 2016). No Brasil, e também a nível global, a harpia é classificada como vulnerável (Banhos et al. 2018, BirdLife International 2021).

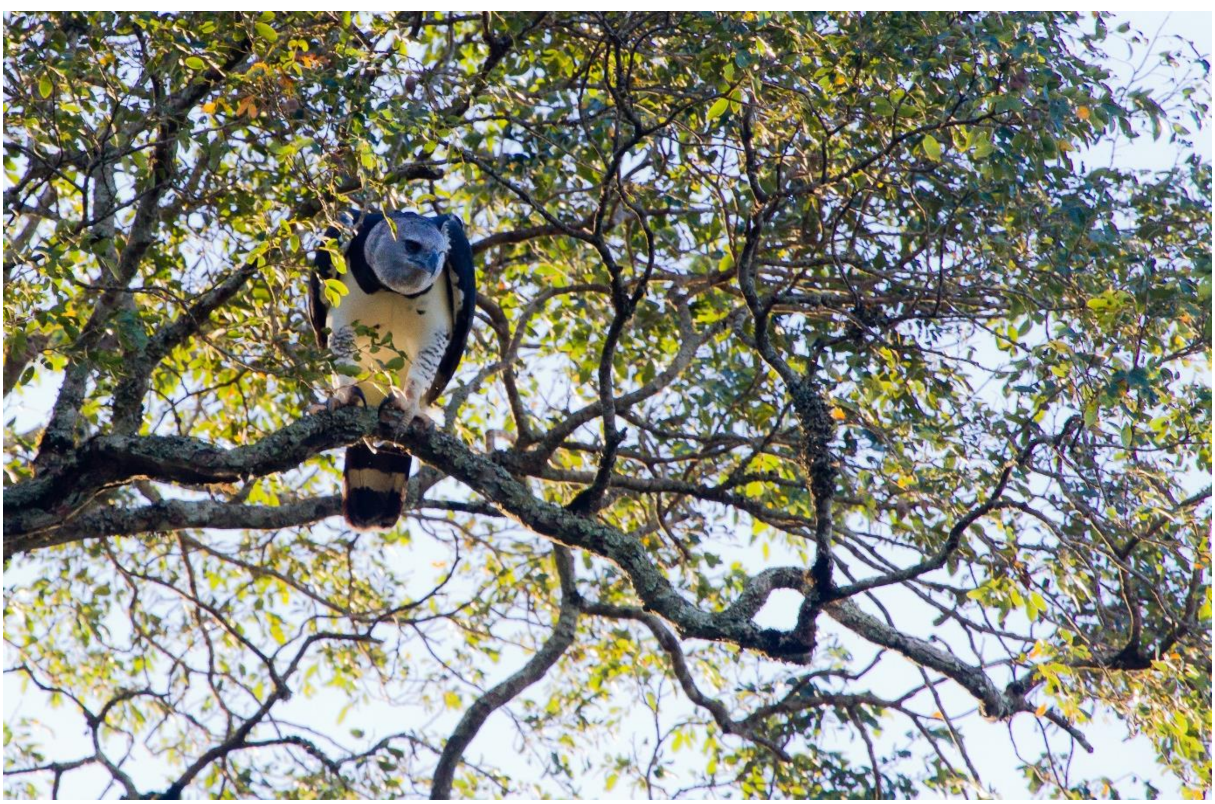

Figura 7. Gavião-real ou harpia (*Harpia harpyja*) adulto, fotografado no Parque Estadual do Turvo em 2015. Fonte: Meller & Guadagnin (2016).

***Morphnus guianensis* – uiraçu**

O uiraçu é uma espécie semelhante à harpia quanto à sua plumagem e linhagem evolutiva, porém menos robusta, chegando a ser esbelta (Figura 8). As fêmeas podem atingir cerca de 90 cm e pesar até 2 kg (Pallinger & Menq 2021). Além de outras características, o uiraçu distingue-se da harpia por não possuir penacho bipartido (apenas simples), e não ter a larga faixa negra no peito (Ferguson-Lees & Christie 2001). Curiosamente, esta é a única águia florestal brasileira que apresenta exemplares melânicos, com níveis de variação quanto ao preto em sua plumagem (Pallinger & Menq 2021). O uiraçu nunca foi estudado na Mata Atlântica, onde possui apenas escassos registros de ocorrência. Esta espécie é a mais rara e menos conhecida das águias florestais brasileiras. No RS consta como extinta na última lista (Rio Grande do Sul 2014), sendo classificada como vulnerável a nível nacional (Sanaiotti et al. 2018), e quase ameaçada a nível mundial (BirdLife International 2017).

Figura 8. Uiraçu (*Morphnus guianensis*) imaturo, em plumagem clara, fotografado no Parque Estadual do Turvo em 2019. Fonte: Meller et al. (2021).

1.3 – OBJETIVOS

Objetivo geral

Realizar análise populacional e da biologia reprodutiva das cinco espécies de águias florestais no Parque Estadual do Turvo, incluindo uma análise detalhada da distribuição e situação populacional de *Harpia harpyja* no extremo sul de sua distribuição.

Objetivos específicos

− Estabelecer um protocolo de amostragem sistematizada para procura de ninhos e territórios de aves de rapina florestais de grande porte através do teste de técnicas diferenciadas com uso de *playback* em transectos lineares e inspeção aérea das copas das árvores com o uso de drone;

− Descrever aspectos da biologia reprodutiva das espécies das quais forem encontrados ninhos, descrevendo os locais de nidificação, características do ninho, período de reprodução e aspectos comportamentais;

− Identificar a dieta das espécies das quais forem encontrados ninhos, através do monitoramento por imagens, e da coleta de restos alimentares nas imediações dos mesmos;

− Estimar a área de vida apresentada por casais dos quais forem encontrados ninhos, pela distribuição dos ninhos no ambiente;

− Avaliar os padrões de distribuição das espécies com base nos registros de indivíduos ou com base nos territórios.

2 – ARTIGO I

INTO THE EAGLES' WILD: APPLYING SISTEMATIC SURVEYS FOR THE SEARCH OF NESTS OF FOREST EAGLES IN SOUTHERN BRAZIL

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ABSTRACT

Neotropical forest eagles are yet poorly known in many aspects of their ecology, especially in some regions, such as southern Brazil. Many ecological aspects of these large raptors are better studied in their nests. These structures, however, are hard to find and most of them are discovered occasionally or throughout reports of local people. Based on this, our aim was to test the efficient of two methods to find nests in primary forests of southern Brazil. The study was conducted in Turvo State Park, Rio Grande do Sul, where we searched for nests through (1) *linear transects* and (2) *drone flights*. We opened 12 km of trails along five transects inside the forest, where playbacks of Harpy Eagle and Crested Eagle were played. There was a total of 30 playback points, each one 500 m from the other in every transect. The second method was the survey for nests in canopy and emergent trees through images captured by a drone, which totalized 39.2 Km^2 of aerial survey. The images were captured in video and analyzed in a 4K television in order to distinguish any nest structure. Further flights or visits *in loco* were carried out to confirm the suspected nests. Linear transects resulted in 10 responses to the playback by two species of *Spizaetus* hawk-eagles, plus 25 spontaneous records of them. In addition, four nests in three sites were found through search in the ground, in the territories identified by the responses of the playbacks. Drone flights resulted in other three nests discovered in at least one new site. Two sites belonged to *S. ornatus* and two to *S. melanoleucus*, including one site with alternative nests for both species. Intraspecific nests are neighbors and allowed us to calculated the density of territorial pairs for the total area of the park, which we estimated in about 10 pairs for *S. melanoleucus* and 14 pairs for *S. ornatus*. Drone images proved useful to find nests and we show that the method can be used in forested areas. Our records confirmed the reproduction of *S. melanoleucus* and *S. ornatus* in the southern limit of its distribution and revealed its use of alternative nests, contributing for the knowledge reproduction and spatial ecology of these species.

KEY-WORDS: Birds of Prey, Drone, *Harpia harpyja*, Raptors, *Spizaetus*, Turvo State Park.

RESUMO

Na natureza selvagem das águias: aplicando buscas sistemáticas para encontrar ninhos de águias florestais no sul do Brasil. As águias florestais neotropicais ainda são pouco conhecidas em muitos aspectos de sua ecologia, principalmente em algumas regiões, como o sul do Brasil. Muitos aspectos ecológicos destas grandes aves de rapina são melhor estudados em seus ninhos. Tais estruturas, no entanto, são difíceis de encontrar e a maioria delas é descoberta ocasionalmente ou através de relatos da população local. Com base nisso, nosso objetivo foi testar a eficiência de dois métodos para encontrar ninhos em uma floresta primária do sul do Brasil. O estudo foi conduzido no Parque Estadual do Turvo, Rio Grande do Sul, onde buscamos ninhos por meio de (1) *transectos lineares* e (2) *voos de drones*. Abrimos 12 km de trilhas ao longo de cinco transectos dentro da floresta, onde reproduzimos playbacks de *Harpia harpyja* e *Morphnus guianensis*. Houve um total de 30 pontos de reprodução, um a cada 500 m do outro em cada transecto. O segundo método foi o levantamento de ninhos na copa de árvores emergentes por meio de imagens capturadas por um drone, que totalizou 39,2 Km^2 de levantamento aéreo. As imagens foram capturadas em vídeo e analisadas em uma televisão 4K a fim de distinguir qualquer estrutura de ninho. Novos voos ou visitas *in loco* foram feitas para confirmar as suspeitas de ninhos. Transectos lineares resultaram em 10 respostas ao playback por duas espécies de águias do gênero *Spizaetus*, além de 25 registros espontâneos delas. Além disso, quatro ninhos em três sítios foram encontrados através da busca no solo, nos territórios identificados pelas respostas dos *playbacks*. Voos de drones resultaram em outros três ninhos descobertos em pelo menos um novo sítio. Dois sítios pertenciam a *S. ornatus* e dois a *S. melanoleucus*, incluindo um sítio com ninhos alternativos para cada uma das espécies. Ninhos intraespecíficos são vizinhos e nos permitiram calcular a densidade de casais territoriais para a área total do parque, que estimamos em cerca de 10 casais para *S. melanoleucus* e 14 casais para *S. ornatus*. Imagens de drones se mostraram úteis para encontrar ninhos e demonstramos que o método pode ser utilizado em áreas florestais. Nossos registros confirmaram a reprodução de *S. melanoleucus* e *S. ornatus* no limite sul de sua distribuição e revelaram o uso de ninhos alternativos, contribuindo para o conhecimento da reprodução e ecologia espacial dessas espécies.

PALAVRAS-CHAVE: Aves de Rapina, Drone, *Harpia harpyja*, Parque Estadual do Turvo, Rapinantes, *Spizaetus*.

2.1 – INTRODUCTION

Neotropical forest eagles include some of the largest and most formidable raptors of the world, still some of them are poorly known and with a population trend in decrease (Brown & Amadon 1968, Del Hoyo et al. 1994). These large raptors are diverse in South America, and as many as five species can cohabit in the rainforests of the continent (Ferguson-Lees & Christie 2001). That is the case of the Atlantic Forest, where forest eagles are represented by three genera and five species: Harpy Eagle (*Harpia harpyja*), Crested Eagle (*Morphnus guianensis*), Black-and-white Hawk-Eagle (*Spizaetus melanoleucus*), Black Hawk-Eagle (*S. tyrannus*) and Ornate Hawk-Eagle (*S. ornatus*) (Sick 1997, Pallinger & Menq 2021). All these forest eagles are locally threatened in this biome and with scarce information relative to their ecology.

In the Brazilian southern portion of Atlantic Forest, the only forest eagle with nest recordings published in literature is *S. ornatus*. These records include two nests in the state of Rio Grande do Sul and one in Santa Catarina, where information were obtained on breeding biology and diet (Joenck et al. 2011, Zilio 2017). Zilio (2017) also reported a possible nest of *S. melanoleucus* for southern Santa Catarina, and Meyer (2020) shared a picture in a citizen science platform of a nest of this species in this same state. No nest of *S. tyrannus* was ever found in the southern region of the Atlantic Forest. For *H. harpyja*, there is no information of nests for the Atlantic Forest of southern Brazil, but five nests were described for Misiones, Argentina (Chebez et al. 1989, De Lucca 1996, Anfuso et al. 2008). The least known of the forest eagles is *M. guianensis*, which has no nest ever found in any portion of the Atlantic Forest (Gomes & Sanaiotti 2015).

Like many other raptors, *Spizaetus* spp. use to soar in thermals, becoming detectable throughout the method of fixed points (Marquez et al. 2005, Grazinolli & Motta-Junior 2010). On the other hand, *H. harpyja* and *M. guianensis* do not have the habit of soaring, or do it so rarely, that makes their detection more difficult (Brown & Amadon 1968, Ferguson-Lees & Christie 2001, Soares et al. 2006). To study *H. harpyja*, the most recommended technique is the search for nests, since these are large structures arranged as a platform above the main bole of large emergent trees (Brown & Amadon 1968, Del Hoyo et al. 1994, Chebez & Anfuso 2008). This search for nests in large trees can also reveal other forest eagles' nests, although the characteristic of the nest can change from one species to another. For instance, *S. ornatus* and

S. melanoleucus build their nests in crotches of major limbs of emergent trees, while *S. tyrannus* nests in trees from the canopy, often within the foliage, on much smaller limbs (Whitacre et al. 2012, Canuto et al. 2012). *Morphnus guianensis* reminds *H. harpyja* in the placement of the nest, but it chooses less prominent trees, being the nest smaller and more discrete (Whitacre et al. 2012, Gomes 2014).

Although eagles' nests are large structures frequently placed in highlighted positions of emerging trees, they are very hard to find. In the case of the Harpy Eagle, many nests are found based on reports from local people who lives in the forest, such as indigenous or river dwellers. This is the most usual way of discovering nests in the Amazon (Muñiz-Lopez et al. 2007, Aguiar-Silva et al. 2014, Aguiar-Silva 2016). In Misiones, Argentina, it was no different, and all known nests have been found or indicated by loggers (Chebez et al. 1989, De Lucca 1996, Anfuso et al. 2008). In protected areas, such as parks, where the free movement of people is restricted, this type of occasional encounter would only occur by rangers or researchers, which makes this type of context less likely. The less conspicuous nest structure of Crested Eagles makes even more difficult to be seen and, because this, the search through transects with the use of playback is the most recommended technique for its detection (Marquez et al. 2005).

The active search for nests can be performed using some standard methods. One of the protocols used is based on the implementation of RAPELD modules, which are represented by two linear transects of five km each, in parallel, spaced one km from each other (Magnusson et al. 2005, Sanaiotti et al. 2015). When there is evidence of nesting, such as the presence of chicks, juveniles or territorial behaviors, an inspection of nearby potential trees, made through the ground, can be a very efficient method (Whitacre et al. 2012). Inspection of potential trees by climbing can also reveal nests of some species (Aguiar-Silva et al. 2012, Whitacre et al. 2012). The search for nests has also been carried out through overflights, which can be done by manned or unmanned aircraft (drones).

The use of drones has now become widespread, favored in part by the reduction in the cost of the current equipment (Canal & Negro 2018). Among the advantages of using drones, there is the low risk, the ease of transport to the desired location and the agility in the necessary logistics. Drones can be operated after a short training period; they do not require long periods of preparation before the flight, and only a clearing without vegetation is necessary for the aircraft to take off and land (Canal & Negro 2018). The accuracy of the data obtained, combined with the flexibility, low cost and agility of this technique, makes it a useful technology and an excellent alternative to the security risks and obstructions associated with traditional research methods (Junda et al. 2015).

In this study we tested the efficiency of two methods to find nests of forest eagles in a primary forest of southern Brazil: (1) *linear transects* with playback and (2) *drone flights*. The nests found were described and the nest spacing was used to estimate minimal home ranges of the reproductive pairs and estimate its abundance in the study area.

2.2 – METHODS

Study area

The study was carried out in Turvo State Park, a protected area situated in the extreme northwest of Rio Grande do Sul state, southern Brazil (27°13’S, 53°51’W). The area of the park is represented by 175 km^2 of well-preserved Seasonal Deciduous Forest, a formation associated to the Atlantic Forest (Veloso et al. 1991, Silva et al. 2005). This park is a great area for surveying raptors, as it is connected with the large and preserved forested region of Misiones (Argentina), which favors the richness of that community (Bencke et al. 2003, 2006, Meller 2011). The search for nests was carried out in the sector of the park situated alongside the Yucumã road, which crosses the park area (Figure 1).

The selection of this area was based on previous records that indicated the potential occurring of forest eagles (Meller 2011, Meller & Guadagnin 2016, Kuhn 2018, Meller 2021, Meller et al. 2021). Maps were composed with the software QGIS v. [3.4.7] (QGIS Development Team 2018) and records were georeferenced with the use of a GPS *Garmin Etrex 20x* and the software Google Earth Pro (Google 2019).

Search for nests

Linear transects. The search was conducted throughout five linear transects (varying 1.9−3.1 km long) spaced 2 km from each other alongside the Yucumã road. Transects totalized 12 km of 1 m paths opened straight through the forest with GPS and compass. All transects started on the Yucumã road and ended in a water course (Figure 1).

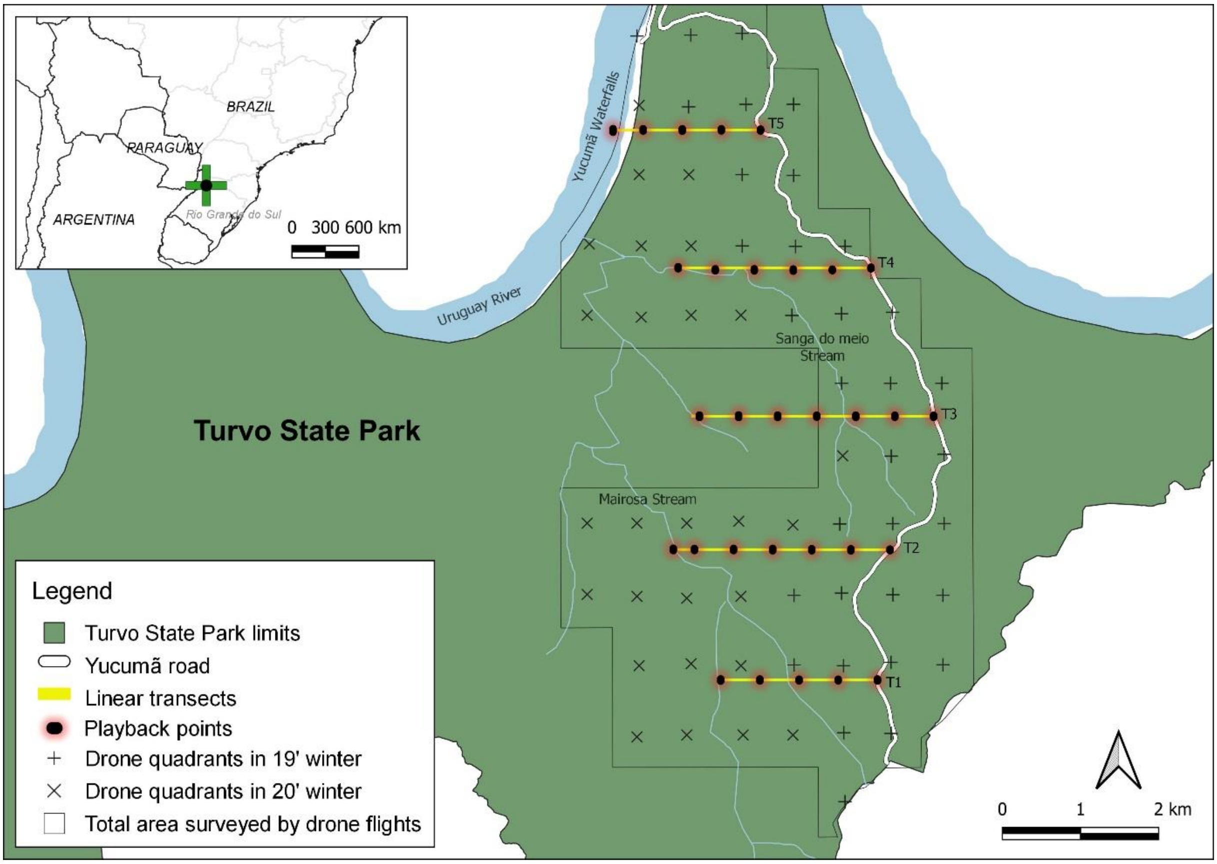

Figure 1. Disposition of five linear transects (T1, T2, T3, T4, T5) and 30 playback points alongside the Yucumã road in Turvo State Park and area where inspection through drone flights was made in winter of 2019 and 2020.

Playbacks of vocalizations of Harpy Eagle and Crested Eagle were reproduced in sampling points located every 500 m, totalizing 30 points (Figure 1). The sounds were obtained from the Wikiaves platform (www.wikiaves.com), and selected in a way that comprised a diversified repertoire, including territorial vocalizations of adults and juveniles begging-calls. At each point, the vocalizations of both species were reproduced (starting with the smaller one). Thus, a repertoire with different types of *M. guianensis* vocalizations was played for about 2 min, followed by a period of 3 min in silence; then the repertoire of vocalizations by *H. harpyja* was played for about 2 min, followed by another 3 min of silence. The minimum time in each point was of 10 min. The vocalizations were reproduced from the ground by an *Iphone 7* connected to a *JBL Xtreme Squad 40W*, emitting sounds in the range of 100 dB, which complies with the recommended for birds of prey (Granzinolli & Motta-Junior 2010).

During the survey, the observers were aware to any spontaneous responses and vocalizations of eagles and other animals reacting to playback. This methodology was reproduced once a month, over a year, from April 2020 to April 2021, totalizing 3600 minutes of playback reproduction over 60 days in the field. Transects were always surveyed in the morning, one by day. Whenever necessary, searches out of the trail were conducted in order to search for nests of the target species in the peripheral area of the transect.

Drone flights. An aerial scan was made over a region similar to that surveyed along the linear transects with the intent to reinforce the inspection of nests and explore the efficiency of this method. The drone used was a *DJI Phantom 3 Professional*, which has a 4K digital camera with format equivalent of 35 mm of lens focal length (https://www.dji.com/br). The method consisted of capturing video images in flight missions arranged at rectangular polygons of 660 m wide by 1000 m long. Each polygon had a total of 25 lines spaced 40 m from each other, in which the drone flew. The area of each polygon represented 0.66 km^2. The total area sampled by the drone represented 39.2 km^2, distributed over 60 polygons.

Drone flights were always done in winter, because most emergent trees are defoliated in this season, which contributes to a better visualization of their ramifications and consequent identification of nests. For the first season of drone flights (winter 1, 2019), the polygons surveyed were the ones along the Yucumã Road, totalizing 33 polygons. Another 27 polygons were sampled during the second season (winter 2, 2020), along the linear transects (Figure 1).

The sampling was done through the Litchi app (https://flylitchi.com), a software that allows the preparation of flight missions through waypoints, with altitude adjustments according to the variations of the terrain. The preparation of flight missions was done based on altimetry maps, with the correction of the altitude each 10 m of unevenness. Missions were performed automatically, without the pilot having to make any manual adjustments during the flight and regardless of signal. That is especially useful for forested areas, as the signal tends to be weakened due to the various obstacles represented by trees or relief accidents. In order to avoid either collisions and too distant aerial images, the flight altitude varied between 45-50 m above ground. The camera angle was adjusted between 23−26º. To have a good quality of light, the filming orientation was always adjusted to the south, with the aircraft moving laterally from the southernmost to the northernmost line in a speed of 24−26 km/h. A *TGi1000 Inverter-type* generator was used to recharge the batteries in the field in order to carry out as many flight missions as possible each day (3 to 4 quadrants/day).

Nest tree characteristics

All nests found were described according to the tree they were built, including the species and their dimensions. Coordinates were extracted with a GPS *Garmin e-trex 20x*. Circumference at breast high (CBH) was calculated with the use of a metric tape. Shaft height, tree top and nest height had their measures calculated with a *Bushnell Trophy 4x20 Rangefinder*. Ramification and number of branches holding the nest were counted with the use of binoculars *Nikon Monarch 10x42*.

Statistical analyses

Inter-nest distance was calculated by the mean distance between neighbors' nests using the method of the Maximum Packed Nest Density (MPND) (Brown 1975). According to the same author, this method uses the mean distance of the nearest nest to estimate total area required for each pair using the equation $A = \pi r^2 * 1.158$, where 1.158 is a constant that includes the portion of the nonoverlapping area between neighboring territories. MPND is an estimative method used in many studies with raptors, including Neotropical forest eagles (González & Vargas 2011, Whitacre et al. 2012). Pair density was calculated by extrapolating the area estimated for one territorial pair to the equivalent numbers of pairs holding territories in the total area of the park.

We tested if the reactions to Harpy Eagle and Crested Eagle voices were different through an ANOVA one-way test. For this analyze, we used all the reactions rather than only the ones from *Spizaetus* hawk-eagles', because the number of records was too low for that. We also tested if there was a significant difference between records of *Spizaetus* hawk-eagles through the method of linear transects through an ANOVA one-way test. For this we considered all *Spizaetus* records, including reactions to playback and spontaneous records. ANOVA tests were made in the software past (Hammer et al. 2001), where we adopted an interval of confidence of 95%.

2.3 RESULTS

Search for nests

Both methods used in the search of forest eagles resulted in the discovery of seven nests: four nests were discovered through linear transects and three through drone flights. We found at least two sites of *S. ornatus* (one perhaps with two alternative nests) and two sites of *S. melanoleucus* (one with one alternative nest).

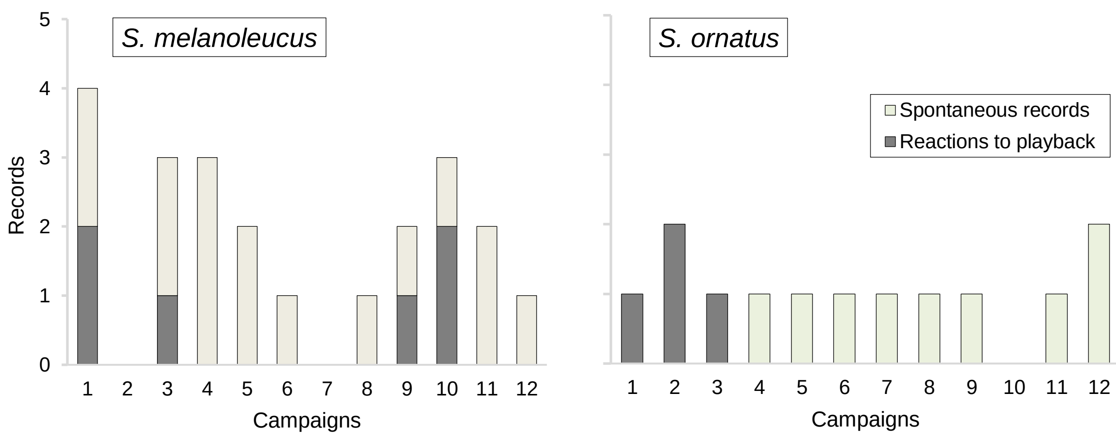

Figure 2. Reactions to the playback of Harpy Eagle and Crested Eagle, plus spontaneous records of *Spizaetus* hawk-eagles in the five linear transects along twelve campaigns.

Linear transects. Along the 12 campaigns we had 35 records of forest eagles: 25 records by visual or spontaneous vocalization and 10 records in response of Harpy Eagle and Crested Eagle playbacks (Figure 2; Figure 4). *Spizaetus melanoleucus* reacted four times to *Morphnus guianensis* playback and two times to *Harpia harpyja* playback. *Spizaetus ornatus* reacted twice for each eagles' playback. There was no significant difference between reactions to the voices of Crested Eagle and Harpy Eagle (p = 0,29), meaning animals react equally to both species (Appendix 3). The difference between *Spizaetus* spp. records was also not significant, however it showed a strong tendency to be (p = 0,07), with more records of *S. melanoleucus* than *S. ornatus*. This suggests that either *S. melanoleucus* could be more abundant in the park or it could be more easily detectable.

Drone flights. We watched 64 hours of drone images on a 4k television in order to search for the presence of nests. From the videos, we selected 204 structures for a second evaluation. We then reselected a minor group of structures based on the presence of four main attributes: emergent tree, position in the branches, volume and the pattern of coloration/texture. The reselection counted with 23 structures, which we classified as potential nests. These 23 structures were them inspected again by drone or *in loco*, to confirm if they were nests or not. From this method we discovered three nests.

Figure 3AE. Images captured from drone flights (subjects indicated by the arrows): (A) Nest 2 (*S. ornatus*) in a *Balfourodendron riedelianum* tree; (B) Nest 3 (*S. ornatus*) in a *Lonchocarpus muehlbergianus* tree; (C) Example of bromeliad; (D) *S. melanoleucus* perched in an emergent tree; (E) *S. melanoleucus* inspecting the aircraft**.**

The first nest (Nest 2) was in the middle of the treetop of an emergent evergreen tree (Figure 3A). The second one, an alternative nest to the preview (Nest 3) was built in a deciduous tree of the canopy (Figure 3B). The third nest (Nest 4) was found indirectly through the drone method, as we evaluated a tree close to the tree of the nest and found it while visiting *in loco*.

Many images in fact proved to be another structures, such as bromeliads and arboreal thermites (Figure 3C). Although not the main role, images from drone also revealed 58 records of raptors, from which we recognized seven species, including *S. melanoleucus* as the only species of interest in our study (Figure 3DE; Appendix 4). On the other hand, despite the drone had flown over nests 1, 5, 6 and 7, they were not able to be recognized as suspicious structures in the video images.

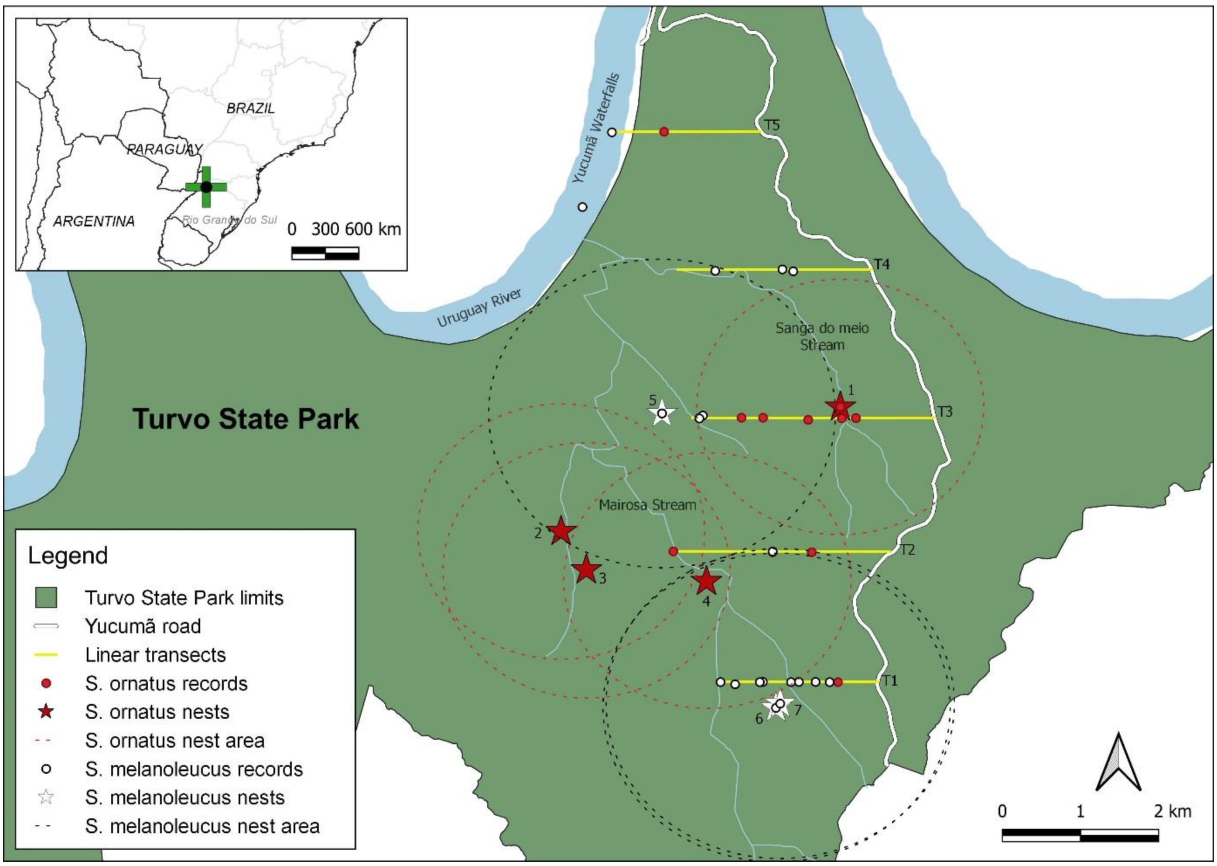

Figure 4. Records made through linear transects and nests discovered. Circles around the nests have radii of one-half the nest distance means (1.83 km for *S. ornatus* and 2.22 km for *S. melanoleucus*).

We found some problems to complete the inspection for nests through drone flights, especially along the transect 3, as can be seen in Figure 1. Some quadrants could not be flown because the drone crashed in the end of winter 1, as it also crashed in the middle of winter 2. In both occasions the aircraft was recovered, with some injuries, which were fixed, but delayed the survey. At the very beginning of winter 3, however, the drone suffered a new crash, which finally resulted in the loss of the aircraft and the interruption of new flights. Either way, we considered the amount of area flown satisfactory, as it represented nearly a quarter of the total area of Turvo State Park. Most important, the method contributed with the discover of three nests for the study (Figure 4).

Nest tree characteristics

All nests were very similar about their characteristics, although there were some exceptions. The structures were always built in emergent species, except for Nest 3, which was built in a deciduous tree from the canopy. Nest 2 was the only one built in an evergreen tree. The CBH of the trees of nests 2 and 3 were also significantly inferior than the others and the platform was built on a third central ramification for nest 2 and on the second ramification for nest 3. The other nests were 4–7.3 m higher and consequently built in much superior branches, close to the top of the tree. Six of the nests found were built over three or four branches, and one over two branches (Table 1).

Table 1. Characteristics of the seven nests found in the study. (Sorn) *Spizaetus ornatus*; (Smel) *Spizaetus melanoleucus*.

Nest	*Hawk-Eagle species*	*Nest's tree*	*CBH (m)*	*Shaft height (m)*	*Tree top (m)*	*Nest height (m)*	*Ramifi-cation*	*Branches at the nest*
1	Sorn	*Peltophorum dubium*	3.3	17.7	32	28	6º	3
2	Sorn	*Balfourodendron riedelianum*	1.79	16.3	30	23.7	3º	4
3	Sorn	*Lonchocarpus muehlbergianus*	1.77	14	25	22	2º	3
4	Sorn	*Peltophorum dubium*	4.4	12.6	34.1	31	5º	5
5	Smel	*Parapiptadenia rigida*	2.6	14.8	30.1	27.7	6º	4
6	Smel	*Peltophorum dubium*	3.03	18.4	33.8	29.3	7º	2
7	Smel	*Apuleia leiocarpa*	2.73	14.3	32.2	28.3	5º	3

Historic of nests discoveries

Nest 1 (S. ornatus). This was the first nest discovered in the study, while still opening transect 3. We already knew that there was a nest somewhere in this area, because previous observations of a juvenile and a pair were made in 2018 (Meller 2021). The nest was discovered in December 2019, after we heard some food-begging calls from a young *S. ornatus* coming from its direction. We followed a stream in the direction of the calls and came across a large tree with a nest in its top. Also a tail feather of an adult Ornate Hawk-Eagle was found in the ground under the nest that day, which helped confirm the species. In January 2020 we observed an adult soaring and vocalizing above the nest and in the next day the young in the nest (Figure 5A). This young Ornate Hawk-Eagle was monitored through the following months (Figure 5B).

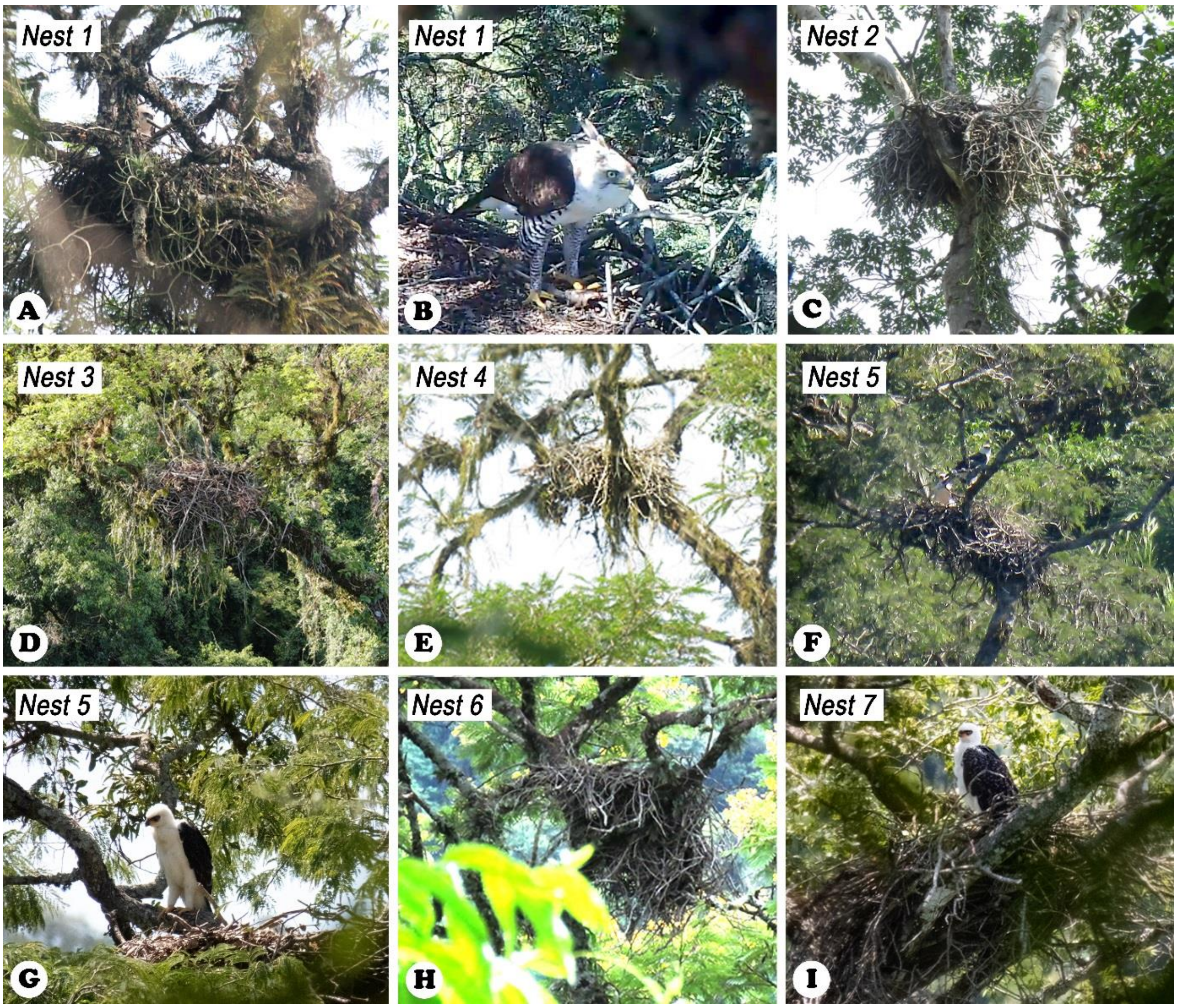

Figure 5a-i. Nest 1 (*S. ornatus*): (A) Juvenile in the nest in 19’ breeding cycle; (B) Juvenile from a view inside the nest. Nest 2 (*S. ornatus*): (C) View of the nest from the ground. Nest 3 (*S. ornatus*): (D) View of the nest from above. Nest 4 (*S. ornatus*): (E) View of the nest from the ground. Nest 5 (*S. melanoleucus*): (F) A pair over the nest; (G) A nestling about 60 days old in the nest. Nest 6 (*S. melanoleucus*): (H) nest almost falling. Nest 7 (*S. melanoleucus*): (I) Nest rebuilt and with a nestling over it. Photos: Dante Andres Meller.

Nest 2 (S. ornatus). This nest was found through the drone method, after the drone flew over it in the winter of 2020, being it recognized some months later, when we watched the images. In April 2021 we first visited this nest *in loco* and confirmed it as a nest (Figure 5C). In this visit we heard a young *S. ornatus* emitting some food-begging calls and also an adult vocalizing hundreds of meters from the nest. At that point we didn't know about the alternative nest (Nest 3), but we suspected it, as we describe below.

Nest 3 (S. ornatus). This nest was found through the drone method, after the drone flew over it in the winter of 2020, being it recognized as suspicious some months later, when we watched the images. In December 2021 we first visited this nest *in loco* and confirmed it (Figure 5D). We considered that breeding was happening in this nest as an alternative to Nest 5, because many times we heard the hawk-eagles calling from this direction while visiting Nest 2.

Nest 4 (*S. ornatus*). This nest was indirectly found through the drone method while we were checking a suspicious structure in a tree close to it. We raised the drone for the inspection and suddenly a hawk-eagle started to vocalize alarming calls from the nest, which we found 15 minutes after that. It was in a high tree, where we saw an adult Ornate Hawk-Eagle as well in December 2021 (Figure 5E). We suspected this nest could represent a new territory, but as it is somewhat close to nest 2 and we don't have evidence of both nests being used simultaneously, we treated them as alternative nests for now.

Nest 5 (S. melanoleucus). This nest was found in April 2020, after we reproduced the playback while surveying the last point of transect 3. The nest was found after we heard the vocalization of a hawk-eagle and inspected the top of the trees over the slope with the use of binoculars. In the following month, we arrived at this place and there was a pair of *S. melanoleucus* perched above the nest (Figure 5F). We didn't confirm reproduction in 2020, but in December 2021 we saw a nestling about 60 days old over the nest, being observed by the female in the surroundings (Figure 5G).

Nest 6 (S. melanoleucus). This nest was found in January 2021 after we did playback in point 3 of transect 1 and heard a young *S. melanoleucus* emitting what we interpreted as food-begging calls. The hawk-eagle soared across a valley and glided into the direction of some high trees in a slope. We then inspected the large trees in the slope with binoculars and found a nest in one of them (Figure 5H). This nest was active by the time, but the young had already left it, probably returning to beg for food, which we confirmed by remains found on the ground. This nest was supported by only two branches and had the appearance of falling, which actually happened, as we confirmed visiting it in April 2021.

Nest 7 (S. melanoleucus). In March 2021 we found a second nest at this site, which was only 83 m to the Nest 6. It had an old, inactive appearance. After the alternative nest felt, this nest started to be reformed, as we observed in June of that year. In August we saw the female incubating in it and in October there was a nestling about 50 days old above it (Figure 5I).

Inter-nest distance and pair density

Distance between nests of *S. ornatus*, as a mean of 3.67 km apart from each other (n=4), was lower than of *S. melanoleucus*, which the mean distance between the nests was of 4.44 km (n=3) (Figure 4). Based on the distances, we calculated the MPND value for both species, estimating 12.27 km^2 for each *S. ornatus* territorial pair, and 17.93 km^2 for each *S. melanoleucus* territorial pair. Extrapolating the values, based on the size of the territories, and considering the 175 km^2 area of Turvo State Park, we estimated that a total of 14.2 pairs of *S. ornatus* and 9.8 pairs of *S. melanoleucus* may hold territories in the forests of the park (Table 2).

Table 2. Area estimated for each territorial pair of *Spizaetus* hawk-eagles in Turvo State Park.

	Number of nests	*Mean distance between neighbors' nests*	*Area estimated for each pair through MPND method*	*Total territorial pairs estimated for Turvo State Park*
S. ornatus	4	3.67 km	12.27 km^2	14.2
S. melanoleucus	3	4.44 km	17.93 km^2	9.8

All the territories studied from each species were active at the same time in at least a year, so we have certainty they represent distinct territorial pairs. However, Nest 4 may represent a new territory for *S. ornatus*, but as we didn't find breeding activity in nests 2 and 3 during 2021/2022 breeding season, we treated them as alternative nests for now. If nest 4 in fact represents a new territory, then estimated numbers for *S. ornatus* would be even higher, reaching about 22 territorial pairs for Turvo State Park. As no other nests were found among the ones studied, despite our efforts in the search for them, we are somewhat convinced that they represent neighbors' nests.

2.4 – DISCUSSION

The use of different techniques resulted us to find seven nests of forest eagles, what can be considered a great success, due the difficulties of the search of these structures in dense forests. Before that, only three nests of *S. ornatus* were discovered in all southern Brazil (Joenck et al. 2011, Zilio 2017) and only another nest for *S. melanoleucus* (Meyer 2020). The results also showed that the two methods of search were not concurrent, but complementary, as they revealed different nests. So, the first aspect regarding our results is that we can improve relevant data from the ecology of these raptors, so methodological considerations and especially ecological aspects will be discussed based on these finds.

Search for nests

Nests were found either by a traditional approach and by a more technological method. By traditional we can consider the use of trails and playbacks to find individuals and identify territories. Four of the seven nests found in our study were discovered through linear transects. Even that we had only 10 reactions of forest eagles to our playback surveys − which over 12 campaigns is a low return − two of them were followed by the discovering of nests. Furthermore, 25 additional spontaneous records of *Spizaetus* spp. made while sampling the transects also revealed the efficiency of the method in encountering these species. We believe that the efficiency of this method, however, is in part linked to the experience and familiarity of the observer to the behavior of the eagles. That includes recognize eagles' voices and interpret territoriality signs, as indicators of nests' locations.

Despite we didn't use *Spizaetus* hawk-eagles' recordings, the voices of the two largest forest eagles revealed to be functional anyway, and presented no differences in their efficiency. We didn't have any responses of Harpy Eagles or Crested Eagles in fact, but an occasional record of the latter was done by us during the period of this research (Meller et al. 2021). Harpy Eagles had anterior records for Turvo State Park (Meller & Guadagnin 2016), and during the time of our study the species was recorded by birdwatchers, being photographed in one occasion and probably recorded in another (Kuhn 2018, Mulbeier 2021).

The more technological way of search for nests uses the relatively new drones, that became accessible to researchers of natural science in the last decade. The use of drones enabled us to find three additional nests for this study. Three nests found by linear transects, however, were not visualized by the drone, even though it overflew them. The main considerations we have about this failure regards to the proximity of the images captured by the camera and the very nature of the trees. To recognize a nest, it is crucial that the drone captures an image close enough of the treetops. Without zoom, some drones do not provide an adequate approach and flights must be as low as possible. We flew at low altitudes to compensate our aircraft limited lens' focal length, but we had to deal with crashes and still some nests were not recognized. We concluded that crashes were caused by an error of the terrains' curve levels, as trees in Turvo State Park are not known to reach higher than 35 m (Silva et al. 2005), and our flights were from 45 to 50 m of altitude.

But why some nests could not be identified even if we flew as low as possible? We considered two reasons at least. The first one is that lines spaced by 40 m still provided a distant image for some of the trees. If the drone had flown in closer lines, the chance of some of the known nests been recognized would probably be greater. The second factor concerns to the very nature of the emergent trees, as only some allow the view inside their crowns. *Apuleia leiocarpa* frequently shows a clear treetop, well-defoliated in winter and with light trunks, providing a clear investigation. One of the nests recorded in this study was built in one of these trees, but the image was too far, and by the drone it was not visible. So, if the drone had captured a closer image probably the nest would be recognized. *Parapiptadenia rigida* and *Peltophorum dubium*, in turn, have darker trunks, often with some vegetation in it. The drone flew over three nests in *P. dubium*, but they were not able to be recognized by the images, still one of the nests was found indirectly through the drone method. We considered that the images were too far in some cases, but still the treetop of these trees were very dense, so it is uncertain if a closer image would be enough to see the nests. The nest built in *P. rigida* was not overflown, as we lost the drone before concluding the search through the area of that nest.

The first nest found through the drone method was placed in a *Balfourodendron riedelianum*, which is an evergreen tree. Even so the nest was in the middle of a foliated crown, we could recognize it. That is probably because the treetop was near to the line the drone was flying, so the image captured was close enough to the nest be distinguished. Furthermore, the light trunks of this tree also allows a great contrast in order to perceive the coloration of the nests' dry twigs. The second nest found through drone flights was in a *Lonchocarpus muehlbergianus* tree. Despite this tree is usually component of the canopy, that specimen was isolated from the surrounding trees, making it somewhat characteristic as an emergent tree. The drone flew very close above the tree, which helped to perceive the structure of the nest.

Many raptors were curious about the presence of the drone, and some of them inspected the aircraft closely, but there was no physical contact in any of the approaches during the pre-programed flights. We noted the reactions of raptors to the aircraft's presence from the images captured by the drone and also direct from the ground (Appendix 4). These reactions, however, are probably underrated, as the camera was always directed downwards and most of the time we had no visual contact with the aircraft. While we were visiting one of the 23 selected trees for a closer inspection of possible nests, during a flight we witnessed our drone being attacked and dropped to the ground by a *S. melanoleucus*. The hawk-eagle didn't seem to have any injuries from the collision, as it flew away normally after the impact.

Nest tree characteristics

All the five species of trees represent new mentions for the construction of *Spizaetus* hawk-eagles' nests, and some may be new for forest eagles at all. An exception would be *A. leiocarpa*, which has already been mentioned as having a nest of Harpy Eagle in the Amazon Forest (Gusmão et al. 2016). Luz (2005) and Giudice et al. (2007) observed that the number of branches is an important factor for the choice of the place to a Harpy Eagle build a nest, where four or more branches increased the chances. For many reasons, two branches are less efficient for sustaining such large nests in long term (Luz 2005). In our study, the only nest built in two branches was the one which felt, and the pair of hawk-eagles decided to reform an old nest instead of rebuild this alternative one. Alternative nests are a known behavior of many eagles (Newton 1979), including some *Spizaetus* hawk-eagles (Whitacre et al. 2012). According to our knowledge, however, this is the first mention of an alternative nest for *S. melanoleucus*. For *S.*

ornatus, in turn, this behavior has been already reported (Whitacre et al. 2012), and the alternative nests discovered by us reaffirm it. Our results confirm the reproduction of *S. melanoleucus* in RS, previously without evidence of nesting (Maurício et al. 2013) and the reproduction of *S. ornatus* in the northwest of this state (Meller 2021).

Three nests of *S. ornatus* were situated in valleys formed by small streams, while one nest of *S. ornatus* and three nests of *S. melanoleucus* were situated in slopes. The nests of *S. melanoleucus* were close to the crest of the hill, with the crown almost reaching their tops. A pattern similar to that was described by Canuto (2008) in Minas Gerais state. All the nests we found were situated in protected conditions, which shows a pattern similar to what has been mentioned for Harpy Eagles' nests in Misiones (E Krauczuk, pers. comm. in Meller & Guadagnin 2016). Such valleys can be advantageous, for instance, in providing shelter against hard winds. The terrain of Turvo State Park has a natural arrangement that provides many sites with those characteristics, as much of the valleys are faced to north, with many streams going towards Uruguay River. These valleys offer covert from crossings of frontal systems coming from Argentina and South Pole, which are the main source of hard winds in this region (Rio Grande do Sul 2014).

We consider that this scenario was underrated before, with the assumption that the park offered few sites for such large raptors (Bencke et al. 2003, Silva et al. 2005). The availability of breeding sites is also contributed by the forest's emergent stratum, which includes a lot of trees adequate for nesting. Among the most common emergent trees, are the species in which we found the nests (Silva et al. 2005). Likewise, the diversity of prey in Turvo State Park, with the richest community of birds and mammals of Rio Grande do Sul (Fontana et al. 2003), favors the abundance of top predators. We highlight that this park is one of the most important areas for the conservation of forest eagles in southern Brazil.

Inter-nest distance and pair density

As we based our estimates of pair density in only two territories for each species, these estimates have to be considered with precaution. Despite of that, they provide a worthy spatial arrangement for *Spizaetus* hawk-eagles in the forests of southern Brazil. In the state of Minas Gerais, Canuto et al. (2012) estimated an approximate density of one *S. melanoleucus* pair for every 42.85 km^2. That is much wider than our results suggest and if we apply it for Turvo State

Park, no more than 4 pairs would have territories, instead of the nearly 10 pairs estimated by us. Thiollay (1989, 2007) suggested an area of 17.24 km^2 per pair, which is much similar to what we found in our study. According to our preview experience watching raptors in the park (Meller 2011, 2014), and with a long list of *S. melanoleucus* observations, including territorial behavior in different places (Meller 2021), we believe that the actual density is more likely to coincide with the higher density estimated by Thiollay (1989, 2007) and ourselves.

For *S. ornatus*, in turn, our density is relatively lower than the one estimated by Whitacre et al. (2012) in the forests of Guatemala, which resulted in a pair per 10 km^2. Our estimate indicates that up to 14 pairs could hold territories in Turvo State Park, instead of 17 if we followed the estimates of those authors. Our data suggests a spatial arrangement with more pairs of *S. ornatus* than *S. melanoleucus* in the park. This contradicts the tendency showed by total records in transects, where *S. melanoleucus* was recorded more times than *S. ornatus* (22 versus 13; $p = 0{,}07$), suggesting that the latter species or has an inferior density or an inferior detectability. In fact, *S. ornatus* has an inferior detectability compared to its congener when it comes to observation through fixed points, and there are surveys in Turvo State Park showing this pattern (Meller 2011). Transects, in turn, seem to overcome this disparity, as shows the results found in our study.

The real numbers of *S. ornatus* in the park could be downtrend because it has a known preference to occur in continued forests rather than fragmented ones (Thiollay 1985). With a large area of edge in its Brazilian limits, Turvo State Park has few forests in its surrounding landscape, which is prevailed by agricultural crops containing an impoverished raptor community (Meller 2014). That is also supported by the current lack of regional records of the Ornate Hawk-Eagle outside the limits of Turvo State Park (Meller 2021). Furthermore, analyzing Figure 5 we can observe that all nests are out or in the limits of the range of any other *Spizaetus* hawk-eagles' territories. If this is coincidence, our estimates about territorial pairs are more likely to be right. If, in turn, there is interspecies segregation of breeding sites, the available area for territories is lower than the one estimated by the MPND method. This interspecies territoriality could even explain the current lack of *S. tyrannus* records in Turvo State Park, suggesting its absence or great rarity.

Based on the new advances in the knowledge of *Spizaetus* hawk-eagles, could be interesting reevaluate the population estimates for southern Brazil, which were done before by

Zilio (2017). It is important to highlight, however, that our estimates are associated to a primary environment, continuous to a huge track of forest, that cannot be found in any other region of Rio Grande do Sul state. For this reason, extrapolating our estimates to a fragmented landscape could not reflect the real situation, so that this should be considered when reproducing our results.

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2.6 – REFERENCES

Aguiar-Silva FH, TM Sanaiotti, O Jaudoin, AC Srbek-Araujo, G Siqueira & A Banhos. 2012 Harpy Eagle sightings, traces and nesting records at the "Reserva Natural Vale", a Brazilian Atlantic Forest remnant in Espírito Santo, Brazil. *Revista Brasileira de Ornitologia.* (2):148-155.

Aguiar-Silva FH, TM Sanaiotti & BB Luz. 2014. Food habits of the Harpy Eagle, a top predator from the Amazonian rainforest canopy. *Journal of Raptor Research* 48(1):24-35.

Aguiar-Silva FH. 2016. *Uso e seleção de recursos por Harpia em múltiplas escalas espaciais: persistência e vulnerabilidade*. Doctoral teshis, INPA, Manaus.

Anfuso J, MVG Suarez & JC Chebez. 2008. Nuevo registro de nidificación de la harpía (*Harpia harpyja*) en la provincia de Misiones, Argentina y consideraciones sobre su conservación. *Nótulas Faunísticas*, 21: 1–13.

Bencke GA, CS Fontana, RA Dias, GN Maurício & JKF Mähler-Jr. 2003. Aves, p. 189–479. In: Fontana CS, GA Bencke & RE Reis (eds.). *Livro vermelho da fauna ameaçada de extinção no Rio Grande do Sul*. EDIPUCRS, Porto Alegre.

Bencke GA, GN Maurício, PF Develey & JM Goerck. 2006. Áreas importantes para a conservação das aves no Brasil. Parte I - estados do domínio da Mata Atlântica. SAVE Brasil, São Paulo, Brazil.

Brown D. 1975. A test of randomness of nest spacing. Wildfowl 26:102–103.

Brown L & D Amadon. 1968. *Eagles, hawks and falcons of the world*. Country Life Books, London.

Canal D & JJ Negro. 2018. Use of drones for research and conservation of birds of prey. Em: J Sarasola, JM Grande & JJ Negro (eds). Birds of Prey. Springer, Cham.

Canuto M. 2008. First description of the nest of the black-and-white Hawk eagle (*Spizaetus melanoleucus)* in the Brazilian Atlantic rainforest, Southeast Brazil. *Ornitología Neotropical* 19: 607–610.

Canuto M, G Zorzin, EPM Carvalho Filho, CEA Carvalho, GDM Carvalho & CET Benfica. 2012. Conservation, management and expansion of protected and non-protected tropical forest remnants through population density estimation, ecology and natural history of top predators; case studies of birds of prey (*Spizaetus* taxon). Pp. 359–388 in Sudarshana, P, M Nageswara-Rao & JR Soneji (eds). Tropical Forests. Volume 1. IntechOpen, London, UK.

Chebez JC & J Anfuso. 2008. Harpia, p. 197–202. In: Chebez JC. *Los que se van. Fauna argentina amenazada. Tomo 2*. Albatros, Buenos Aires.

Chebez JC, M Silva-Croome, A Serret & A Taborda. 1989. La nidificación de la harpía (*Harpia harpyja*) en Argentina. *El Hornero*, 13: 155–158.

De Lucca ER. 1996. Observaciones de un nido exitoso de Harpía (*Harpia harpyja*) en

Argentina. *El Hornero* 14(3): 70–72.

Del Hoyo J, A Elliot & J Sargatal. 1994. *Handbook of the birds of the world. Volume 2. New World Vultures to Guineafowl.* Lynx Edicions, Barcelona.

DJI – https://www.dji.com/br

Ferguson-Lees J & DA Christie. 2001. *Raptors of the world.* Houghton Mifflin Company, New York.

Fontana CS, GA Bencke & RE Reis. 2003. Livro Vermelho da Fauna Ameaçada de Extinção no Rio Grande do Sul. Edipucrs, Porto Alegre, Rio Grande do Sul, Brazil.

Giudice R, R Piana & M Williams. 2007. Tree architecture as a determinant factor for nest-tree selection by harpy eagles, p. 14-22. Em: *Neotropical Raptors.* Bildstein KL, DR Barber & A Zimmerman (eds.). Hawk Mountain Sanctuary, Orwigsbury.

Gomes FBR. 2014. Distribuição e ecologia do Uiraçu-falso (*Morphnus guianensis,* Daudin, 1800). Doctoral Thesis, Instituto Nacional de Pesquisas da Amazônia – INPA, Manaus

Gomes FBR & TM Sanaiotti. 2015. A review of the distribution of the crested eagle, *Morphnus guianensis* (Daudin, 1800) (Accipitridae: Harpiinae), including range extensions. Revista Brasileira de Ornitologia, 23(1): 36–63.

González JJV & FH Vargas. 2011. Nesting density of Harpy Eagles in Darien with population size estimates for Panama. Journal of Raptor Research 45:199-210

Google. 2019. Google Earth. Available at http://www.google. com. br/earth/ [Accessed 23 May 2019]

Granzinolli MAM & JC Motta-Junior. 2010. Aves de rapina: levantamento, seleção de habitat e dieta, p. 167-188. Em: Matter et al. (eds). Ornitologia e conservação: ciência aplicada, técnicas de pesquisa e levantamento. Technical Books, Rio de Janeiro.

Gusmão CA, A Banhos, FH Aguiar-Silva, LS Souza, TM Sanaiotti, AM Silva, TM Costa, LE Oliveira, WG Morais & SF Ferrari. 2016. Records of the occurrence, nesting, and hunting of the Harpy Eagle (*Harpia harpyja*) (Aves: Accipitridae) in Rondônia, Southwestern Brazilian Amazonia. *Atualidades Ornitológicas,* 190: 18-23.

Hammer Ø, DAT Harper & PD Ryan. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Available at https://palaeo-electronica.org/2001_1/past/issue1_01.htm Acessed on 23 Dec 2021.

Joenck CM, F Zilio & A Mendonça-Lima. 2011. First record of breeding of the Ornate hawk-eagle (*Spizaetus ornatus*) in south-ern Brazil. *El Hornero* 26: 163–166.

Junda J, E Greene & DM Bird. 2015. Proper flight technique for using a small rotary-winged drone aircraft to safely, quickly, and accurately survey raptor nests. *J. Unmanned Veh. Syst.* 3: 222–236. dx.doi.org/10.1139/juvs-2015-0003

Kuhn CN. 2018. [WA2997981, *Harpia harpyja* (Linnaeus, 1758)]. Wiki Aves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/2997981> Accessed in 09 May 2019.

Litchi App – https://flylitchi.com

Luz BB. 2005. *Características de árvores emergentes utilizadas por Gavião-real (Harpia harpyja) para nidificação no centro e leste da Amazônia Brasileira*. Masters Dissertation, INPA, Manaus.

Magnusson WE, AP Lima, RC Luizão, F Luizão, FRC Costa, CV Castilho & VF Kinupp. 2005. RAPELD: uma modificação do método de Gentry para inventários de biodiversidade em sítios para pesquisa ecológica de longa duração. Biota Neotropica, 5(2): 1-6.

Marquez C, M Bechard, F Gast & VH Vanegas. 2005. Aves Rapaces Diurnas de Colombia. Ramos López, Bogotá.

Maurício, GN, GA Bencke, M Repenning, DB Machado, RA Dias & L Bugoni. 2013. Review of the breeding status of birds in Rio Grande do Sul, Brazil. Iheringia. Série Zoologia 103: 163–184.

Meller DA. 2011. *Aves de Rapina do Parque Estadual do Turvo, Rio Grande do Sul, Brasil*. Monography, Universidade regional Integrada do Alto Uruguai e das Missões – URI – Campus Santo Ângelo, Santo Ângelo, Rio Grande do Sul, Brazil.

Meller DA. 2014. *Aves de Rapina da Mata do Alto Uruguai*. Masters dissertation, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil.

Meller DA. 2021. Recent records of hawk-eagles (*Spizaetus* spp.) in northwestern Rio Grande do Sul, Brazil. *Ornitología Neotropical* 32: 158-165.

Meller DA & DL Guadagnin. 2016. Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil. *Revista Brasileira de Ornitologia* 24(1): 53–57.

Meller DA, A Fick, A Banhos, TM Sanaiotti & CB Kasper. 2021. The rediscovery of the Crested Eagle (*Morphnus guianensis*) in Rio Grande do Sul state, Brazil. *Ornithology*

Research 29: 89–93. https://doi.org/10.1007/s43388-021-00056-z

Meyer D. 2020. [WA4015687, *Spizaetus melanoleucus* (Vieillot, 1816)]. WikiAves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/4015687> Acesso em: 19 Nov 2021.

Miranda EBP, CA Peres, V Carvalho-Rocha, BV Miguel, N Lormand, N Huizinga, CA Munn, TBF Semedo, TV Ferreira, JB Pinho, VQ Piacentini, MA Marini & CT Downs. 2021. Tropical deforestation induces thresholds of reproductive viability and habitat suitability in Earth's largest eagles. *Scientific Reports* 11: 13048. https://doi.org/10.1038/s41598-021-92372-z

Mulbeier AF. 2021. [WA4191282, *Harpia harpyja* (Linnaeus, 1758)]. Wiki Aves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/4191282> Acessed in 12 Nov 2021.

Muñiz-Lopez R, O Criollo & A Mendúa. 2007. Results of five years of the "Harpy Eagle (*Harpia harpyja*) research program" in the Ecuadorian Tropical Forest, p. 23-32. Em: Neotropical Raptors. Bildstein KL, DR Barber & A Zimmerman (eds). Hawk Mountain Sanctuary, Orwigsburg.

Newton I. 1979. Population Ecology of Raptors. Buteo Books, Vermillion.

Pallinger F & W Menq. 2021. Aves de Rapina do Brasil. Volume I: diurnos. Pallinger: Arte e Vida Selvagem, São Paulo.

QGIS Development Team. 2018. QGIS Geographic Information System. Available at http://www.qgis.org/ Accessed on 23 May 2019.

Rio Grande do Sul. 2014. Atlas eólico: Rio Grande do Sul. Porto Alegre: SDPI: AGDI.

Sanaiotti TM, TG Junqueira, V Palhares, FH Aguiar-Silva, LMP Henriques, G Oliveira, VY Guimarães, V Castro, D Mota, DF Trombin, DNA Villar, KM Lara, D Fernandes, L Castilho, E Yosheno, RM Alencar, L Cesca, SM Dantas, TO Laranjeiras, PC Mathias, & PVC Mendonça. 2015. Abundance of Harpy and Crested Eagles from a reservoir-impact area in the Low and Mid-Xingu River. *Brazilian Journal of Biology*, 75(3): 190–204.

Sick H. 1997. *Ornitologia brasileira*. 2 ed. Nova Fronteira, Rio de Janeiro.

Silva CP, JKF Mähler Jr, SB Marcuzzo & S Ferreira. 2005. Plano de Manejo do Parque Estadual do Turvo. Secretaria Estadual do Meio Ambiente, Porto Alegre.

Soares ES, FSR Amaral, EPM Carvalho Filho, MA Granzinolli, JBL Albuquerque, JS Lisboa, MAG Azevedo, W Moraes, T Sanaiotti & IG Guimarães. 2006. Plano de ação nacional para a conservação de aves de rapina. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília, Série Espécies Ameaçadas, vol. 5.

Thiollay JM. 1985. Composition of Falconiformes Communities Along Successional Gradients from Primary Rainforest to Secondary Habitats. Pp. 181–190 in Newton, I & RD Chancellor (eds). Conservation Studies on Raptors. ICBP/Paston Press, Nor-wich, UK.

Thiollay JM. 1989. Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation Biology* 3:128-137.

Thiollay JM. 2007. Raptor communities in French Guiana: distribution, habitat selection, and conservation. *Journal of Raptor Research* 41:90-105.

Veloso HP, ALR Rangel Filho & JCA Lima. 1991. *Classificação da vegetação brasileira, adaptada a um sistema universal*. IBGE, Departamento de Recursos Naturais e Estudos Ambientais, Rio de Janeiro.

Whitacre DF, JA Madrid, HD Madrid, R Cruz, CJ Flatten & SH Funes. 2012. Ornate hawk-eagle. Pp. 203–233 in Whitacre, DF (ed). Neotropical Birds of Prey: biology and ecology of a forest raptor community. Cornell University Press, Ithaca, USA.

WikiAves – www.wikiaves.com

Zilio F. 2017. Breeding biology and conservation of hawk-eagles (*Spizaetus* spp.) Aves, Accipitridae) in southern Atlantic Forest, Brazil. *Iheringia, Série Zoologia*, 107: 1–14.

3 – ARTIGO II

BREEDING BIOLOGY AND DIET OF *SPIZAETUS ORNATUS* AND *S. MELANOLEUCUS* IN TURVO STATE PARK, RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

Spizaetus spp. are large raptors with Neotropical distribution and with special concern of conservation. Breeding biology of *Spizaetus ornatus* has been studied in detail by some authors, however, *S. melanoleucus* has few information regarding this aspect, with a couple of nests studied along the years. As a natural consequence, diet of *S. ornatus* is also much more known, with data including even three nests from southern Brazil. *Spizaetus melanoleucus* is frequently mentioned as a bird specialist, but the lack of studies in nests keeps the knowledge of its diet as still poorly known. In this paper we present data from breeding biology and diet collected from seven nests studied at Turvo State Park through 2018−2021 years. Breeding biology was described from direct observations and from images captured by camera traps. Diet was identified from collects under the nests, images by camera traps and direct observations.

Two breeding cycles were monitored for each species, where *S. melanoleucus* has bred earlier than *S. ornatus*. Diet from each species were based on a total of 58 prey items, from which 42 were identified at least at a class level. Birds represented the main group of animals for *S. ornatus* diet, composing 70% of the total, while mammals represented 23% and reptiles 7%. For *S. melanoleucus*, birds represented 100% of the items. Two new birds, *Leptodon cayanensis* and *Pyrrhura frontalis*, are mentioned for the diet of *S. ornatus*, besides a new reptile, *Salvator merianae*. *Vanellus chilensis* is the only new item for the diet of *S. melanoleucus*.

KEY-WORDS: Atlantic Forest, Birds of Prey, Black-and-white Hawk-Eagle, Forest Eagles, Ornate Hawk-Eagle, Raptors.

RESUMO

Biologia reprodutiva e dieta de *Spizaetus ornatus* e *S. melanoleucus* no Parque Estadual do Turvo, Rio Grande do Sul, Brasil. *Spizaetus* spp. são grandes aves de rapina com distribuição Neotropical e com especial interesse de conservação. A biologia reprodutiva de *Spizaetus ornatus* tem sido estudada em detalhes por alguns autores, por sua vez, *S. melanoleucus* possui poucas informações sobre este aspecto, com poucos ninhos estudados ao longo dos anos. Como consequência natural, a dieta de *S. ornatus* é muito mais conhecida, com dados incluindo até mesmo três ninhos do sul do Brasil. *Spizaetus melanoleucus* é frequentemente citado como especialista em aves, mas a falta de estudos em ninhos mantém sua dieta como ainda pouco conhecida. Neste artigo apresentamos dados da biologia reprodutiva e dieta coletados de sete ninhos estudados no Parque Estadual do Turvo durante os anos de 2018 a 2021. A biologia reprodutiva foi descrita a partir de observações diretas e de imagens capturadas por armadilhas fotográficas. A dieta foi identificada a partir de coletas sob os ninhos, imagens de armadilhas fotográficas e observações diretas. Dois ciclos reprodutivos foram monitorados para cada espécie, onde *S. melanoleucus* reproduziu mais cedo que *S. ornatus*. A dieta de cada espécie foi baseada em um total de 58 presas, das quais 42 foram identificadas pelo menos a nível de classe. As aves representaram o principal grupo de animais para a dieta de *S. ornatus*, compondo 70% do total, enquanto os mamíferos representaram 23% e os répteis 7%. Para *S. melanoleucus*, as aves representaram 100% dos itens. Duas novas aves,

Leptodon cayanensis e *Pyrrhura frontalis*, são mencionadas para a dieta de *S. ornatus*, além de um novo réptil, *Salvator merianae*. *Vanellus chilensis* é o único item novo para a dieta de *S. melanoleucus*.

PALAVRAS-CHAVE: Águias Florestais, Aves de rapina, Gavião-de-penacho, Gavião-pato, Mata Atlântica, Rapinantes.

3.1 – INTRODUCTION

Spizaetus ornatus and *S. melanoleucus* are large raptors that inhabits forest formations all over Neotropical region (del Hoyo et al. 1994, Ferguson-Lees & Christie 2001). Despite their wide distributions, these species' populations are in decline with deforestation and hunt, being classified as threatened in many places, as in southern Brazil, as is the case of Rio Grande do Sul state (Rio Grande do Sul 2014).

Raptors play important role in conservation and their decline may affect the environment in many ways (Sergio et al. 2008, Donázar et al. 2016). Despite of that, many species still have aspects of their biology and ecology poorly known (Bierregaard 1998). As usual for many raptors, geographic distribution is mostly known by punctual records, however nests are the primarily source of information regarding ecological aspects as breeding, diet and density (Newton 1979, Sarasola et al. 2018).

Breeding biology of *Spizaetus ornatus* has been studied in detail by some authors, including three nests in southern Brazil (Joenck et al. 2011, Zilio 2017). On the other hand, *S. melanoleucus* has few information regarding this aspect, with a couple of nests studied through history. For instance, the description of its first nest was made only recently (Canuto 2008). After that, others nests were also found, but the information divulged in literature is still scarce for this species.

Diet of *S. ornatus* has been described by studies from nests by many authors. It's main class of prey are birds, followed by mammals and reptiles (Teixeira et al. 2019). *Spizaetus melanoleucus* is frequently mentioned as a bird specialist (Pallinger & Menq 2021), although many other animals are mentioned as prey items in the generalist literature (del Hoyo et al. 1994, Ferguson-Lees & Christie 2001). The inconsistency of its feeding ecology seems to be partly derivative from the lack of studies in nests, since these are the main source of knowledge regarding ecology of raptors (Brown & Amadon 1968, Newton 1979).

In this paper we present data from breeding biology and diet collected from seven nests studied at Turvo State Park through 2018−2021 years.

3.2 – METHODS

Study area

The study was conducted in Turvo State Park, Rio Grande do Sul state, southern Brazil (27°13’S, 53°51’W). The area of the park is represented by 175 km^2 of well-preserved Seasonal Deciduous Forest, a formation associated to the Atlantic Forest (Veloso et al. 1991, Silva et al. 2005). In this park we monitored seven nests of *Spizaetus* spp. between December 2019 to April 2022 (Figure 1).

Maps were composed with the software QGIS v. [3.4.7] (QGIS Development Team 2018) and nests were georeferenced with the use of a GPS *Garmin Etrex 20x* and the software Google Earth Pro (Google 2019).

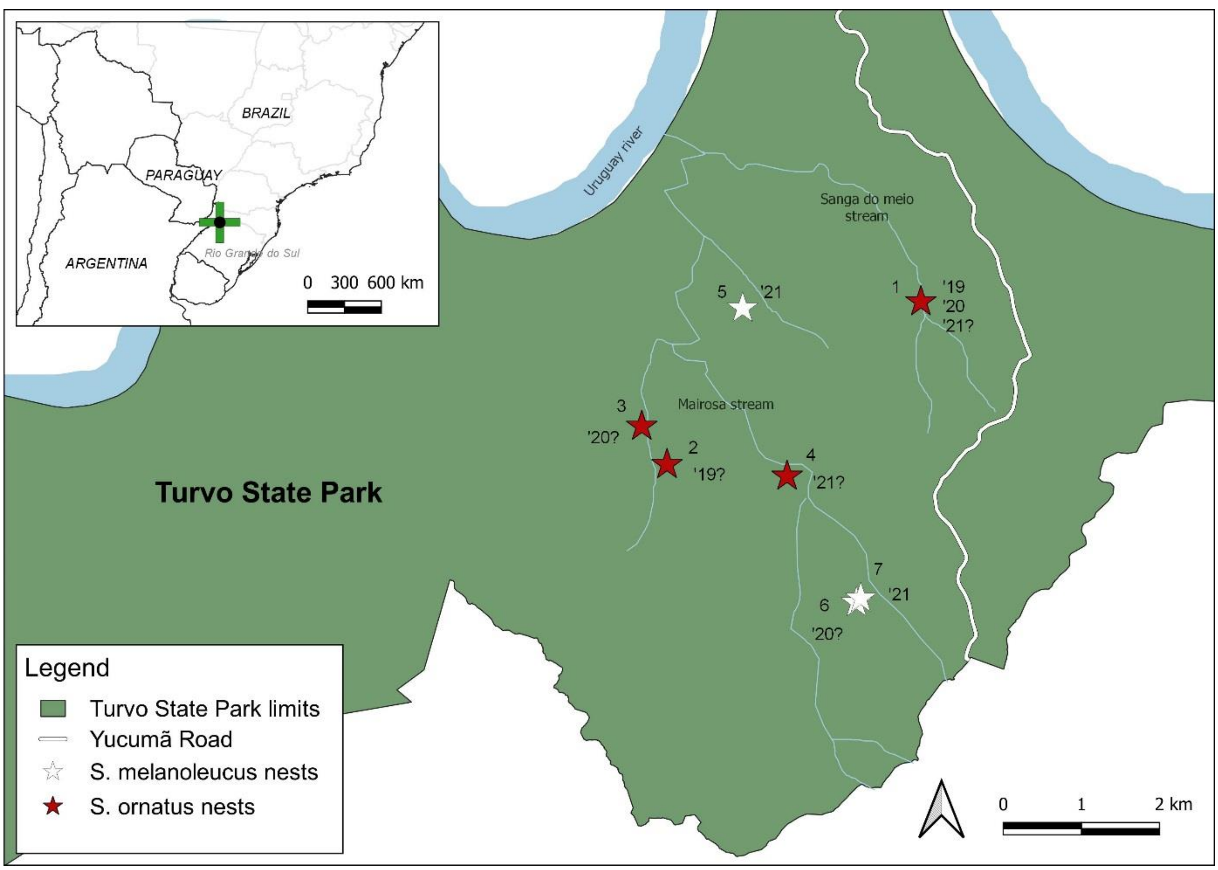

Figure 1. Location of seven *Spizaetus* spp. nests at Turvo State Park. Aside to the nests are the years in which reproduction was confirmed or suspected (?).

Nests monitoring

To monitor activities related to breeding, we visited the nests regularly (once or twice every two months). Nesting was confirmed through different years based on observations of nestlings, fledglings or juveniles in the nests or its vicinity. We set camera traps to record videos of the activity in one *S. melanoleucus* nest and in two *S. ornatus* nests. One of these *S. ornatus* nests had its nesting phenology based on accurate observations along a whole breeding season. Other three breeding events had their nesting phenology calculated from our own observation while visiting the active nests, but also from our preview experience with the camera traps and information from literature (Whitacre et al. 2012, Pallinger & Menq 2021).

To collect information about the diet of the eagles, we adopted two main methods. The first one was the search for prey remains in the ground under the nest, which in two cases was complemented with the installation of a net (nylon mesh), for interception, one-meter-high from the ground, below the nest (Aguiar-Silva et al. 2015). We also installed camera traps above the nest for visual images of delivering prey (Aguiar-Silva 2016, Aguiar-Silva et al. 2017) at three nests, but this method was not possible to be replicable in all nests, because of the conditions of the trees. Direct observations of prey being delivered in the nest were also accounted for. The importance of a combination of methods has been reported for Crested Eagle diet (Gomes et al. 2021).

The installation of camera traps *Bushnell HD Nature View 12MP* at the nests was made from the ground in two cases, using the same technique used to throw a rope for ascension in trees (Matter et al. 2010). In another case we installed the camera at the nest through climbing techniques with the use of equipment for ascension in rope, which included one ascension rope, one security rope, one harness, one helmet, two ascenders, one ATC descender, one RIG self-breaking descender, seven carabineers and three slings. In this last case, an instructor was on the ground providing support and safety to the climber (Matter et al. 2010).

3.3 – RESULTS

Spizaetus ornatus' breeding attempts

Nest 1 (S. ornatus). (19'): In January 2020 we observed an adult soaring and vocalizing above the nest, and in the day after a young aside to the nest with a *Patagioenas picazuro* in its claws (Figure 2A). We monitored this nest with the help of a camera trap installed in April 2020 (Figure 2B). This young was seen at the nest until August, many times receiving prey from the adults (Figure 2C). After it dispersed, the adults started the activities for a new breeding season.

(20'): This following season was monitored with the camera trap from the pre-posture to the post-fledgling period. We observed many behaviors of the female, which included bringing green foliage of *Helietta apiculata* Benth. to the nest, and shading and feeding the chick (Figure 2D). The female started to eat at the nest only after the chick was born. The female laid the egg in September 30' and the egg hatched in November 7', which comprehended a 39 days' period of incubation. After that, it took 61 days to the young fledge and leave the nest for the first time. The camera trap accidently felt hit by a broken branch on March 2021 and we didn't reinstall it after that. We still monitored the young from the ground, which was seen for the last time in August 2021, when it arrived at the nest after a vigorous diving flight from the sky. It was begging for food and an adult was also heard in the surroundings.

(21'?): In October of this same year we saw the female apparently incubating at the nest again (Figure 2E), what means the young left the site anytime between August and October (September as a mean). In December the female was still at the nest, but we are not sure if the egg had already hatched. In February we returned to this nest and there was no sign of the adults or the young. Under the nest also there was no sign of prey remains, but we observed that a huge trunk of the tree had broken, although not one of those which the nest is supported. We suspected that breeding has failed because climate conditions, since this region experienced a drastic drought through that summer. We revisited the nest 18 times over these years, where we searched for prey remains in the ground, assisted by an interception net.

Nest 2 (S. ornatus). (19'?) In a visit to this nest in April 2021 we heard a young *S. ornatus* emitting some food-begging calls and also an adult vocalizing, both hundreds of meters away. We found prey remains in the ground. We installed a camera trap on the ground in May, which captured a low quality image of two eagles at the nest, one of them probably a young (Figure 2F). In August we climbed the nest and installed a camera trap on it. This day a young and an adult *S. ornatus* were again heard vocalizing hundreds of meters away from the nest, at the same direction than before. Finally, in November 2021 we recovered the camera trap and there were images of an adult Ornate Hawk-Eagle in it, with a prey in its claws (Figure 2G).

The branch where the camera was installed has broken, which was also one of the branches holding the nest. The nest didn't fall, but it became very exposed, and it is uncertain if the pair will continue to use this structure to breed. Either way, we confirm the reproductive site by the presence of the young and the adult visiting the nest. After that, we actually found an alternative nest in the area, as we describe in the following. We visited this nest five times.

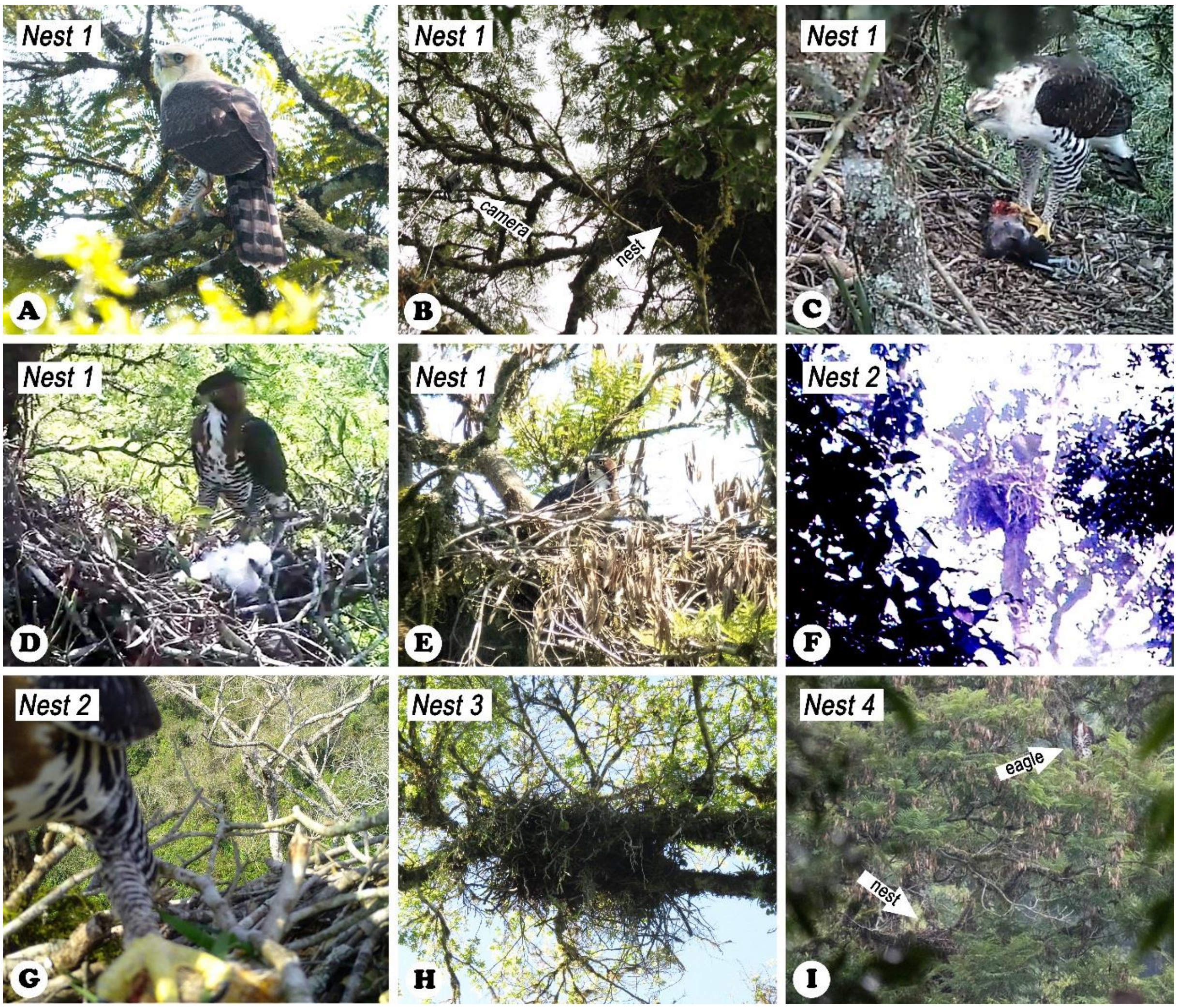

Figure 2a-i (*Spizaetus ornatus*). Nest 1: (A) A young aside to the nest in the 19' breeding cycle with a prey in its claws; (B) Camera trap installed at the nest; (C) A young monitored by camera trap; (D) Female with a hatchling in the 20' breeding cycle; (E) Female at the nest incubating in the 21' breeding cycle. Nest 2: (F) A poor photo of two eagles at the nest; (G) An adult with a prey at the nest. Nest 3: (H) View of the nest from the ground. Nest 4: (I) Nest with the female few meters above it. Photos: Gabriel Brutti (A) & Dante Andres Meller (B–I).

Nest 3 (S. ornatus). (20'?): In December 2021 we first visited this nest *in loco* (Figure 2H). In this occasion we found the remains of a prey (bird) under the nest. We believe that breeding was happening in this nest as an alternative to Nest 2 in the season of 2020/2021, because we heard sometimes the hawk-eagles calling from this direction while visiting that nest. The remains found under the nest in this only visit we have made also support our suspects.

Nest 4 (S. ornatus). (21'?): This nest was visited the first time in December 2020 after it was discovered. At this opportunity, we saw the female apparently incubating the egg (Figure 2I). We didn't visit the ground under the nest to avoid perturbing the incubation of the female at the occasion. In February 2021 we returned to the nest and there was no sign of the adults or young. Under the nest also there was no sign of prey remains. We suspect that the breeding failed because climate conditions, since this region experienced a drastic drought through that summer, similar to what we believe happened in 21' breeding cycle of Nest 1. We suspect this nest could represent a new territory to the relatively close Nest 2.

***Spizaetus melanoleucus'* breeding attempts**

Nest 5 (S. melanoleucus). When we first found this nest in April 2020, we saw the eagles in pre-breeding activity (Figure 3A). Mating displays around the vicinity of the nest were observed, including flying together, touch of talons, and even copulation, followed by delivered of prey to the female. After that, we decided to install a camera trap in it, which we accomplished by July 2020 (Figure 3B). After a short appearance to the camera, we suspected the female felt disturbed, as it stopped coming to the nest with the same attendance we were seeing before (Figure 3C). We found many prey items in the ground under the nest over the eight times we inspected it.

(21'): From November on, there was no sign of the eagles in the nest, although eventually we heard or saw an adult somewhere in the territory. We suspected that they had an alternative nest, which we couldn't find. The camera felt in December of that year and we decided to not reinstall it. Camera at this nest didn't function at all and no useful information from it was collected. In February 2021 we also removed the interception net we had installed months before under the nest (Figure 3D). Finally, in August 2021 we saw the female around the nest and in early November we saw a hawk-eagle at the nest but couldn't distinguished it. In December 2021 we saw a nestling about 60 days old over the nest, being observed by the female in the surroundings (Figure 3E).

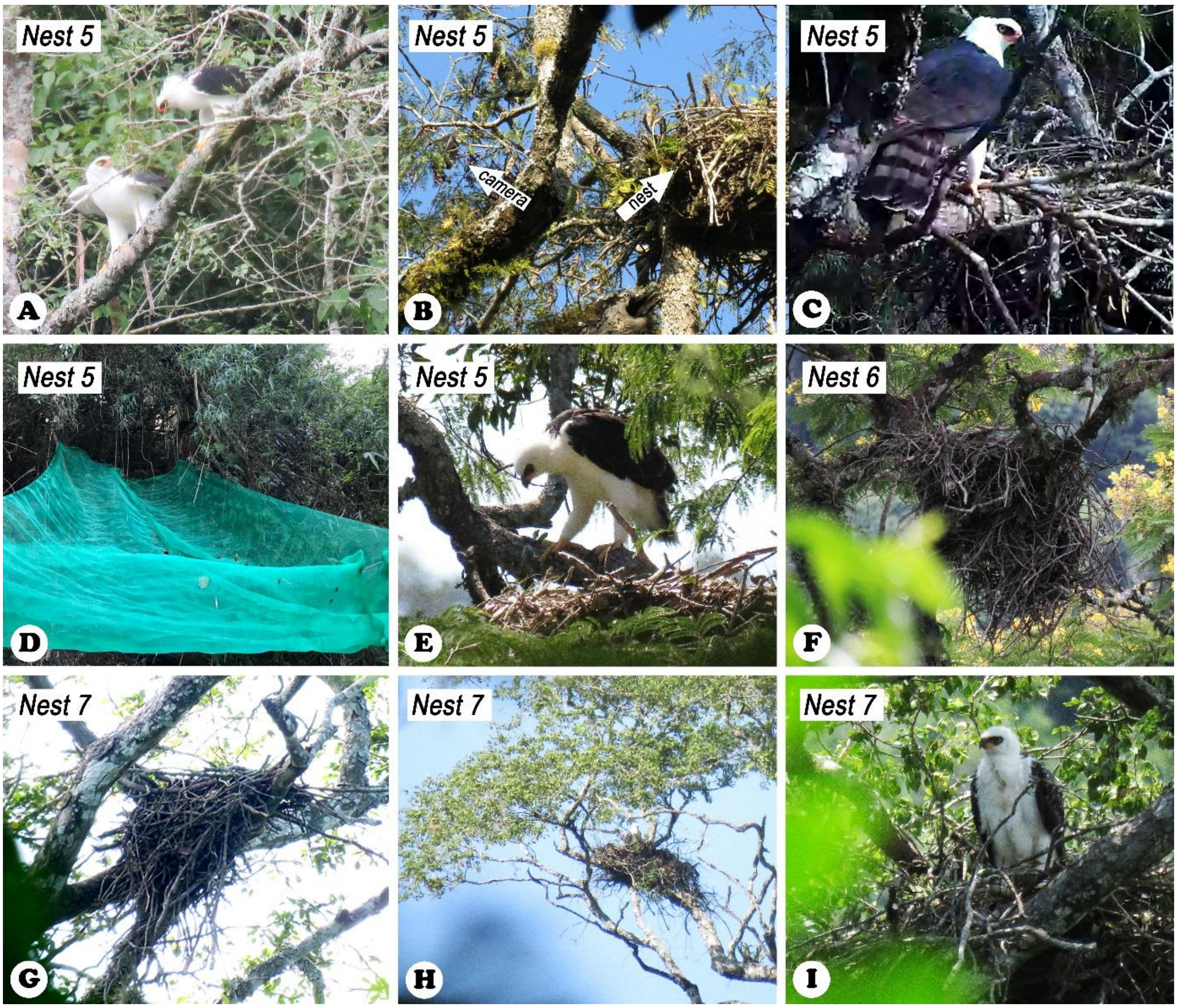

Figure 3a-i (*Spizaetus melanoleucus*). Nest 5: (A) A pair in pre-breeding behavior close to the nest; (B) Camera trap installed above the nest; (C) An adult pictured by the camera trap; (D) Net installed under the nest; (E) A nestling about 60 days old in the nest. Nest 6: (F) Nest almost falling. Nest 7: (G) Nest inactive, with an old appearance; (H) Nest rebuilt and with a nestling over it; (I) Nest with a nestling about 50 days old above it. Photos: Dante Andres Meller.

Nest 6 (S. melanoleucus). (20'?): This nest was active by the time we found it in January 2021, but the young had already left it, probably returning to it to beg for food, which we confirmed by remains found on the ground in five visits we made to inspect it (Figure 3F). In April 2021 this nest had felt, but the eagles started using the alternative nest we had found a month before (see below).

Nest 7 (S. melanoleucus). (21'): In March 2021 we found a second nest at the site of Nest 6. This alternative nest had an old, inactive appearance (Figure 3G). After Nest 6 felt, this nest started to be reformed, as we observed in June of that year. In August we saw the female incubating in it and in October there was a nestling about 50 days old above it (Figure 3HI). We found some remains of prey under the nest over the five visits for inspection.

In Figure 4 we synthetize four confirmed breeding seasons for the two species of *Spizaetus* hawk-eagles we are treating here.

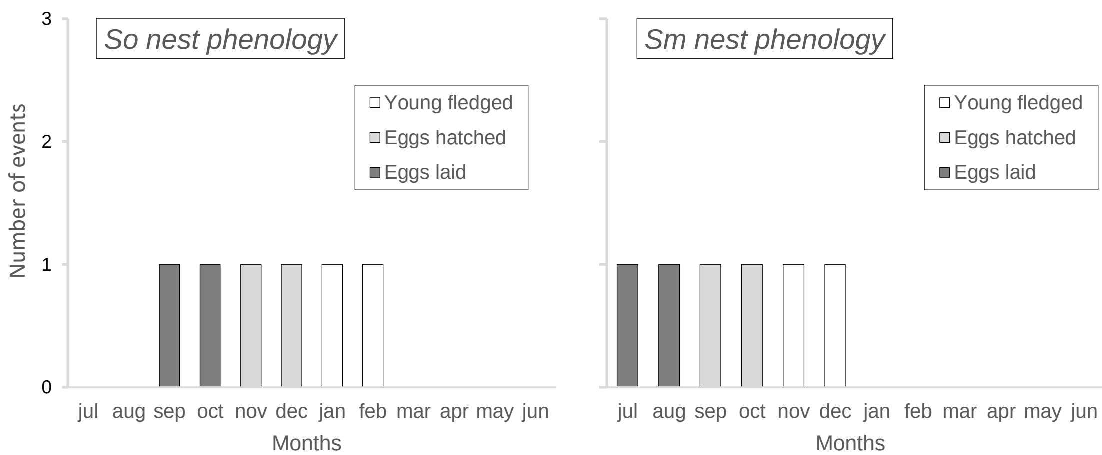

Figure 4. Nesting phenology of *Spizaetus ornatus* and *S. melanoleucus* through months in two breeding cycles for each species in Turvo State Park.

Diet

Most of the diet information was captured from items observed through a camera trap installed in Nest 1 (Figure 5A). To avoid replication of prey, we excluded information from collects from the ground under this nest, which in fact was significantly less effective than the camera trap, somatizing less than half of the prey items collected for this nest (Figure 5B).

Other nests had their diets mostly based from items collected from the ground, as camera traps faced problems in the other nests they were installed. Some occasional direct visualizations also allowed us to identify prey, and one of them was not related to any nests, which we reported as well (Figure 6A). A total of 58 prey items were counted, from which 42 we identified at least at a class level. Birds represented the main group of animals for *S. ornatus* diet, composing 70% of the total, while mammals represented 23% and reptiles 7%. For *S. melanoleucus*, birds represented 100% of the items (Figure 6B).

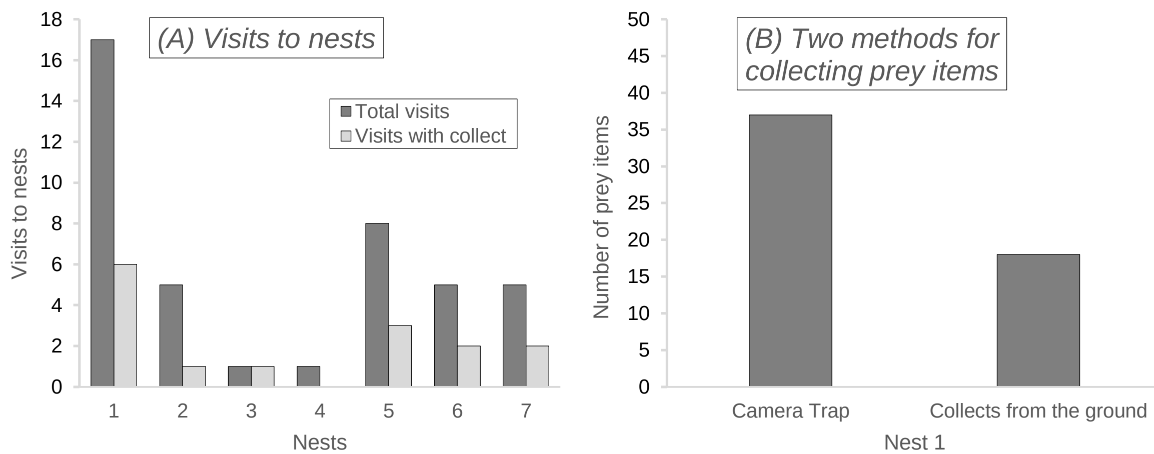

Figure 5. (A) Visits to the seven nests of *Spizaetus* hawk-eagles in Turvo State Park and (B) differences of methods at Nest 1.

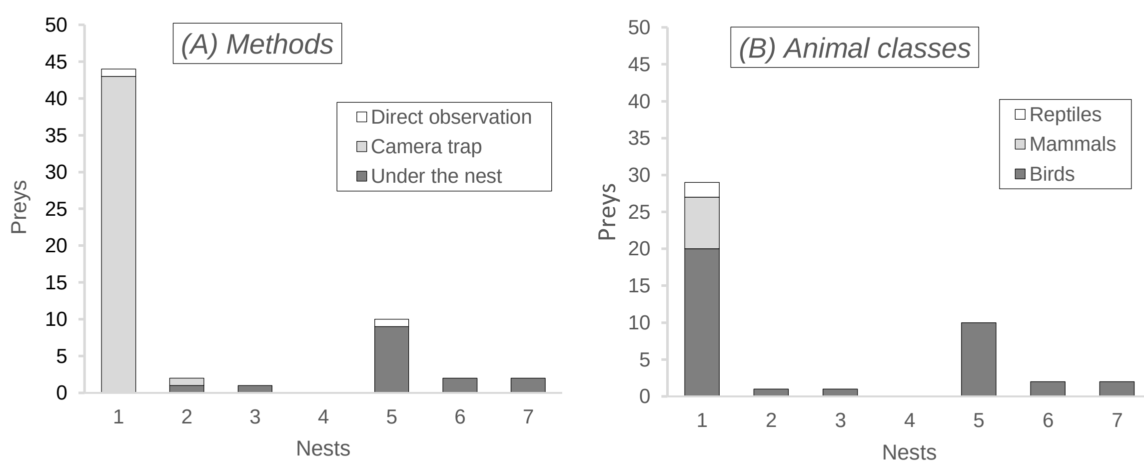

Figure 6. (A) Different methods for the identification of prey and (B) animal classes composing the diet of seven nests of two *Spizaetus* hawk-eagles in Turvo State Park.

Preys were identified mostly by the camera trap images, but also through direct observation. Seven items were identified at species level, four at genre level and three at family level. Three species were new items for *S. ornatus* and one for *S. melanoleucus* (Table 1).

Table 1. Prey items of the seven *Spizaetus* hawk-eagles' nests found in the study. (N) nest; (T) transect; (Sorn) *Spizaetus ornatus*; (Smel) *S. melanoleucus*.

Class	*Taxa*	*N1 (Sorn)*	*N5 (Sorn)*	*N6 (Sorn)*	*N7 (Sorn)*	*T5 (Sorn)**	*N2 (Smel)*	*N3 (Smel)*	*N4 (Smel)*
Aves	*Crypturellus sp.*	1							
Aves	*Coragyps atratus*					1			
Aves	*Leptodon cayanensis***	1							
Aves	*Vanellus chilensis****							1	1
Aves	Cracidae		1						
Aves	*Leptotila* sp.	3							
Aves	*Patagioenas picazuro*	1							
Aves	Columbidae								1
Aves	*Trogon surrucura*	1							
Aves	Strigidae	1							
Aves	*Pyrrhura frontalis***	1							
Aves	Not identified	11		1			9		
Mammalia	*Didelphis* sp.	5							
Mammalia	Not identified	12							
Reptilia	*Salvator merianae***	2							

* Additional observation made in transect 5 during the study;

** New item for the diet of *S. ornatus*;

*** New item for the diet of *S. melanoleucus*.

3.4 – DISCUSSION

Breeding biology

Figure 4 summarizes the stages of four events of nesting over the months for the two hawk-eagles – two for each species. The results indicate that *S. ornatus* breeds later than *S. melanoleucus* in this region. The female of *S. ornatus* laying in September-October, with eggs hatching in November-December and the young fledgling in January-February. We also have dispersing observations for August-September. Zilio (2017) observed a similar timing for one

S. ornatus nest found in an *Araucaria angustifolia* tree in southern Brazil, with the egg hatching in November. Joenck et al. (2011), in turn, found a nestling in a *Myrocarpus frondosus* tree in Esmeralda, Rio Grande do Sul, which had probably hatched in mid-August. For *S. melanoleucus* our data indicates that the female lay in July-August, with eggs hatching in September-October, and young fledgling in November-December. This relatively earlier breeding behavior for *S. melanoleucus* was also found by Canuto (2008), which found a chick in the nest in September.

With two years of successful breeding in a row and a following attempt, we highlight the exceptional rate of offspring raised by the pair of *S. ornatus* in Nest 1. Many large eagles are known to breed every other year, because of the prolonged juvenile dependence (Brown & Amadon 1968, Del Hoyo et al. 1994). *Spizaetus* hawk-eagles are no exception to that and Whitacre et al. (2012) found a proportion of 1 attempt of breeding in every two years in many nests of *S. ornatus* studied in Guatemala. These authors also reported that a year with a following attempt was preceded by a failure in the early stages of the breeding of the year before. What then are the reasons for the behavior seen in Nest 1? We explore two hypotheses:

The first one regards to food availability. A site with great abundance of prey can provide more attempts of breeding over the years than a scarce one, and consequently more offspring (Newton 1979). So, the amount of food available would then stimulate these raptors to breed every year. If this behavior is a particularity of this pair alone, that could be the motive. But it is strange that this behavior has not been reported in some tropical forests which are known to have even greater diversity of vertebrates.

The second explanation could be more complex if this is not an exclusivity of the pair in Nest 1 and also other pairs of *Spizaetus* hawk-eagles breed at the same frequency in these seasonal forests, as we suspected by the use of alternative nests in two other territories. That leads us to another hypothesis which we gained from what Newton (1979) discussed when he observed that higher latitudes could shorten the breeding cycle in some raptors. The species referred by Newton (1979) have migratory habits, so by winter their offspring should be able to disperse already. But it is interesting that the higher the latitude a certain population reproduces, the faster the juvenile develops. *Spizaetus* hawk-eagles, in turn, are sedentary birds, so if these hawk-eagles have shorter breeding cycles at the extreme of their latitude, there must be some climate reason involved that reduces the offspring dependence. An interesting fact is

– if our observation on the incubation length through the camera trap during 20’ breeding cycle in Nest 1 is precise – that the period lasted only 39 days. This is much lesser than the reported by Whitacre et al. (2012), which varied between 43−48 days. Tikal National Park, in Guatemala, where those authors studied *S. ornatus*, is 10º lower than Turvo State Park’s latitude, which supports the hypothesis of a faster development of the offspring in higher latitudes.

Diet

Camera traps were effective not only in collecting data about nesting phenology and behavior of the hawk-eagles, but also in recognizing preys delivered to the nest. Most of the items were recognized through this method, although it has been installed with efficiency in only one nest. We have some considerations about the method, however, because it may cause disturbance in some cases, as we suspected it happened at Nest 5. We believe the best time to install the camera is in the advanced nestling phase, because parents hardly would leave the nest from disturbance at that time, as the young will call begging for food and stimulate their natural instinct. There are some protocols to follow in the installation of cameras (Aguiar-Silva 2016, Aguiar-Silva et al. 2017), however the method we used was with the use of ropes instead of climbing the tree. We finally consider that the ropes should be positioned in a disposition that the entrance and exit of the nest stay clear for the eagles.

The main prey items found in *S. ornatus* nests we studied is composed by birds, followed by mammals and reptiles. Birds as the main prey corroborates other studies for *S. ornatus* (Whitacre et al. 2012, Joenck et al. 2011, Zilio 2017, Teixeira et al. 2019). Whitacre et al. (2012) also found a significant proportion of mammals (43.7%) in the composition, but strangely no reptiles, being the remaining 56,3% of the diet composed by birds. We found birds (70%) in a proportion more than twice greater than mammals (23%). And reptiles, in spite of contributing little (7%), were represented in the composition. In an extensive revision of Ornate Hawk-Eagle’s diet, Teixeira et al. (2019) gathered data about 121 taxa eaten by the species, including 78 species of birds and 38 of mammals. The only reptile cited was an *Iguana iguana*, besides some unidentified snakes and lizards. As new prey not mentioned by those authors we found in our study three species: *Leptodon cayanensis*, *Pyrrhura frontalis* and *Salvator merianae*.

Despite our observations of Tegu Lizards represent an additional prey for the compilation made by Teixeira et al. (2019), this reptile had already been reported before by Meller (2021) as a prey of Ornate Hawk-Eagle in Turvo State Park. It is interesting that the proportion of reptiles in our study was more representative than in any other studies and we explore a possible reason for that. Turvo State Park has a road that crosses the forests of the park, including part of the territory of Nest 1, where Ornate Hawk-Eagle is frequently seen hunting (Meller 2021). In this road, tegus are one of the most common animals in spring and summer (Silva et al. 2005), so it is not a surprise that it would end up preyed by the Ornate Hawk-Eagle.

The diet of *S. melanoleucus* is still poorly known and there is scarce and relatively few information in literature about it. Based on direct observations, some authors affirm that it is specialized in birds (Willis 1988, Robinson 1994, Thiollay 2007), but other preys have been mentioned as well, such as mammals, reptiles and even frogs, suggesting a more generalist hunter (Ferguson-Lees & Christie 2001). We disagree with this last suggestion, as all the remains we collected under the nests belonged to birds, pointing to a bird specialized hawk-eagle, corroborating what specific studies affirms. Among the identified prey, we believe *Vanellus chilensis* could represent a new item to its known diet. We highlight that *V. chilensis* remains were found under a nest inside the forest, which means *S. melanoleucus* probably hunted this prey beyond the limits of the park, in the open landscape. This fact is well supported by many occurrences of *S. melanoleucus* in the surroundings of the park, including in the area of the Visitor's Center (Meller 2021). Moreover, according to territories' estimates, this last area stays inside the territory of nests 6 and 7 of this study.

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3.6 – REFERENCES

Aguiar-Silva FH, TG Junqueira, TM Sanaiotti, VY Guimarães, PVC Mathias, & CV Mendonça. 2015. Resource availability and diet in Harpy Eagle breeding territories on the Xingu River, Brazilian Amazon. *Brazilian Journal of Biology* 75(3):181-189.

Aguiar-Silva FH, O Jaudoin, TM Sanaiotti, GHF Seixas, S Duleba & FD Martins. 2017. Camera trapping at Harpy Eagle nests: interspecies interaction under predation risk. *J. Raptor Res.* 51(1): 72-78.

Aguiar-Silva FH. 2016. *Uso e seleção de recursos por Harpia em múltiplas escalas espaciais: persistência e vulnerabilidade*. Doctoral teshis, INPA, Manaus.

Bierregaard Jr. RO. 1998. Conservation status of birds of prey in the South American tropics. *J. Raptor Res.*, v. 32, p. 19-27.

Brown L & D Amadon. 1968. *Eagles, hawks and falcons of the world*. Country Life Books, London.

Canuto M. 2008. First description of the nest of the black-and-white Hawk eagle (*Spizaetus melanoleucus)* in the Brazilian Atlantic rainforest, Southeast Brazil. *Ornitología Neotropical* 19: 607–610.

Del Hoyo J, A Elliot & J Sargatal. 1994. *Handbook of the birds of the world. Volume 2. New World Vultures to Guineafowl.* Lynx Edicions, Barcelona.

Donázar JA, A Cortés-Avizanda, JA Fargallo, A Margalida, M Moleón, Z Morales-Reyes, R Moreno-Opo, JM Pérez-García, JA Sánchez-Zapata, I Zuberogoitia & D Serrano. 2016.

Roles of raptors in a changing world: from flagships to providers of key ecosystem services. *Ardeola* 63(1): 181-234.

Ferguson-Lees J & DA Christie. 2001. *Raptors of the world.* Houghton Mifflin Company, New York.

Gomes FBR, TM Sanaiotti & C Bantel 2021. Diet and feeding strategies of the crested eagle (*Morphnus guianensis*) in the Brazilian amazon. *Journal of Raptor Research* 55(2): 211-219.

Joenck CM, F Zilio & A Mendonça-Lima. 2011. First record of breeding of the Ornate hawk-eagle (*Spizaetus ornatus*) in south-ern Brazil. *El Hornero* 26: 163–166.

Matter SV, L Naka, T Fontoura, FM dos Santos, WD da Rocha & J Nuscheler. 2010. Técnicas para o estudo de aves em dosséis florestais, p. 105-165. Em: Matter et al. (eds). *Ornitologia e conservação: ciência aplicada, técnicas de pesquisa e levantamento*. Technical Books, Rio de Janeiro.

Meller DA. 2021. Recent records of hawk-eagles (*Spizaetus* spp.) in northwestern Rio Grande do Sul, Brazil. *Ornitología Neotropical* 32: 158-165.

Newton I. 1979. Population Ecology of Raptors. Buteo Books, Vermillion.

Pallinger F & W Menq. 2021. Aves de Rapina do Brasil. Volume I: diurnos. Pallinger: Arte e Vida Selvagem, São Paulo.

Rio Grande do Sul. 2014. *Lista das espécies da fauna ameaçadas de extinção no estado do Rio Grande do Sul. Instrução Normativa n° 3. Decreto No 51.797.* Diário Oficial do Estado do Rio Grande do Sul, Secretaria do Meio Ambiente, Porto Alegre.

Robinson SK. 1994. Habitat selection and foraging ecology of raptors in Amazonian Peru. *Biotropica* 26: 443–458.

Sarasola JH, JM Grande & JJ Negro. 2018. *Birds of Prey: Biology and conservation in the XXI century.* Springer International Publishing AG, part of Springer Nature.

Sergio F, T Caro, D Brown, B Clucas, J Hunter, J Ketchum, K McHugh & F Hiraldo. 2008. Top Predators as Conservation Tools: Ecological Rationale, Assumptions, and Efficacy. 10.1146/annurev.ecolsys.39.110707.173545.

Silva CP, JKF Mähler Jr, SB Marcuzzo & S Ferreira. 2005. Plano de Manejo do Parque Estadual do Turvo. Secretaria Estadual do Meio Ambiente, Porto Alegre.

Teixeira FD, EP Mesquita, MA Ferreira & FC Araújo. 2019. Diet of Ornate Hawk-Eagle

(*Spizaetus ornatus*). *Revista Brasileira de Ornitologia* 27(1): 31–39.

Thiollay JM. 2007. Raptor communities in French Guiana: distribution, habitat selection, and conservation. *Journal of Raptor Research* 41:90-105.

Whitacre DF, JA Madrid, HD Madrid, R Cruz, CJ Flatten & SH Funes. 2012. Ornate hawk-eagle. Pp. 203–233 in Whitacre, DF (ed). Neotropical Birds of Prey: biology and ecology of a forest raptor community. Cornell University Press, Ithaca, USA.

Willis EO. 1988. A hunting technique of the Black-and-white Hawk-Eagle (*Spizastur melanoleucus*). *Wilson Bulletin* 100(4): 672-675.

Zilio F. 2017. Breeding biology and conservation of hawk-eagles (*Spizaetus* spp.) Aves, Accipitridae) in southern Atlantic Forest, Brazil. *Iheringia, Série Zoologia*, 107: 1–14.

4 – ARTIGO III

THE HARPY EAGLE IN THE SOUTHERN ATLANTIC FOREST: NEW RECORDS AND AN OVERVIEW ABOUT THE POPULATION OF THE GREEN CORRIDOR

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ABSTRACT

The Harpy Eagle (*Harpia harpyja*) is a large raptor that originally inhabited most of lowland forests of Neotropical region. Nowadays its populations are decreasing by loss of habitat and hunting, being classified as vulnerable. In the southern region of the Atlantic Forest, the species has become very rare, with few records through time and scarce discovery of nests. We report here new information on the Harpy Eagle records for Rio Grande do Sul, made at Turvo State Park (three recent) and Riozinho municipality (one historical). These new records are analyzed along with of all known records for the southern Atlantic Forest through revision and plotting on a map. We found 49 records and 5 nests of Harpy Eagle in the southern Atlantic Forest through time. Finally, we analyzed in detail the population of this eagle on the Green Corridor of Argentina and Brazil, estimating the number of pairs and individuals supported by the protected areas where occurrence is evidenced or most likely. In the extent of the Green Corridor, the Harpy Eagle must occur in 11 protected areas, totalizing an area of 613,183 ha. By the amount of protected forest, we estimated a supportable population of the Harpy Eagle in the Green Corridor between 10 and 77 mature pairs (as a mean 43). Although the Green Corridor protects almost a million hectares of preserved forests, there are some issues that do not favor Harpy Eagle, as selective logging, disconnection through fragmentation and hunting. So, the real population's number can even be lower than the mean estimated in our analysis.

KEY-WORDS: Birds of Prey, Conservation, *Harpia harpyja*, Iguaçu National Park, Misiones, Raptors, Turvo State Park.

RESUMO

A harpia no sul da Mata Atlântica: Novos registros e uma visão geral sobre a população do Corredor Verde. A harpia (*Harpia harpyja*) é uma grande ave de rapina que originalmente habitava a maior parte das florestas úmidas da região Neotropical. Atualmente sua população está diminuindo pela perda de hábitat e pela caça, sendo globalmente classificada como vulnerável. Na região sul da Mata Atlântica, a espécie tornou-se muito rara, com poucos registros ao longo do tempo e escassez de descoberta de ninhos. Relatamos aqui novas informações sobre registros da harpia no Rio Grande do Sul, feitos no Parque Estadual do Turvo (três recentes) e no município de Riozinho (um histórico). Esses novos registros são analisados juntamente com todos os registros conhecidos para a Mata Atlântica meridional por meio de revisão e plotagem em um mapa. Encontramos 49 registros e 5 ninhos de harpia no sul da Mata Atlântica ao longo do tempo. Por fim, analisamos detalhadamente as populações desta águia no Corredor Verde da Argentina e do Brasil, estimando o número de casais e indivíduos sustentados pelas áreas protegidas onde a ocorrência é evidenciada ou mais provável. Na extensão do Corredor Verde, a Harpia deve ocorrer em 11 áreas protegidas, totalizando uma área de 613.183 ha. Pela quantidade de floresta protegida, estimamos uma população suportável de harpias no Corredor Verde entre 10 e 77 casais (como média 43). Embora o Corredor Verde proteja quase um milhão de hectares de florestas preservadas, existem algumas questões que não favorecem a harpia, como extração seletiva de madeira, desconexão por fragmentação e

caça. Sendo assim, consideramos que os números reais podem ser até mesmo menores do que a média estimada por nós.

PALAVRAS-CHAVE: Aves de Rapina, Conservação, *Harpia harpyja*, Misiones, Parque Estadual do Turvo, Parque Nacional do Iguaçu, Rapinantes.

4.1 – INTRODUCTION

The Harpy Eagle (*Harpia harpyja* Linnaeus, 1758) is an incredible raptor, being emphasized as one of the largest and definitely the most powerful of all eagles (Brown & Amadon 1968, Ferguson-Lees & Christie 2001). Formerly, the species inhabited lowland forests of Neotropical region, ranging from southern Mexico to northern Argentina and southern Brazil (Del Hoyo et al. 1994, Ferguson-Lees & Christie 2001). Deforestation and hunting have made the Harpy Eagle disappear from wide parts of its original range, especially out of the Amazon, as is the case of the Atlantic Forest (Sick 1997, Vargas et al. 2006, Miranda et al. 2019). Most of the current records in this biome, including the discover of nests, are from Bahia and Espírito Santo states, in Brazil, and from Misiones, in the northeast of Argentina (Srbek-Araujo & Chiarello 2006, Anfuso et al. 2008, Aguiar-Silva et al. 2012, Banhos et al. 2018).

In Rio Grande do Sul state, south of Brazil, the Harpy Eagle was considered extinct for many decades, until its rediscovery in recent years (Meller & Guadagnin 2016). It is now classified as critically endangered (Rio Grande do Sul 2014), because they occurrence is limited to a single area in this state: Turvo State Park. The species is also considered critically endangered in the two other states of southern Brazil: Paraná and Santa Catarina (Mikich & Bérnils 2004, CONSEMA 2011). In Argentina and Paraguay, the species status is classified as endangered (Chebez & Anfuso 2008, MADES 2019), and these populations are crucial for the conservation of the species in its southern limit of distribution. In Brazil, and at a global level, the species is classified as vulnerable, but with a population trend decreasing by loss of habitat and hunting (Banhos et al. 2018, BirdLife International 2021).

In order to have a more current understanding of the situation of the Harpy Eagle in the southern Atlantic Forest, we have compiled information on the species' occurrence, including unpublished data and records published on citizen science platforms. We gathered this information with an extensive review of the records published in the literature and constructed an updated map of the species' occurrence in the southern Atlantic Forest. Finally, we analyzed in detail its population on the Green Corridor of Argentina and Brazil, estimating its possible numbers according to available habitat.

4.2 – METHODS

Study area

The Atlantic Forest ranges along the Atlantic coast from northeastern to southern Brazil (Veloso et al. 1991). In Paraná state, the biome enters the continent and reaches the southeast of Paraguay and northeast of Argentina, where it is known as Interior Atlantic Forest (Bodrati et al. 2005). In its southern limits, the forest is classified in three forest formations: Dense Ombrophilous, Mixed Ombrophilous and Semidecidous Seasonal (Marchiori 2002).

Most of these interior forests have been modified by the use of land and nowadays there are few blocks large enough to preserve the original biome's biodiversity (Tabarelli et al. 2003). The most important of them is the Green Corridor, an area throughout Misiones province, Argentina that reaches Brazilian areas of Iguaçu National Park in the north and Turvo State Park in the south (Paviolo et al. 2008). The Green Corridor has an area of almost a million hectares of continuous forest (Pardo et al. 2017), and is it inhabited by the most important population of Harpy Eagle of the Interior Atlantic Forest.

New information on records

Observations of birds of prey were carried out by the first author in the Turvo State Park from 2008 to 2022. Between 2009 and 2013 the surveys were carried out mostly through points that project good views over the canopy forest within this park and its surroundings (Meller 2011, 2014). In these 14 years, the first author also made several visits to Turvo State Park for birdwatching (many of them with the Ave Missões group – http://avemissoes.blogspot.com). These were intensified between 2013–2017 and 2018–2022. The observations were made with 10x42 binoculars and by cameras with telephoto lens.

In addition to field campaigns, we also searched for new records on WikiAves (http://wikiaves.com) - a widely used citizen science platform - and conducted interviews and informal conversations with local residents, rangers, ornithologists and birdwatchers in search of information about the Harpy Eagle."

Literature review and maps

An exhaustive research of the records of Harpy Eagle in southern Atlantic Forest was made through literature review. We gathered all published records, including the ones reported online. We distinguished historical records from current ones taking the year 2000 as a limit, as adopted by Zilio (2017). Moreover, its generation length in the wild of 20 years also supports this categorization (BirdLife International 2021). We plotted the records in a map, highlighting the Green Corridor and demarking polygons of protected areas where any of these eagles have been mentioned to occur through reliable records. Those without coordinates were included based on localities mentioned in their reports. Neighboring protected areas were included when records were mentioned as near to them, considering most likely to occur in that area too. Maps were composed with software QGIS (v. [3.4.7]) (2019).

Population estimates

Harpy Eagles need great areas for living and their density seems to vary according to the region. Thiollay (1989) estimated more than 100 km^2 for a pair in French Guiana. Álvarez-Cordero (1996), by the distance of nests, found in Venezuela that the territory of a pair of Harpy Eagles will be between 45 and 79 km^2, and in Panamá between 10 and 20 km^2.

There is no data for southern Atlantic Forest, but as the Harpy Eagle are rare in this biome, at least nowadays, and the forest has already suffered many impacts over the years, the estimates should be the lowest ones. Therefore, we consider adopting for our analysis the territory of a mature pair of Harpy Eagles ranging between 79–100 km^2, following the estimates of Thiollay (1989) and the lowest value of pairs per area of Álvarez-Cordero (1996).

4.3 – RESULTS

New information on records

We report new information on three records of the Harpy Eagle for Turvo State Park, made after the rediscovery announced by Meller & Guadagnin (2016). These records were shared mostly in citizen science platforms, and lacked details such as coordinates, circumstances of the record and age or sex of the eagle. We also report an historical and unknown record, documented by an old picture, for Riozinho municipality, representing a new locality of occurrence for this state. It is also worthy mention the lack of records during most of the field activity through the 14 years of observations in Turvo State Park, suggesting its great rarity.

The first of the new records was made in Turvo State Park by DAM and AC de Siqueira, who saw an adult Harpy Eagle on June 26’ 2016. The eagle was flying slowly over the canopy and then it suddenly perched on an *Apuleia leiocarpa* (Vogel) tree aside the road that leads to Yucumã Falls, in a place known as "Cascalho" (27°11'26"S; 53°50'39"W). At the time the eagle perched, some Black-horned Capuchins (*Sapajus nigritus* Goldfuss, 1800) started to produce aggressive sounds and the eagle soon after flew away. By the size of the eagle, and particularly of its tarsus, we suspect it was a male. Soon the eagle flew off and was not seen anymore. This place is not so far (1,7 km) from another record divulged before by Meller and Guadagnin (2016). This record was mentioned as a footnote by Meller & Guadagnin (2016), but as it lacked the photo and more specific circumstances, we included it here completely (Figure 1A).

The second record is of an immature Harpy Eagle recorded by V Klein an CN Kuhn in the road that leads to Yucumã Falls, about the km 11 (27°8'50"S; 53°51'59"W) (CN Kuhn, pers. comm.). The record was made on June 8’ 2018 and shared in the WikiAves citizen science platform (Kuhn 2018). The eagle was again perched in an *Apuleia leiocarpa* tree. A week later, DAM, TMS and CN Kuhn revisited this place, but there was no signal of the eagle in the area. By the size of its tarsus, this eagle was probably a female. According to Ferguson-Lees & Christie (2001), the black mottled on the upper wings covert, the face rather white and the crest already black-tipped, suggests it is a third-year immature (Figure 1B).

The third record is a recording made by A Mulbeier at Turvo State Park in January 30’ 2021 near the recreational area of the Yucumã Falls (27°8'24"S, 53°52'55"W) (A Mulbeier, pers. comm.). The recording was shared in the WikiAves citizen science platform (Mulbeier 2021) and shows what seems to be a begging voice of a Harpy Eagle (Figure 1C). This record is not so far (1,7 km) from the immature one exposed before and even closer (1,1 km) to an observation of the Harpy Eagle made by an Argentinean ranger in Yucumã Waterfalls (Meller & Guadagnin 2016).

The last record we report here is an historical record represented by an adult Harpy Eagle shot in the municipality of Riozinho in the 1950’s. This record is documented by an old picture were three dwellers exhibits the eagle (Figure 1D). The image shows an impressive large eagle, which we identify as a female. The picture was sent to us by M Torres, which received it from the grandson of one of those dwellers, explaining the context of the record (M Torres, pers. comm.). This is the first mention of Harpy Eagle to the Ombrophilous Forest of Rio Grande do Sul.

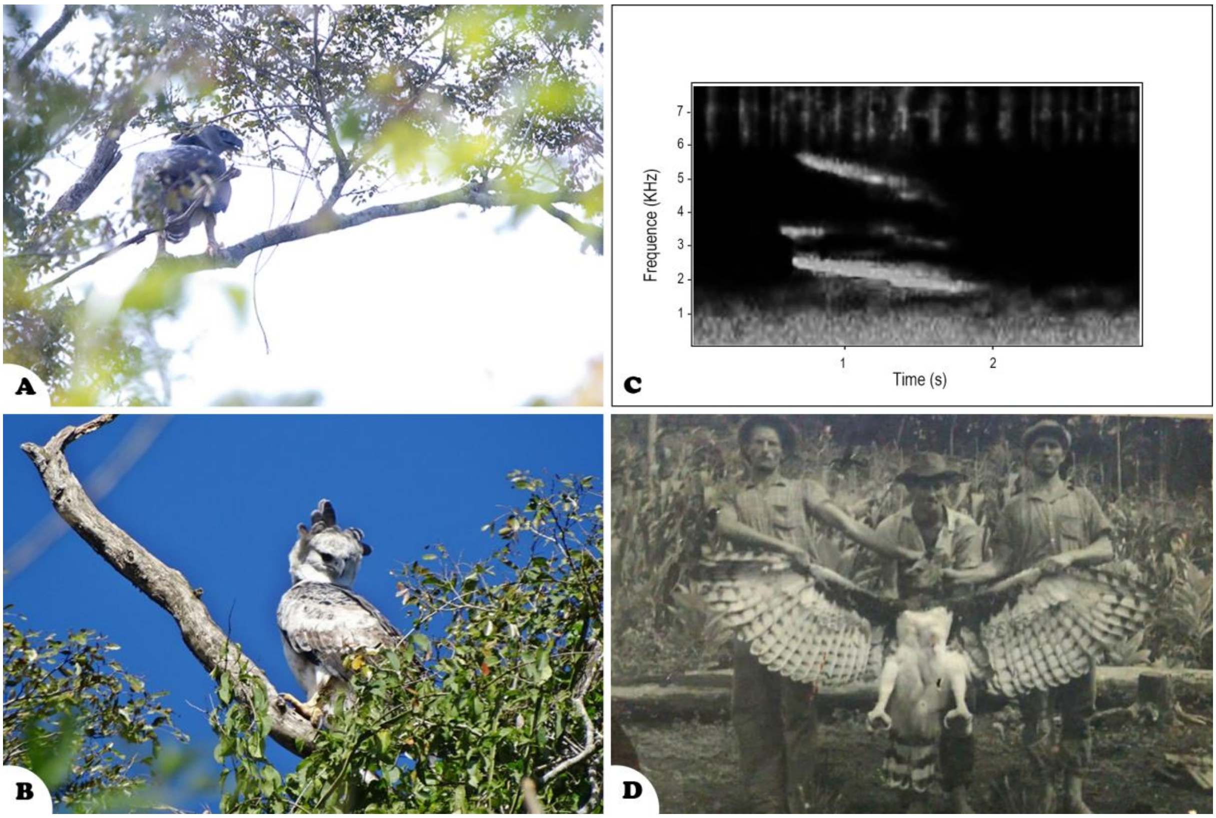

Figure 1a-d. Previously unpublished records of Harpy Eagle (*Harpia harpyja*) in Rio Grande do Sul, Brazil. (A) Adult (probable male) Harpy Eagle photographed by DAM on June 26' 2016 in Turvo State Park; (B) Immature (probable female) Harpy Eagle photographed by CN Kuhn on June 8' 2018 in Turvo State Park. (C) Sonogram of a probable Harpy Eagle on January 30' 2021 in Turvo State Park recorded by A Mulbeier; (D) Adult (probable female) killed by dwellers in Riozinho municipality in the 1950's (picture given by M Torres).

Harpy Eagle occurrence in southern Atlantic Forest

In the southern range of Atlantic Forest, records of Harpy Eagle are scarce and mostly historical, with few recent observations. We gathered a total of 49 records plus 5 nests mentioned for the southern Atlantic Forest (Table 1). Seven historical records were reported in the literature for Rio Grande do Sul (Bencke et al. 2003, Favretto 2008, Meller & Guadagnin 2016), while we found four recent records (Meller & Guadagnin 2016, this Study). For Santa Catarina there are seven historical records and none recent (Albuquerque 1995, Rosário 1996, 2020, Preuss & Steffens 2019). And for Paraná there are six historical (Scherer-Neto & Straube 1995, Mikich & Bérnils 2004, Banhos 2009) and three recent records (Scherer-Neto & Ribas 2004, Banhos 2009). Most of the records in the southern Atlantic Forest comes from Misiones, Argentina, where Chebez & Casañas (2000) listed 13 localities of historical occurrence, to which we add other four records reported in recent years, including a nest (Bodrati et al. 2005, Anfuso et al. 2008, Chebez & Anfuso 2008, Bodrati 2016). In Paraguay, there are four records, none of them made after year 2000 (Madroño-Nieto & Esquivel 1995, Morlis et al 1995, Lowen et al. 1996, Brooks 1998).

Table 1. Records and nests of Harpy Eagle (*Harpia harpyja*) in the southern range of Atlantic Forest according to literature reports, museum specimens and online records. *References are mentioned in footer, in chronological order for each state/province.

State/Province	*Records*	*Nests*	*References for records***
Rio Grande do Sul, Brazil	11	–	a1, a2, a3, a4
Santa Catarina, Brazil	7	–	b1, b2, b3, b4
Paraná, Brazil	10	–	c1, c2, c3, c4, c5
Misiones, Argentina	17	5	d1, d2, d3, d4, d5, d6, d7, d8, d9, d10
Canindeyu, Paraguay	2	–	e1, e2
Alto Parana, Paraguay	1	–	e3
Itapua, Paraguay	1	–	e4
Total	**49**	**5**	

*Brazil (Rio Grande do Sul): (a1) Bencke et al. (2003), (a2) Favretto (2008), (a3) Meller & Guadagnin (2016), (a4) this Study; (Santa Catarina): (b1) Albuquerque (1995), (b2) Rosário (1996), (b3) Rosário 2020, (b4) Preuss & Steffens (2019); (Paraná): (c1) Scherer-Neto & Straube (1995), (c2) Mikich & Bérnils (2004), (c3) Scherer-Neto & Ribas (2004), (c4) Banhos (2009), (c5) Hamada (2020); Argentina (Misiones): (d1) Bertoni (1913), (d2) Foerster (1972), (d3) Chebez et al. (1989), (d4) Chebez (1992), (d5) De Lucca (1996), (d6) Chebez & Casañas (2000), (d7) Bodrati et al. (2005), (d8) Anfuso et al. (2008), (d9) Chebez & Anfuso (2008), (d10) Bodrati (2016); Paraguay (Canindeyu): (e1) Madroño-Nieto & Esquivel (1995), (e2) Brooks (1998); (Alto Parana) (e3) Morlis et al (1995), (e4) Lowen et al. (1996).

An overview of the Harpy Eagle in the Green Corridor

In the extent of the Green Corridor there are the records from Misiones (including five nests), the ones from Turvo State Park, and one from Céu Azul, municipality that harbors great part of Iguaçu National Park (D'Amico et al. 2018). Such records indicate the likely occurrence of the Harpy Eagle in 11 protected areas in the Green Corridor, which together comprehend an area of more than 600 thousand hectares (Figure 2).

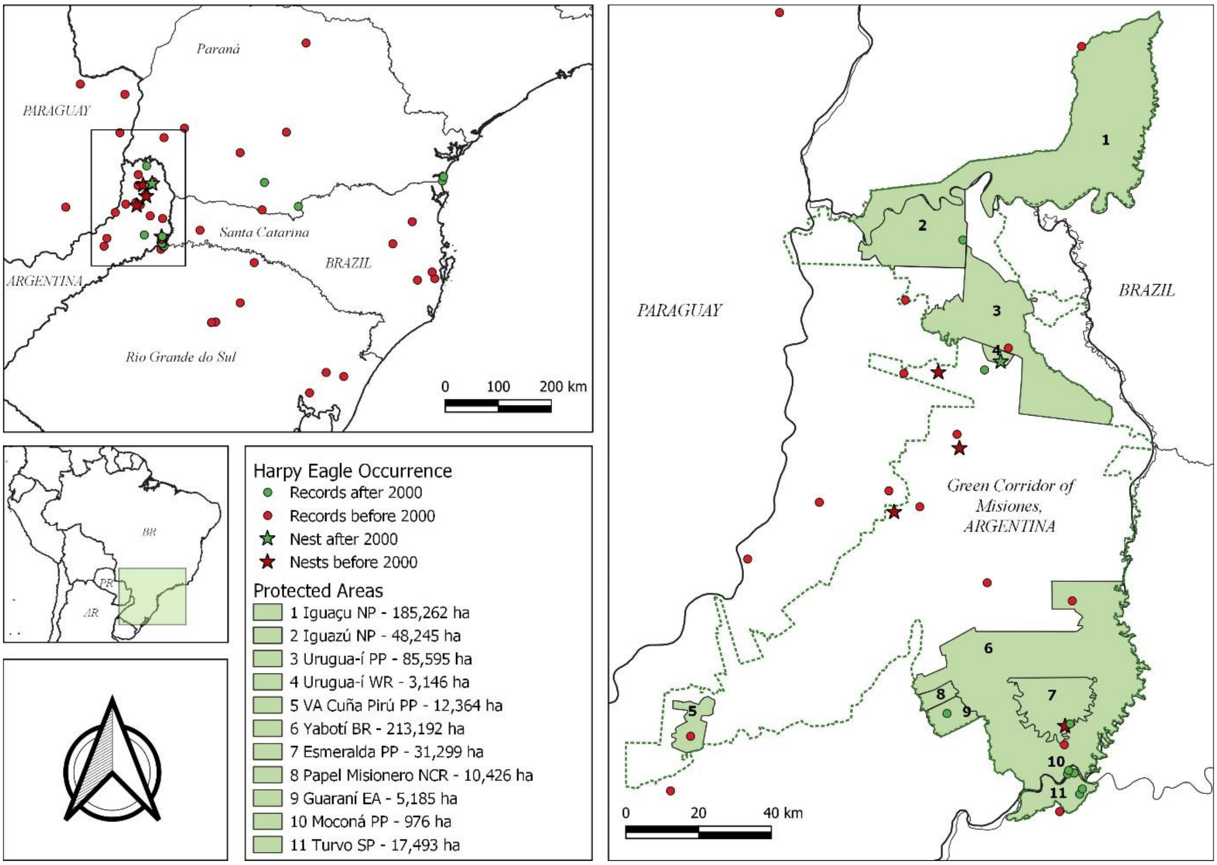

Figure 2. Records of the Harpy Eagle (*Harpia harpyja*) in southern Atlantic Forest. The Green Corridor of Argentina and Brazil are bound by dashed line. Green polygons represent protected areas in which the Harpy Eagle has been recorded or are much likely to occur.

All over their occurrence, the Harpy Eagle is mentioned to be rare and occupy large tracks of well-preserved forest (Birdlife International 2021). Misiones, Argentina, concentrates most of the records and includes the only nests ever discovered in southern Atlantic Forest. Such nests proportioned valuable information about the breeding sites, such as the species of trees used to build the nest, plus some diet items as well (Chebez & Anfuso 2008). All these nests were situated in the limits of the Green Corridor, including many protected areas. If we gathered all the protected areas with occurrence of Harpy Eagle through history in this region, the amount of area would be 613,183 ha, and that would generate a range of 61–77 pairs when adopting an area of life of 79–100 km^2 for a mature pair [according to Thiollay (1989) and Álvarez-Cordero (1996)]. On the other hand, in recent years the Harpy Eagle has been recorded in 106,344 ha of protected areas of the Green Corridor, which would generate a range of 10–13 mature pairs. As the protected areas are somewhat original in their composition, the real number would be a range between the extremes, ranging from 10–77 pairs, and 43 as a mean.

Although the population analysis is quite general, the lack of data does not allow us to go into more detail, but the analysis still provides a safe scenario of the range of mature pairs likely to be inhabiting the Green Corridor nowadays. We discuss bellow whether the real number of pairs is lower or higher that the mean estimated by us.

4.4 – DISCUSSION

From the current records made in Turvo State Park, we can assume that at least three different specimens of Harpy Eagle were seeing in the area in the last few years, including a female in 2015, a male in 2016 and an immature in 2018 (Meller & Guadagnin 2016, this Study). The records of adults and juvenile indicate that the species is still breeding in the southern portion of the Green Corridor, even likely in Turvo State Park, where the records were made. These are important observations, because the last nest found in Misiones, Argentina, was about 15 years ago (Anfuso et al. 2008).

Harpy Eagles nesting in Turvo State Park were already suggested by the finding of a supposedly nest inside the park in the 1980's and also by the photograph of a juvenile eagle shot in the surroundings of the park in the 1970's (Meller & Guadagnin 2016). However, as this new record represents a third-year immature, this could be an eagle in its dispersal phase, as it is a common behavior in many large eagles (Brown & Amadon 1968, Ferguson-Lees & Christie 2001). It is plausible that this eagle has come from Yabotí Biosphere Reserve (Misiones), where the area of forest is much larger. On the other hand, Turvo State Park has no selective logging, in contrast to Yabotí Biosphere Reserve, which could make its sites more appropriated for Harpy Eagles to nest (Meller & Guadagnin 2016).

The record of an adult Harpy Eagle following some Black-horned Capuchins suggests this could be an important prey in the diet of the species in Turvo State Park. In fact, remains of Capuchin Monkeys have been found in the vicinity of a nest in Misiones (Anfuso et al. 2008). In Turvo State Park, Capuchin Monkeys are the most common non-human primate; in its turn, the Brown Howler Monkey (*Alouatta guariba* Humboldt, 1812) is much rarer (Silva et al. 2005, Kasper et al. 2007). Due to the recent outbreaks of yellow fever in Misiones, the Brown Howler Monkey population has decreased close to extinction in Argentina (Holzmann et al. 2010). The situation in Turvo State Park seems similar and the species has been rarely seen or heard in the last thirteen years (DAM, pers. obs.). Whether this affects Harpy Eagle's diet is still unknown, but Howlers Monkeys are frequently mentioned as a prey for the species in Amazon (Aguiar-Silva et al. 2014, 2015). There could be some conservation actions plausible to help recover this decline of Brown Howler Monkeys, such as reintroduction and vaccination against yellow fever.

In a future perspective, the connection established through the Green Corridor is really hopeful for Harpy Eagle's population. Together, this corridor protects about almost a million ha of Interior Atlantic Forest in Argentina and Brazil (Pardo et al. 2017). The Harpy Eagle's population in the Green Corridor, however, could be lower than the suggested by the area of habitat preserved. For a comparative purpose, another top predator of this environment, the jaguars (*Panthera onca* Linnaeus, 1758), has their population estimated in 86 individuals inhabiting the Green Corridor (Paviolo et al. 2008, Paviolo et al. 2016). Some authors consider that the Harpy Eagles have even greater requirements of habitat than jaguars, what would reveal an even more critical situation for the eagle in this region (Anfuso et al. 2008).

In fact, there are some issues that draw a long term dramatic scenario to the Green Corridor conservancy. For instance, Yabotí Biosphere Reserve, one of the greatest protected areas of the Green Corridor, despite of its protection against loss of habitat by agriculture and livestock, allows selective logging in most of its area (Bodrati et al. 2005, Anfuso et al. 2008). This is a big concern for a species that nests in the biggest trees of the forest, which are the ones explored by logging industry. Although Harpy Eagles have been recorded inhabiting forests with some level of disturbance (Álvarez-Cordero 1996), it is also known that this kind of management reduces the number of available trees for eagles to nest (Luz et al. 2010). So, their numbers can be lower than the ones expected in a primary, undisturbed forest.

Many other areas – including national, provincial and state parks in Misiones region – are fully protected. However, for species that need wide uninterrupted areas to keep a viable population, fragmentation is a real problem. In the extent of the Green Corridor, there are some bottlenecks in which the connection is weaker or than threatened by development projects. As Brazilian borders examples, we have the imminent Panambi's Hydroelectric project, which can prejudice the connection between Turvo State Park and Yabotí Biosphere Reserve (Meller & Guadagnin 2016). In the northernmost part of the Green Corridor, the project of reopening the Colono's Road, inside Iguaçu National Park, can fragment and cause damage to an important area of the Brazilian park (D'Amico et al. 2018).

Pardo et al. (2017) have made a detailed analysis over the main corridors for jaguars throughout the Green Corridor of Argentina. These authors identified five main areas where the connection is fragile and represents future challenges for the conservation of these large cats. If these corridors are especially important for large mammals such as jaguars, tapirs and peccaries (Paviolo et al. 2008, Pardo et al. 2017), it is likely to be for the Harpy Eagles as well. Most relevant for Harpy Eagles must be the ones that link the large blocks from the central-east, represented mainly by the Yabotí Biosphere Reserve, with the ones from the north, represented by Urugua-í Provincial Park and Iguazú National Park [see Pardo et al. (2017) for more details].

Hunting is always a threat for Harpy Eagles (BirdLife International 2021, Miranda et al. 2021) and it is known to occur all over the extent of the Green Corridor, even in protected areas, such as Turvo State Park, Yabotí Biosphere Reserve, Urugua-í Provincial Park and Iguaçu National Park (Silva et al. 2005, Paviolo et al. 2008, D'Amico et al. 2018). In Turvo State Park, for instance, an event of a Harpy Eagle being killed by dwellers in the past was already reported (Meller & Guadagnin 2016).

To conclude, it is possible that many of these factors may adjust the Harpy Eagle's numbers downward, and the estimate made by us must be viewed as a tentative of pairs inhabiting this region. To detect and protect breeding sites is one of the challenges actions that would help maintain viable populations of this threatened eagle in the Green Corridor of Brazil and Argentina in the future.

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4.6 – REFERENCES

Aguiar-Silva FH, TM Sanaiotti, O Jaudoin, AC Srbek-Araujo, G Siqueira & A Banhos. 2012 Harpy Eagle sightings, traces and nesting records at the "Reserva Natural Vale", a Brazilian Atlantic Forest remnant in Espírito Santo, Brazil. *Revista Brasileira de Ornitologia.* (2):148-155.

Aguiar-Silva FH, TM Sanaiotti & BB Luz. 2014. Food habits of the Harpy Eagle, a top predator from the Amazonian rainforest canopy. *Journal of Raptor Research* 48(1):24-35.

Aguiar-Silva FH, TG Junqueira, TM Sanaiotti, VY Guimarães, PVC Mathias, & CV Mendonça. 2015. Resource availability and diet in Harpy Eagle breeding territories on the Xingu River, Brazilian Amazon. *Brazilian Journal of Biology* 75(3):181-189.

Albuquerque JLB. 1995. Observations of rare raptors in Southern Atlantic Rainforest of Brazil. *Journal of Field Ornithology*, 66: 363–369.

Álvarez-Cordero E. 1996. *Biology and conservation of the Harpy Eagle in Venezuela and Panamá*. Tese de doutorado. University of Florida, Gainesville.

Anfuso J, MVG Suarez & JC Chebez. 2008. Nuevo registro de nidificación de la harpía (*Harpia harpyja*) en la provincia de Misiones, Argentina y consideraciones sobre su conservación. *Nótulas Faunísticas*, 21: 1–13.

Banhos A. 2009. *Genética, distribuição e conservação do gavião-real (Harpia harpyja) no Brasil.* Tese de doutorado. Instituto Nacional de Pesquisas da Amazônia, Manaus.

Banhos A, TM Sanaiotti, FH Aguiar-Silva, FD Martins, BB da Luz, AS Carvalho & CM Ruiz. 2018. *Harpia harpyja* (Linnaeus, 1758), p. 124–128. In: Instituto Chico Mendes de Conservação da Biodiversidade (Org.). *Livro Vermelho da Fauna Brasileira Ameaçada* *de Extinção: Volume III - Aves*. ICMBio, Brasília.

Bencke GA, CS Fontana, RA Dias, GN Maurício & JKF Mähler-Jr. 2003. Aves, p. 189–479. In: Fontana CS, GA Bencke & RE Reis (eds.). *Livro vermelho da fauna ameaçada de extinção no Rio Grande do Sul*. EDIPUCRS, Porto Alegre.

BirdLife International. 2021. *Harpia harpyja*. The IUCN Red List of Threatened Species 2021: e.T22695998A197957213. Accessed on 21 December 2021.

Bodrati A. 2016. Harpía (*Harpia harpyja*) en la Reserva de Biosfera Yaboty, Misiones, Argentina. *Nuestras Aves,* 61: 26.

Bodrati A, K Cockle, V Matuchaka & C Maders. 2005. Reserva de la Biosfera Yabotí, p. 300-302. Em Di Giacomo AS (ed). *Áreas importantes para la conservación de las aves en Argentina. Sitios prioritarios para la conservación de la biodiversidad*. Temas de Naturaleza y Conservación 5. Aves Argentinas/Asociación Ornitológica del Plata, Buenos Aires.

Brooks TM. 1998. A record of a Harpy Eagle from Eastern Paraguay. *The Journal of Raptor Research.* 32(4): 318–321.

Brown L & D Amadon. 1968. *Eagles, hawks and falcons of the world*. Country Life Books, London.

Chebez JC. 1992. Notas sobre algunas aves poco conocidas o amenazadas de Misiones (Argentina). *Aprona, Bol. Cient.* (21): 12–30.

Chebez JC & H Casañas. 2000. *Áreas Importantes para la Conservación de la Biodiversidad de la Provincia de Misiones, Argentina. Fauna Vertebrada*. Inf. Inéd., FVSA, Puerto Iguazú.

Chebez JC & J Anfuso. 2008. Harpia, p. 197–202. In: Chebez JC. *Los que se van. Fauna argentina amenazada. Tomo 2*. Albatros, Buenos Aires.

Chebez JC, M Silva-Croome, A Serret & A Taborda. 1989. La nidificación de la harpía (*Harpia harpyja*) en Argentina. *El Hornero,* 13: 155–158.

CONSEMA – Conselho Estadual do Meio Ambiente. 2011. *Resolução nº02/2011—Reconhece a lista oficial de espécies da fauna ameaçadas de extinção no Estado de Santa Catarina e dá outras providências*. CONSEMA/ SDS, Florianópolis, Santa Catarina, Brazil.

D'Amico AR, CM Amato, CM Parola, IC Baptiston, LFP Moraes & MC Xavier. 2018. Plano de manejo do Parque Nacional do Iguaçu. Instituo Chico Mendes de Conservação da

Biodiversidade, Brasília.

De Lucca ER. 1996. Observaciones de un nido exitoso de Harpía (*Harpia harpyja*) en Argentina. *El Hornero* 14(3): 70–72.

Del Hoyo J, A Elliot & J Sargatal. 1994. *Handbook of the birds of the world. Volume 2. New World Vultures to Guineafowl.* Lynx Edicions, Barcelona.

Favretto MA. 2008. As aves do Museu Frei Miguel, Luzerna, Santa Catarina. *Atualidades Ornitológicas*, 146: 43–44.

Ferguson-Lees J & DA Christie. 2001. *Raptors of the world.* Houghton Mifflin Company, New York.

Foerster J (1972) Notas biológicas sobre *Harpia harpyja* (Linne) (Aves: Falconiformes). *Neotrópica*, 18(57): 146–148.

Hamada, FH (2020) [WA3757314, Harpia harpyja (Linnaeus, 1758)]. Wiki Aves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/3757314> Acesso em: 25 Nov 2021.

Holzmann I, I Agostini, JI Areta, H Ferreyra, P Beldomenico & MS Di Bitetti. 2010. Impact of yellow fever outbreaks on two howler monkey species (*Alouatta guariba clamitans* and *A. caraya*) in Misiones, Argentina. *American Journal of Primatology,* 71: 1–6.

Kuhn CN. 2018. [WA2997981, *Harpia harpyja* (Linnaeus, 1758)]. Wiki Aves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/2997981> Accessed in 09 May 2019.

Kasper CB, FD Mazim, JBG Soares TG Oliveira & ME Fabián. 2007. Composição e abundância relativa dos mamíferos de médio e grande porte no Parque Estadual do Turvo, Rio Grande do Sul, Brasil. *Revista Brasileira de Zoologia*, 24: 1087–1100.

Lowen JC, L Bartrina, RP Clay & A Tobias. 1996. *Biological surveys and conservation priorities in eastern Paraguay*. CSB Publications, Cambridge.

Luz BB, FH Aguiar-Silva & TM Sanaiotti. 2010. Árvores utilizadas como local de reprodução de harpias são alvo de exploração madeireira. *Resumos 61º Congresso Nacional de Botânica*. INPA, Manaus.

MADES – Ministerio del Ambiente y Desarrollo Sostenible. 2019. *Resolución N° 254/19 por la cual se actualiza el listado de las especies protegidas de la vida silvestre de la clase Aves*. MADES, Asunción, Paraguay.

Madroño-Nieto A & EZ Esquivel. 1995. Reserva natural del Bosque Mbaracayú: su importancia en la conservación de las aves amenazadas, cuasi-amenazadas y endémicas del Bosque Atlántico. *Cotinga* 4: 52–57.

Marchiori JNC. 2001. *Fitogeografia do Rio Grande do Sul: enfoque histórico e sistemas de classificação*. Edições EST, Porto Alegre.

Meller DA. 2011. *Aves de Rapina do Parque Estadual do Turvo, Rio Grande do Sul, Brasil*. Umpublished monography, Universidade regional Integrada do Alto Uruguai e das Missões – URI – Campus Santo Ângelo, Santo Ângelo, Rio Grande do Sul, Brazil.

Meller DA. 2014. *Aves de Rapina da Mata do Alto Uruguai*. Umpublished masters dissertation, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil.

Meller DA & DL Guadagnin. 2016. Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil. *Revista Brasileira de Ornitologia* 24(1): 53–57.

Mikich SB & RS Berníls. 2004. *Livro Vermelho da Fauna Ameaçada no Estado do Paraná*. Governo do Estado do Paraná / SEMA / IAP, Curitiba.

Miranda EBP, JFS Menezes, CC Farias, C Munn & CA Peres. 2019. Species distribution modeling reveals strongholds and potential reintroduction areas for the world's largest eagle. *PLoS One* 14, e0216323.

Miranda EBP, AC Peres & CT Downs. 2021. Landowner perceptions of livestock predation: implications for persecution of an Amazonian apex predator. *Animal Conservation.* doi:10.1111/acv.12727

Morlis GW, AD Rodas, NP Villamayor, AC Jara, JV Humbeck & WS Avalos. 1995. Vertebrados del area de Itaipú. *Biota* 2: 1–64.

Mulbeier AF. 2021. [WA4191282, *Harpia harpyja* (Linnaeus, 1758)]. Wiki Aves - A Enciclopédia das Aves do Brasil. Disponível em: <http://www.wikiaves.com/4191282> Acessed in 12 Nov 2021.

Pardo JM, A Paviolo, S Saura & C De Angelo. 2017. Halting the isolation of jaguars: where to act locally to sustain connectivity in their southernmost population. *Animal Conservation*, 1–12.

Paviolo A, C De Angelo, Y Di Blanco & M Di Bitetti. 2008. Jaguar population decline in the Upper Parana Atlantic Forest of Argentina and Brazil. *Oryx* 42, 554–561.

Paviolo, A, C De Angelo, KMPMB Ferraz, RG Morato, JM Pardo, AC Srbek-Araujo, B Beisegel, F Lima, D Sana, M Xavier Da Silva, M Velazquez, L Cullen Jr., PG Crawshaw Jr., MLSP Jorge, PM Galetti Jr., MS Di Bitetti, RC De Paula, E Eizirik, TM Aide, MP Cruz, M Perilli, ASMC Souza, VA Quiroga, E Nakaro, F Ramirez, S Fernandez, SA Costa, EA Moraes & FCC Azevedo. 2016. A biodiversity hotspot losing its top predator: the challenge of jaguar conservation in the Atlantic Forest of South America. *Sci. Rep.* 6, 37147.

Peres CA. 1990. A Harpy Eagle successfully captures an adult male Red Howler Monkey. *Wilson Bulletin*, 102: 560–561.

Preuss JF & SR Steffens. 2019. Historical record of *Harpia harpyja* (Accipitriformes: Accipitridae) in the state of Santa Catarina, Southern Brazil. *Atualidades Ornitológicas*, 208: 23.

QGIS Development Team (2018) QGIS Geographic Information System. Available at http://www.qgis.org/ Accessed on 23 May 2019.

Rio Grande do Sul. 2014. *Lista das espécies da fauna ameaçadas de extinção no estado do Rio Grande do Sul. Instrução Normativa n° 3. Decreto No 51.797.* Diário Oficial do Estado do Rio Grande do Sul, Secretaria do Meio Ambiente, Porto Alegre.

Rosário LA. 1996. As aves em Santa Catarina: distribuição geográfica e meio ambiente. FATMA, Florianópolis.

Rosário LA. 2020. Aves de Santa Catarina: Banco de dados da avifauna catarinense. Gavião-real. In: < http://avesdesantacatarina.com.br/especies/175> Accessed on February 25 2020.

Scherer-Neto P & CF Ribas. 2004. Registro de Harpia *Harpia harpyja* no litoral sul do Brasil. *Atualidades Ornitológicas*, 122: 4–8.

Scherer-Neto P & F Straube. 1995. *Aves do Paraná: história, lista anotada e bibliografia*. Logo Press, Campo Largo.

Sick H. 1997. *Ornitologia brasileira*. 2 ed. Nova Fronteira, Rio de Janeiro.

Silva CP, JKF Mähler-Jr, SB Marcuzzo & S Ferreira. 2005. *Plano de Manejo do Parque Estadual do Turvo.* Secretaria Estadual do Meio Ambiente, Porto Alegre.

Srbek-Araujo AC & AG Chiarello. 2006. Registro recente de Harpia, *Harpia harpyja* (Linnaeus) (Aves, Accipitridae), na Mata Atlântica da Reserva Natural Vale do Rio

Doce, Linhares, EspíritoSanto e implicações para a conservação regional da espécie. *Revista Brasileira de Zoologia*, 23: 1264-1267.

Tabarelli M, LP Pinto, JMC Silva & CMR Costa. 2003. The Atlantic Forest of Brazil: endangered species and conservation planning. In: Galindo-Leal C & IG Câmara (eds.), p. 86–94. In: *The Atlantic Forest of South America: biodiversity status, trends, and outlook*. Center for Applied Biodiversity Science, Island Press, Washington DC.

Thiollay JM. 1989. Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation y*, 3: 128–137.

Vargas JJG, D Whitacre, R Mosquera, J Albuquerque, R Piana, JM Thiollay, C Márquez, JE Sánchez, M Lezama-López, S Midence, S Matola, S Aguilar, N Rettig & T Sanaiotti. 2006. Estado y distribución actual del águila arpía (*Harpia harpyja*) en Centro e Sur América. *Ornitologia Neotropical*, 17: 39–55.

Veloso HP, ALR Rangel Filho & JCA Lima. 1991. *Classificação da vegetação brasileira, adaptada a um sistema universal.* IBGE, Departamento de Recursos Naturais e Estudos Ambientais, Rio de Janeiro.

Zilio F. 2017. Breeding biology and conservation of hawk-eagles (*Spizaetus* spp.) Aves, Accipitridae) in southern Atlantic Forest, Brazil. *Iheringia, Série Zoologia*, 107: 1–14.

5 – ARTIGO III

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SHORT COMMUNICATION

The rediscovery of the Crested Eagle (*Morphnus guianensis*) in Rio Grande do Sul state, Brazil

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Abstract
The Crested Eagle (*Morphnus guianensis*) is a large raptor that inhabits the lowland forests in the Neotropical region, whose population is currently decreasing owing to habitat loss and hunting. This species has become very rare in the southern region of the Atlantic Forest and is considered locally threatened or even extinct in some localities, including Rio Grande do Sul state, in southern Brazil. There are only two historic records of this eagle in this state, represented by specimens shot in the municipalities of Igrejinha before 1885 and Santa Cruz do Sul in the 1920s. Here, we report the rediscovery of the Crested Eagle in Rio Grande do Sul on 26 August 2019, when we observed an immature Crested Eagle vocalizing while perched on a *Parapiptadenia rigida* tree inside the Turvo State Park. We also report compiled information on the occurrence of this eagle in the southern Atlantic Forest and mapped the published historical and recent records. There is little information about this eagle in the Atlantic Forest and almost no information related to diet and nesting. We recorded the first images and audio of a wild Crested Eagle in the southern Atlantic Forest. Our records suggest that this species is breeding in this region. The Turvo State Park has recent records of Harpy Eagles (*Harpia harpyja*), which could suggest that the Crested Eagle is using the park without partitioning the habitat.

Keywords Birds of prey · Conservation · Green corridor · Misiones · Raptors · Turvo State Park

The Crested Eagle *Morphnus guianensis* (Daudin, 1800) is a very large, slender eagle that inhabits the lowland forests of the Neotropical region from Guatemala and Honduras to Paraguay, northern Argentina (Misiones), and southern Brazil (Del Hoyo et al. 1994; Ferguson-Lees and Christie 2001). The Crested Eagle resembles the Harpy Eagle *Harpia harpyja* (Linnaeus, 1758), but it is smaller and much less bulky, with thinner legs and smaller feet and bills. It also does not have the Harpy Eagle's typical black markings on the chest and underwing linings. It has a characteristic small dark mask, and its crest is not divided (Brown and Amadon 1968; Ferguson-Lees and Christie 2001). There is a melanistic form in which the black markings on the ventral parts vary from barred to all black (Ferguson-Lees and Christie 2001); however, this form has never been recorded in the Atlantic Forest (Chebez and Anfuso 2008a).

The records of the Crested Eagle in the southern Atlantic Forest are few and widely scattered in both space and time (Fig. 1). There have been only two previous records in the state of Rio Grande do Sul, Brazil, and both are about a century old, represented by juvenile eagles that were shot in the municipalities of Igrejinha before 1885 (von Berlepsch and von Ihering 1885; Bencke et al. 2003), and Santa Cruz do Sul in the 1920s (Bencke 1997). In Santa Catarina state, there are two specimens that were collected in the past, one before 1926 in Joinville, held at Museu Frei Miguel, and another between 1965 and 1970 in Lontras, presently held at Universidade Federal de Santa Catarina Bird Collection

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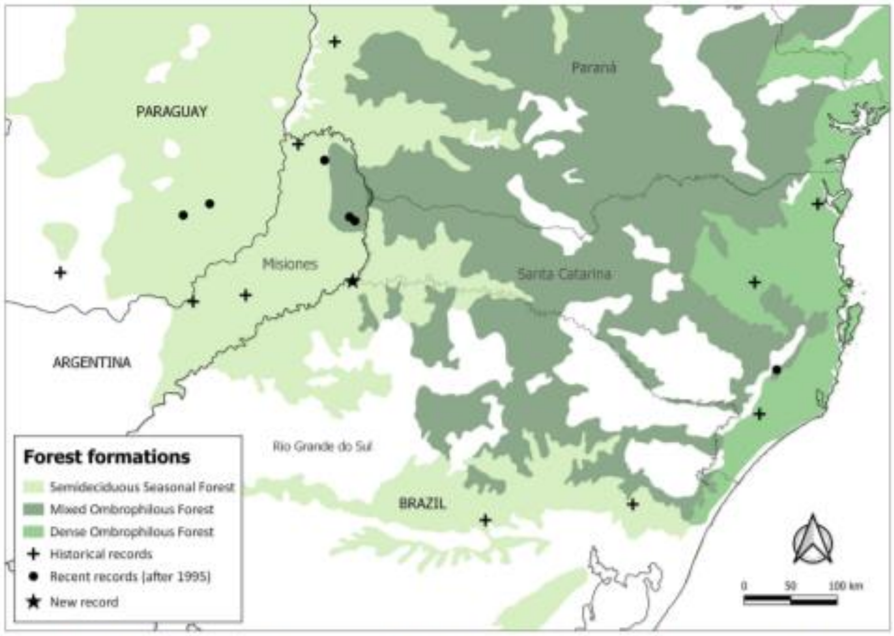

Fig. 1 Records of Crested Eagle (*Morphnus guianensis*) in southern Atlantic Forest. The star indicates rediscovery record for Rio Grande do Sul state, Brazil. Dots indicate recent records (after 1995). Crosses indicate historical records (before 1995)

(CAUFSC 362), acquired form G. Knoll collection (Favretto 2008; Gomes and Sanaiotti 2015; Müller and Vieira 2016). There are also two reports of visual observation for this state, one from Siderópolis in 1977 (Albuquerque 1983; Rosário 1996), and the other from 2005 in Aiure, Grão-Pará (Albuquerque et al. 2006). In the Paraná state, there is only one record, of a juvenile specimen collected in 1964 about 70 km north of the Iguaçu National Park, in the municipality of Pato Bragado (previously part of Marechal Cândido Rondon municipality up to 1990), held at Museu Sete Quedas (MSSQ-52 ex MSQ-196) (Mikich and Bérnils 2004; Straube and Urben-Filho 2010).

In Misiones, Argentina, there are six known records of the Crested Eagle, three of which are historical, while the other three are recent. The historical data are from Santa Ana around the end of the 19th century (Bertoni 1913; Chebez and Anfuso 2008a), Cerro Moreno in 1974 (Chebez and Anfuso 2008a), and Iguazu National Park in 1980 (Olrog 1985). The three recent records are from Urugua-í Provincial Park in 1996 (Chebez and Anfuso 2008a), El Piñalito Provincial Park in 1999 (Pearman 2001), and the surroundings of Tobuna in 2000 (Chebez and Anfuso 2008a).

There are also three confirmed records of the Crested Eagle from eastern Paraguay, including a very old one from Misiones (Chebez and Anfuso 2008a). There are two unconfirmed observations from San Rafael National Park (Madroño-Nieto et al. 1997), which were verified later by the capture of an adult Crested Eagle in the same area. This specimen survived at Itaipu Zoo until 2002 and is presently held at Museu de Historia Natural da Itaipu Binacional (MHNIB 872). There is also one observation from Colonia Aurora in 2002 (Del Castillo and Clay 2004; Chebez and Anfuso 2008a).

The records from Misiones, Argentina, led Belton (1994) and Bencke et al. (2003) to believe that the Crested Eagle may still exist in the Turvo State Park, in the state of Rio Grande do Sul, despite it being considered extinct in this state (Belton 1994; Bencke et al. 2003; Rio Grande do Sul 2014). The species is also considered extinct in Paraná (Mikich and Bérnils 2004) and "critically endangered" in Santa Catarina (CONSEMA 2011) states. The species is classified as "vulnerable" in Brazil (Sanaiotti et al. 2018) and "endangered" in Argentina and Paraguay (Chebez and Anfuso 2008a; MADES 2019). Globally, the Crested Eagle is listed as "near threatened," with a decreasing population owing to habitat loss and hunting (BirdLife International 2017).

We rediscovered the Crested Eagle in Rio Grande do Sul on 26 August 2019, after D.A.M., A.F., and R.T. Araújo observed a Crested Eagle perched on a *Parapiptadenia rigida* (Benth.) tree at 08:00 h, inside the Turvo State Park (Fig. 2a).

The observation occurred in an area along the road that leads to Yucumã Falls, about 10 km from the entrance of the park (27°9′20″S; 53°51′56″W). The Crested Eagle continually vocalized and was mobbed by a group of plush-crested jays *Cyanocorax chrysops* (Vieillot, 1818). We observed the Crested Eagle for 4 min, after which it flew away into a valley and has not been observed since.

Based on the plumage characteristics outlined in Ferguson-Lees and Christie (2001), the Crested Eagle that we observed in the Turvo State Park could be classified as a third-year pale-morph. The individual displayed some gray mottling on the upper wing coverts and a white abdomen without barring (Fig. 2a). To the best of our knowledge, this is the first picture ever taken in the wild of a Crested Eagle in the southern Atlantic Forest. We recorded the audio of this individual as it vocalized, which, to our knowledge, is also the first recording of Crested Eagle vocalization ever made in this biome. The audio recording was deposited in the WikiAves catalog using the code WA3511853 (Meller 2019).

The Crested Eagle is very rare in the Atlantic Forest, and there is almost no information related to its breeding and

Fig. 2 **a** Immature Crested Eagle (*Morphnus guianensis*) recorded in Turvo State Park, Rio Grande do Sul state, Brazil, on 26 August 2019. Photo: DA Meller. **b** Crowned Eagle (*Urubitinga coronata*) specimen collected in 1885 by H. von Ihering in São Lourenço do Sul, Rio Grande do Sul, Brazil, and deposited at the Senckenberg Museum, Frankfurt, Germany (number 13848). Photo: G. Mayr

feeding habits there. Rather, most of the knowledge of the Crested Eagle breeding and feeding is based on nests in Amazonia and Central America (Bierregaard-Jr 1984; Whitacre et al. 2012; Gomes 2014). Unlike many other large eagles, the Crested Eagle does not choose emergent trees to nest and instead opts for those in the sub-canopy (Whitacre et al. 2012; Gomes 2014) where it can be difficult to locate nests, as they tend to be much less visible. There are no records of Crested Eagle nests in the Atlantic Forest (Gomes and Sanaiotti 2015), but our observation of an immature Crested Eagle suggests that the species is breeding in the region of the Turvo State Park. Bencke et al. (2003) also suggested that in the past the species bred in other areas of Rio Grande do Sul, as the two historical records from this state were of juvenile eagles.

As regards the old specimens from Rio Grande do Sul, only the bird from Santa Cruz do Sul is now known to be preserved, placed at the museum of Mauá school, in that city (Bencke 1997). The record from Igrejinha, reported by von Berlepsch and von Ihering (1885), was presumed to be in the Senckenberg Museum, in Frankfurt, Germany, among the specimens collected by H. von Ihering in Rio Grande do Sul, which were part of H. von Berlepsch collection (Naumberg 1931). In fact, there is a specimen identified as *M. guianensis* at the Senckenberg Museum, collected by H. von Ihering in 1885, which was presumed to be the one from Igrejinha, but in its tag it is mentioned to be from the municipality of São Lourenço do Sul. However, in a recent consultation to the museum curator, we discovered that this specimen (catalogued by the number 13848) has been wrongly identified, as proved by a picture sent to us (G. Mayr, in litt.). The specimen, composed by skull and tarsus, both with skin, reveled to be an *Urubitinga coronata* (Vieillot, 1817), which, among other features, was recognized by the yellow cere in the basis of its prominent bill (Fig. 2b). In *M. guianensis*, the cere is dark (Ferguson-Lees and Christie 2001). So, the specimen collected in Igrejinha has its whereabouts now unknown. Misidentification of juvenile *U. coronata* by another large eagle, *H. harpyja*, has been reported previously for a Brazilian museum (Banhos and Sanaiotti 2011).

The Crested Eagle observed at the Turvo State Park was in an area close to a valley, near the location of some recent records of Harpy Eagles reported by Meller and Guadagnin (2016) in this park. In Misiones, Argentina, there are some records indicating that Crested Eagles prefer the dense forests of river valleys at lower altitudes, rather than mountainous areas, which the Harpy Eagle prefers (Chebez and Anfuso 2008a, 2008b). Because valleys at lower altitudes are the mostly affected areas of Misiones, the Crested Eagle conservation status in Argentina is considered more critical than that of the Harpy Eagle (Chebez and Anfuso 2008a). However, some records of the Crested Eagle in the mountainous areas of Argentina and Paraguay call this partition of habitat further into question (see Chebez and Anfuso 2008a). The overlap of territories between these two large eagles has also been confirmed in the Amazon Forest, both species inhabiting and nesting at the same portions of forest (Sanaiotti et al. 2015). Our data also suggest that these species cohabit.

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References

Albuquerque JLB (1983) Sobre la presencia de *Harpyhaliaetus coronatus* y *Morphnus guianensis* [sic] en el sudeste de Brasil y recomendaciones para la conservacion de las especies mediante el mantenimiento de su medio ambiente natural. Hornero 12:70–73

Albuquerque JLB, Ghizoni-Jr IR, Silva ES, Trainini G, Franz I, Barcellos A, Hassdenteufel CB, Arend FL, Martins-Ferreira C (2006) Águia-cinzenta (*Harpyhaliaetus coronatus*) e o Gavião-real-falso (*Morphnus guianensis*) em Santa Catarina e Rio Grande do Sul: prioridades e desafios para sua conservação. Rev Bras Ornitol 14: 411–415

Banhos A, Sanaiotti TM (2011) Registro histórico de nidificação de *Urubutinga coronata* em Santa Teresa, Espirito Santo, Brasil. Rev Bras Ornitol 19:85–87

Belton W (1994) Aves do Rio Grande do Sul: distribuição e biologia. Unisinos, São Leopoldo

Bencke GA (1997) Sobre a coleção de aves do Museu do Colégio Mauá, Santa Cruz do Sul (RS). Biociências 5:143–164

Bencke GA, Fontana CS, Dias RA, Mauricio GN, Mähler-Jr JKF (2003) Aves. In: Fontana CS, Bencke GA, Reis RE (eds) Livro vermelho da fauna ameaçada de extinção no Rio Grande do Sul. EDIPUCRS, Porto Alegre, pp 189–479

Bertoni AW (1913) Contribución para un catálogo de aves argentinas. An Soc Cient Argent 75:64–102

Bierregaard-Jr RO (1984) Observations of the nesting biology of the Guiana Crested Eagle (*Morphnus guianensis*). Wilson Bull 96:1–5

BirdLife International (2017) *Morphnus guianensis*. The IUCN red list of threatened species 2017: e.T22695991A118209977. 10.2305/IUCN.UK.2017-3.RLTS.T22695991A118209977.en. Accessed 07 Jul 2020

Brown L, Amadon D (1968) Eagles, hawks and falcons of the world. Country Life Books, London

Chebez JC, Anfuso J (2008a) Águila Monera. In: Chebez JC (ed) Los que se van. Fauna argentina amenazada, Tomo, vol 2. Albatros, Buenos Aires, pp 192–196

Chebez JC, Anfuso J (2008b) Harpia. In: Chebez JC (ed) Los que se van. Fauna argentina amenazada, Tomo, vol 2. Albatros, Buenos Aires, pp 197–202

CONSEMA – Conselho Estadual do Meio Ambiente (2011) Resolução No. 02/2011—Reconhece a lista oficial de espécies da fauna ameaçadas de extinção no Estado de Santa Catarina e dá outras providências. CONSEMA/ SDS, Florianópolis, Santa Catarina, Brazil

Del Castillo H, Clay RP (2004) Annotated checklist of the birds of Paraguay. Asociación Guyra Paraguay, Asunción, Paraguay

Del Hoyo J, Elliot A, Sargatal J (1994) Handbook of the birds of the world, vol 2. New World vultures to guineafowl, Lynx Editions, Barcelona

Favretto MA (2008) As aves do Museu Frei Miguel, Luzerna, Santa Catarina. Atual Ornitol 146:43–44

Ferguson-Lees J, Christie DA (2001) Raptors of the world. Houghton Mifflin Company, New York

Gomes FBR (2014) Distribuição e ecologia do Uiraçu-falso (*Morphnus guianensis*, Daudin, 1800). Doctoral Thesis, Instituto Nacional de Pesquisas da Amazônia – INPA, Manaus

Gomes FBR, Sanaiotti TM (2015) A review of the distribution of the Crested Eagle, *Morphnus guianensis* (Daudin, 1800) (Accipitridae: Harpiinae), including range extensions. Rev Bras Ornitol 23:36–63. https://doi.org/10.1007/BF03544289

MADES – Ministerio del Ambiente y Desarrollo Sostenible (2019) Resolución No. 254/19 por la cual se actualiza el listado de las especies protegidas de la vida silvestre de la clase Aves. MADES, Asunción, Paraguay

Madroño-Nieto A, Clay RP, Robbins MB, Rice NH, Faucett RC, Lowen JC (1997) An avifaunal survey of the vanishing interior Atlantic Forest of San Rafael National Park, Departments Itapúa/Caazapá, Paraguay. Cotinga 7:45–53

Meller DA (2019) [WA3511853, *Morphnus guianensis* (Daudin, 1800)]. WikiAves - A enciclopédia das aves do Brasil. http://www.wikiaves.com/3511853. Accessed 07 Jul 2020

Meller DA, Guadagnin DL (2016) Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil. Rev Bras Ornitol 24:53–57. https://doi.org/10.1007/BF03544329

Mikich SB, Bérnils RS (2004) Livro vermelho da fauna ameaçada no estado do Paraná. Governo do Estado do Paraná/SEMA/IAP, Curitiba

Müller IH, Vieira BP (2016) Estado de conservação dos espécimes da coleção de aves da Universidade Federal de Santa Catarina. Atual Ornitol 194:52–74

Naumberg EMB (1931) The Senckenberg Museum, Frankfort-on-main, Germany. Auk 48:379–384. https://doi.org/10.2307/4076482

Olrog CC (1985) Status of wet forest raptors in northern Argentina. In Conservation studies on raptors, Newton I, Chancellor RD (eds). ICBP/Paston Press, Technical Publication 5, Norwich, pp 191–197

Pearman M (2001) Notes and range extensions of some poorly known birds of northern Argentina. Cotinga 16:76–80

Rio Grande do Sul (2014) Lista das espécies da fauna ameaçadas de extinção no estado do Rio Grande do Sul. Instrução Normativa No. 3. Decreto No. 51797. Diário Oficial do Estado do Rio Grande do Sul, Secretaria do Meio Ambiente, Porto Alegre

Rosário LA (1996) As aves em Santa Catarina: distribuição geográfica e meio ambiente. FATMA, Florianópolis

Sanaiotti TM, Junqueira TG, Palhares V, Aguiar-Silva FH, Henriques LMP, Oliveira G, Guimarães VY, Castro V, Mota D, Trombin DF, Villar DNA, Lara KM, Fernandes D, Castilho L, Yosheno E, Alencar RM, Cesca L, Dantas SM, Laranjeiras TO, Mathias PC, Mendonça CV (2015) Abundance of Harpy and Crested Eagles from a reservoir-impact area in the low and mid-Xingu River. Braz J Biol 75:190–204. https://doi.org/10.1590/1519-6984.00614BM

Sanaiotti TM, Banhos A, Aguiar-Silva FH, Martins FD, Luz BB, Carvalho AS, Ruiz CM (2018) *Morphnus guianensis* (Daudin, 1800). In Livro vermelho da fauna brasileira ameaçada de extinção, vol. 3 – Aves, Instituto Chico Mendes de Conservação da Biodiversidade (Ed). ICMBio, Brasília, pp 121–124

Straube FC, Urben-Filho A (2010) Comentários e retificações sobre o único registro de *Morphnus guianensis* (Accipitriformes: Accipitridae) para o Paraná. Atual Ornitol 157:4–6

von Berlepsch H, von Ihering H (1885) Die Vögel der Umgegend von Taquara do Mundo Novo, Prov. Rio Grande do Sul. Z Gesammte Ornithol 1885:1–88

Whitacre DF, López J, López G (2012) Crested Eagle. In Whitacre DF (ed) Neotropical birds of prey: biology and ecology of a forest raptor community. Cornell University Press, Ithaca, pp 164–184

6 – CONSIDERAÇÕES FINAIS

O Parque Estadual do Turvo apresenta uma riqueza expressiva em relação às aves de rapina, destacando-se em sua composição as cinco águias florestais com ocorrência na Mata Atlântica (Meller 2011, Este estudo). Quantitativamente, porém, a utilização desta floresta pelas diferentes espécies de águias varia de espécie para espécie, e isto é evidenciado pelos dados coletados desde que a primeira destas águias foi mencionada para o local. A observação de *Spizaetus tyrannus* foi precursora no revelar o Parque Estadual do Turvo como importante área para as águias florestais (Mähler 1996). Aliado a este fato, deu-se ainda mais destaque ao parque pela posterior descoberta de *S. melanoleucus* no local, e pelas reflexões para a avaliação do *status* de ameaça de extinção destas espécies a nível estadual (Bencke et al. 2003).

Quando foi publicado em 2003, o Livro Vermelho da Fauna Ameaçada de Extinção no Rio Grande do Sul trazia a imagem de que a maioria das águias florestais gaúchas havia desaparecido do estado há muito tempo, como consequência do vasto desmatamento da metade norte do estado (Fontana et al. 2003). *Spizaetus ornatus*, *Morphnus guianensis* e *Harpia harpyja* foram consideradas como Provavelmente Extintas naquela avaliação estadual, embora houvessem especulações sobre a possível sobrevivência destas espécies no Parque Estadual do Turvo (Belton 1994, Bencke et al. 2003). O conhecimento ornitológico carecia, no entanto, de informações seguras sobre a ocorrência destas espécies na área, tanto atuais quanto históricas.

Tal visão começou a ser transformada a partir da divulgação da redescoberta estadual de *S. ornatus* feita na calha do rio Pelotas por Mendonça-Lima et al. (2006). Poucos anos depois, a espécie haveria de ser descoberta também no Parque Estadual do Turvo, onde uma sucessão de registros a partir de 2009 indicaria que sua ocorrência na área não era apenas acidental, mas fruto de uma população estabelecida (Meller 2011, Meller 2021). Tal fato era ainda mais perceptível em relação a *S. melanoleucus*, que se revelara como a águia mais comumente avistada e de mais ampla distribuição naquela região (Meller 2011, 2014, 2021).

Por ter sido a primeira das águias a ser mencionada para o Parque Estadual do Turvo, *S. tyrannus* era vista como uma das águias possivelmente mais presentes no parque (Bencke et al.

2003). Tal fato acabou por tornar-se um equívoco, e mesmo depois do registro visual divulgado por Mähler (1996) a espécie nunca mais foi avistada na área, sendo que até o momento ainda carece de documentação. A espécie foi, curiosamente, descoberta em anos recentes na calha do rio Ijuí, na região das Missões, habitando uma paisagem de floresta secundária (Meller 2021). Isso leva à especulação de que *S. tyrannus* poderia se afastar das matas primárias em vista do comportamento territorial de seus congêneres (Este estudo).

O Parque Estadual do Turvo abrange, então, diversos territórios de *S. ornatus* e *S. melanoleucus*, o que ficou evidenciado através da descoberta de territórios e ninhos (Meller 2021, Este estudo). Por outro lado, nenhum território de *S. tyrannus* foi encontrado no local, sendo que se a espécie lá ocorre de forma estabelecida, ela deve possuir baixíssima densidade, em níveis comparáveis aos das águias mais escassas (*Harpia harpyja* e *Morphnus guianensis*).

Harpia harpyja é uma águia emblemática e poderosa, e não menos expressiva é *Morphnus guianensis*, que pela raridade das aparições instiga muitos especialistas a descobrirem qualquer informação sobre seus hábitos de vida (Del Hoyo et al. 1994, Ferguson-Lees & Christie 2001, Pallinger & Menq 2021). O cenário atual relativo às harpias gaúchas começou a ser esclarecido quando um espécime foi fotografado em 2015 no Parque Estadual do Turvo, onde a este registro somaram-se um relato de avistamento e uma foto histórica de um exemplar abatido no entorno deste parque (Meller & Guadagnin 2016). Este trabalho culminou na redescoberta a nível estadual da espécie, depois de 70 anos sem registros. Os anos seguintes revelaram novos encontros, um em 2016 e outro em 2018. Por se tratar provavelmente de diferentes espécimes – fêmea, macho e imaturo – os registros revelaram que a ocorrência regional de *H. harpyja* ainda é suportada através de eventos reprodutivos. Tal reprodução pode mesmo estar se dando dentro do território do Parque Estadual do Turvo, ou então nas imediações argentinas, já que estimativas territoriais mostram haver área suficiente para suportar territórios tanto na argentina quanto no lado brasileiro (Este estudo).

Embora não tenham sido encontrados ninhos de *H. harpyja* em nosso estudo, as possibilidades não foram esgotadas, em vista de que amostramos cerca de 30% da área total do Parque Estadual do Turvo. Há, portanto, diversos locais ainda a procurar e muitas questões a serem respondidas a respeito da espécie na região, tais como: Quais são as características de seu sítio reprodutivo? Quais são as árvores importantes para seus ninhos? Quais são as presas que ela está consumindo? Etc.

Por fim, a redescoberta de *Morphnus guianensis*, encontrado em 2019 no Parque Estadual do Turvo, adicionou mais uma águia à composição dos rapinantes florestais da área (Meller et al. 2021). Assim como aconteceu ao registro de *H. harpyja* em 2018, este era também um exemplar imaturo, que em algum momento recente estava associado a um ninho da espécie, provavelmente no parque ou nas imediações argentinas. O registro por si só acrescentou informações interessantes, incluindo a possibilidade de encontrar um ninho na região, o que traria dados inéditos para a espécie a nível de bioma, já que nunca foi encontrado um ninho de *M. guianensis* na Mata Atlântica. Neste bioma também não é conhecida uma presa sequer da espécie. Semelhante a *H. harpyja*, há diversos locais ainda onde procurar por ninhos no parque e diversas questões a serem respondidas sobre esta espécie a nível regional.

REFERÊNCIAS

Aguiar-Silva FH, TM Sanaiotti, O Jaudoin, AC Srbek-Araujo, G Siqueira & A Banhos. 2012 Harpy Eagle sightings, traces and nesting records at the "Reserva Natural Vale", a Brazilian Atlantic Forest remnant in Espírito Santo, Brazil. *Revista Brasileira de Ornitologia.* (2):148-155.

Albuquerque EP. 1981. Lista preliminar das aves observadas no Parque Estadual do Turvo, Tenente, Portela, Rio Grande do Sul, Brasil. *Roessléria* 4(1): 107–122.

Banhos A, TM Sanaiotti, FH Aguiar-Silva, FD Martins, BB da Luz, AS Carvalho & CM Ruiz. 2018. *Harpia harpyja* (Linnaeus, 1758), p. 124–128. In: Instituto Chico Mendes de Conservação da Biodiversidade (Org.). *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume III - Aves*. ICMBio, Brasília.

Belton W. 1994. Aves do Rio Grande do Sul: distribuição e biologia. Unisinos, São Leopoldo.

Bencke GA, CS Fontana, RA Dias, GN Maurício & JKF Mähler-Jr. 2003. Aves, p. 189–479. In: Fontana CS, GA Bencke & RE Reis (eds.). *Livro vermelho da fauna ameaçada de extinção no Rio Grande do Sul*. EDIPUCRS, Porto Alegre.

Bencke GA, GN Maurício, PF Develey & JM Goerck. 2006. Áreas importantes para a conservação das aves no Brasil. Parte I - estados do domínio da Mata Atlântica. SAVE Brasil, São Paulo, Brasil.

Bierregaard Jr. RO. 1998. Conservation status of birds of prey in the South American tropics. *J. Raptor Res.*, v. 32, p. 19-27.

BirdLife International. 2016. *Spizaetus ornatus*. The IUCN Red List of Threatened Species 2016: e.T22696197A93548774. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22696197A93548774.en. Acesso em 25 de fevereiro de 2022.

BirdLife International. 2017. *Morphnus guianensis.* The IUCN Red List of Threatened Species 2017: e.T22695991A118209977. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22695991A118209977.en. Acesso em 25 de fevereiro de 2022.

BirdLife International. 2021. *Harpia harpyja*. The IUCN Red List of Threatened Species 2021:

e.T22695998A197957213. Acesso em 21 de Dezembro de 2021.

Brown L & D Amadon. 1968. *Eagles, hawks and falcons of the world*. Country Life Books, London.

Cabrera A & A Willink. 1973. Biogeografia de América Latina. OEA, Washington, DC.

Chebez JC. 2008. Los que se van: especies argentinas en peligro. Albatros, Buenos Aires, Argentina.

Del Hoyo J, A Elliot, J Sargatal. 1994. *Handbook of the birds of the world. Volume 2. New World Vultures to Guineafowl.* Lynx Edicions, Barcelona.

Donázar JA, A Cortés-Avizanda, JA Fargallo, A Margalida, M Moleón, Z Morales-Reyes, R Moreno-Opo, JM Pérez-García, JA Sánchez-Zapata, I Zuberogoitia & D Serrano. 2016. Roles of raptors in a changing world: from flagships to providers of key ecosystem services. *Ardeola* 63(1): 181-234.

Ferguson-Lees J & DA Christie. 2001. *Raptors of the world.* Houghton Mifflin Company, New York.

Fick A, AC Hendgen, DC Kunzler & LG Silva. 2021. Primeiro registro do cachorro-vinagre *Speothos venaticus* (Carnivora, Canidae) para a Mata Atlântica do estado do Rio Grande do Sul, sul do Brasil. *Biotemas* 34(3): 1-6.

Fontana CS, GA Bencke & RE Reis. 2003. Livro Vermelho da Fauna Ameaçada de Extinção no Rio Grande do Sul. Edipucrs, Porto Alegre, Rio Grande do Sul, Brasil.

Granzinolli MAM & JC Motta-Junior. 2010. Aves de rapina: levantamento, seleção de habitat e dieta, p. 167-188. Em: Matter et al. (eds). *Ornitologia e conservação: ciência aplicada, técnicas de pesquisa e levantamento*. Technical Books, Rio de Janeiro.

IBGE. 1986. Folhas SH 22 Porto Alegre e parte das folhas SH 21 e SI 22 Lagoa Mirim: Levantamento de Recursos Naturais. Geologia, geomorfologia, pedologia, vegetação, uso potencial da terra. Rio de Janeiro, v. 33.

ICMBIO. 2018. *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume III - Aves*. ICMBio, Brasília.

Mähler Jr. JKF. 1996. Contribuição ao conhecimento da Avifauna do Parque Estadual do Turvo, Rio Grande do Sul, Brasil. Acta Biolo-gica Leopoldinense 18: 123–128.

Meller DA. 2011. *Aves de Rapina do Parque Estadual do Turvo, Rio Grande do Sul, Brasil*. Monografia, Universidade regional Integrada do Alto Uruguai e das Missões – URI –

Campus Santo Ângelo, Santo Ângelo, Rio Grande do Sul, Brasil.

Meller DA. 2014. *Aves de Rapina da Mata do Alto Uruguai*. Dissertação, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brasil.

Meller DA. 2017. *Aves da Região Noroeste do Rio Grande do Sul.* Tenondé, São Miguel das Missões.

Meller DA. 2021. Recent records of hawk-eagles (*Spizaetus* spp.) in northwestern Rio Grande do Sul, Brazil. *Ornitología Neotropical* 32: 158-165.

Meller DA & DL Guadagnin. 2016. Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil. *Revista Brasileira de Ornitologia* 24(1): 53–57.

Meller DA, A Fick, A Banhos, TM Sanaiotti & CB Kasper. 2021. The rediscovery of the Crested Eagle (*Morphnus guianensis*) in Rio Grande do Sul state, Brazil. *Ornithology Research* 29: 89–93. https://doi.org/10.1007/s43388-021-00056-z

Mendonça-Lima A, F Zilio, CM Joenck & A Barcillos. 2006. Novos Registros de *Spizaetus ornatus* (Accipitridae) no Sul do Brasil. *Revista Brasileira de Ornitologia* 14: 279–282.

Miranda EBP, CA Peres, V Carvalho-Rocha, BV Miguel, N Lormand, N Huizinga, CA Munn, TBF Semedo, TV Ferreira, JB Pinho, VQ Piacentini, MA Marini & CT Downs. 2021. Tropical deforestation induces thresholds of reproductive viability and habitat suitability in Earth's largest eagles. *Scientific Reports* 11: 13048. https://doi.org/10.1038/s41598-021-92372-z

Newton I. 1979. *Population Ecology of Raptors.* Buteo Books, Vermillion.

Pallinger F & W Menq. 2021. Aves de Rapina do Brasil. Volume I: diurnos. Pallinger: Arte e Vida Selvagem, São Paulo.

Primack RB & E Rodrigues. 2001. *Biologia da Conservação*. E. Rodrigues, Londrina.

Ribeiro MC, JP Metzger, AC Martensen, FJ Ponzoni & MM Hirota. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141–1153.

Rio Grande do Sul. 2014. *Lista das espécies da fauna ameaçadas de extinção no estado do Rio Grande do Sul. Instrução Normativa n° 3. Decreto No 51.797.* Diário Oficial do Estado do Rio Grande do Sul, Secretaria do Meio Ambiente, Porto Alegre.

Sanaiotti TM, A Banhos, FH Aguiar-Silva, FD Martins, BB Luz, AS Carvalho & CM Ruiz.

2018. *Morphnus guianensis* (Daudin, 1800). In Livro vermelho da fauna brasileira ameaçada de extinção, vol. 3 – Aves, Instituto Chico Mendes de Conservação da Biodiversidade (Ed). ICMBio, Brasília, pp 121–124.

Sanaiotti TM, TG Junqueira, V Palhares, FH Aguiar-Silva, LMP Henriques, G Oliveira, VY Guimarães, V Castro, D Mota, DF Trombin, DNA Villar, KM Lara, D Fernandes, L Castilho, E Yosheno, RM Alencar, L Cesca, SM Dantas, TO Laranjeiras, PC Mathias, & PVC Mendonça. 2015. Abundance of Harpy and Crested Eagles from a reservoir-impact area in the Low and Mid-Xingu River. *Brazilian Journal of Biology*, 75(3): 190–204.

Sarasola JH, JM Grande & JJ Negro. 2018. *Birds of Prey: Biology and conservation in the XXI century.* Springer International Publishing AG, part of Springer Nature.

Sergio F, T Caro, D Brown, B Clucas, J Hunter, J Ketchum, K McHugh & F Hiraldo. 2008. Top Predators as Conservation Tools: Ecological Rationale, Assumptions, and Efficacy. 10.1146/annurev.ecolsys.39.110707.173545.

Sick H. 1997. *Ornitologia brasileira*. 2 ed. Nova Fronteira, Rio de Janeiro.

Silva CP, JKF Mähler-Jr, SB Marcuzzo & S Ferreira. 2005. Plano de Manejo do Parque Estadual do Turvo. Secretaria Estadual do Meio Ambiente, Porto Alegre.

Soares ES, FSR Amaral, EPM Carvalho Filho, MA Granzinolli, JBL Albuquerque, JS Lisboa, MAG Azevedo, W Moraes, T Sanaiotti & IG Guimarães. 2006. Plano de ação nacional para a conservação de aves de rapina. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília, Série Espécies Ameaçadas, v. 5.

Tabarelli M, LP Pinto, JMC Silva & CMR Costa. 2003. The Atlantic Forest of Brazil: endangered species and conservation planning. In: Galindo-Leal C & IG Câmara (eds.), p. 86–94. In: *The Atlantic Forest of South America: biodiversity status, trends, and outlook*. Center for Applied Biodiversity Science, Island Press, Washington DC.

Veloso HP, ALR Rangel Filho & JCA Lima. 1991. *Classificação da vegetação brasileira, adaptada a um sistema universal.* IBGE, Departamento de Recursos Naturais e Estudos Ambientais, Rio de Janeiro.

Whitacre DF. 2012. *Neotropical Birds of Prey: biology and ecology of a forest raptor community*. Cornell University Press, Ithaca.

WikiAves – www.wikiaves.com

Apêndice 1

Figura. Equipamentos utilizados em campo. (1) Binóculos *Nikon Monarch 10x42*, (2) máquina fotográfica *Canon 7D* lente *100-400mm*, (3A) GPS *Garmin e-trex 20x,* (3B) rádio comunicador, (3C) monóculo medidor de distâncias *Bushnell 4x20 Trophy*, (4) *Iphone* 7, (5) fita métrica 10 m, (6) armadilha fotográfica *Bushnell HD Nature View 12MP*, (7) caixa de som portátil JBL *Xtreme Squad* 40W, (8) drone *Phantom 3 Profissional* e (9) gerador *TGi1000*.

Apêndice 2

Figura. Equipamento de escalada: (1A) corda de ascensão estática, (1B) corda de segurança dinâmica, (2A) fita 2m, (2B) fita 1,5m, (3) cadeirinha, (4) ascensor, (5A) blocante corda de ascensão, (5B) blocante corda de segurança, (6A) freio atc, (6B) freio 8, (7A) mosquetões de alumínio, (7B) mosquetões de aço, (8A) capacete, (8B) luvas, (8C) óculos e (9A) estilingue, (9B) balim, (9C) linha de nylon e (9D) cordelete.

Apêndice 3

Table. Total reactions of animals to the playback of Harpy and Crested Eagles in the five linear transects along twelve campaigns. In parenthesis we added natural records of *Spizaetus* hawk-eagles.

Class	*Species*	*Reactions to Crested Eagle playback*	*Reactions to Harpy Eagle playback*	*Total of reactions*
Ave	*Cyanocorax chrysops*	11	17	28
Mammalia	*Sapajus nigritus*	4	5	9
Ave	*Spizaetus melanoleucus*	4	2	6 (16)
Ave	*Spizaetus ornatus*	2	2	4 (9)
Ave	*Elanoides forficatus*	1	1	2
Ave	*Rupornis magnirostris*	1	1	2
Ave	*Micrastur rufficolis*	1	1	2
Ave	*Mackenziaena severa*	2	–	2
Ave	*Tityra inquisitor*	–	2	2
Ave	*Trichothraupis melanops*	1	1	2
Ave	*Cissopis leverianus*	2	–	2
Mammalia	*Nasua nasua*	–	1	1
Ave	*Penelope superciliaris*	1	–	1
Ave	*Harpagus diodon*	–	1	1
Ave	*Accipitridae not identified*	1	–	1
Ave	*Glaucidium brasilianum*	1	–	1
Ave	*Baryphthengus ruficapillus*	–	1	1
Ave	*Notharchus swainsoni*	–	1	1
Ave	*Selenidera maculirostris*	–	1	1
Ave	*Pteroglossus castanotis*	–	1	1
Ave	*Dryocopus lineatus*	–	1	1
Ave	*Caracara plancus*	1	–	1
Ave	*Pionus maximiliani*	1	–	1
Ave	*Pyriglena leucoptera*	1	–	1
Ave	*Chamaeza campanisona*	1	–	1
Ave	*Dendrocolaptes platyrostris*	–	1	1
Ave	*Synallaxis cinerascens*	–	1	1
Ave	*Tityra cayana*	–	1	1
Ave	*Myiothlypis leucoblephara*	–	1	1
Ave	*Hemithraupis guira*	1	–	1
Ave	*Cacicus chrysopterus*	1	–	1
Ave	*Cacicus haemorhous*	–	1	1
Total		**38**	**44**	**82**

Apêndice 4

Table. Raptors recorded by the drone and inspecting it.

Species	*Records from drone images*			*Inspections from raptors*		
	Perched	*Flying*	***Total***	*Drone **	*Ground ***	***Total***
Cathartes aura	–	17	**17**	11	–	**11**
Coragyps atratus	13	9	**22**	5	2	**7**
Sarcoramphus papa	–	1	**1**	–	–	–
Elanoides forficatus	–	2	**2**	1	–	**1**
Rupornis magnirostris	–	1	**1**	1	–	**1**
Spizaetus melanoleucus	2	2	**4**	2	2	**4**
Caracara plancus	–	5	**5**	4	1	**5**
Falco rufigularis	–	–	**–**	–	1	**1**
Unidentified raptor	–	4	**4**	2	–	**2**

* Raptors inspections seen from the drone images;

** Raptors inspections seen from the ground.

Anexo 1

REPÚBLICA FEDERATIVA DO BRASIL
FEDERATIVE REPUBLIC OF BRAZIL

AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL
NATIONAL CIVIL AVIATION AGENCY

ANAC

CERTIDÃO DE CADASTRO DE AERONAVE NÃO TRIPULADA – USO NÃO RECREATIVO
UNMANNED AIRCRAFT INSCRIPTION CERTIFICATE – NON-RECREATIONAL

Esta certidão de cadastro, emitida de acordo com o RBAC-E nº 94, é válida até **20/12/2020**, salvo em caso de cancelamento, suspensão ou revogação pela Autoridade de Aviação Civil Brasileira.

This Inscription Certificate, issued in accordance with RBAC-E nr. 94, shall remain valid ***12/20/2020****, unless it is cancelled, suspended or revoked by the Brazilian Civil Aviation Authority.*

Operador *(Operator)*
DANTE ANDRES MELLER

CPF *(document)*:
991.599.100-20

O descumprimento da regulamentação aplicável pode ensejar consequências administrativas, civis e/ou criminais para o infrator.

Nº do cadastro ***(Inscription Number)*****:**
PP-014071982

Uso *(Purpose)*: não recreativo *(non-recreational)*
Ramo de atividade *(Business)*: Pesquisas biológicas e ecológicas a aves silvestres.
Fabricante *(Maker)*: DJI
Modelo *(Model)*: Phantom 3
Nº de série *(Serial Number)*: P76DCL21B26655
Peso máximo de decolagem *(MTOW)*: 1,28 kg
Foto *(Picture)*:

Informações adicionais *(additional information)*:

O detentor desta certidão de cadastro (o operador), ou aquele com quem for compartilhada sua aeronave, é considerado apto pela ANAC a realizar voos recreativos e não recreativos no Brasil, com a aeronave não tripulada acima identificada, em conformidade com os regulamentos aplicáveis da ANAC. É responsabilidade do operador tomar as providências necessárias para a operação segura da aeronave, assim como conhecer e cumprir os regulamentos do DECEA, da Anatel, e de outras autoridades competentes.

The holder of this inscription certificate (the operator), or the person with whom this aircraft is shared, is considered apt by Brazilian Civil Aviation Authority to perform recreational and non-recreational flights in Brazil, using the above identified unmanned aircraft, in conformity with the applicable regulations of Brazilian Civil Aviation Authority. It's the operator's responsibility to take the necessary actions to ensure a safe operation, as well as know and comply with the regulations of air traffic control (ATC), telecommunications, and other competent authorities

A validade desta certidão pode ser verificada pelo link
https://sistemas.anac.gov.br/SISANT/Aeronave/ConsultarAeronave

Local e data da emissão *(Place and date of issue)*
Brasília, 20 de dezembro de 2018
Brasília, December 20th, 2018

Esta certidão de cadastro não é válida para aeronaves não tripuladas acima de 25 kg de peso máximo de decolagem, ou em voos além da linha de visada visual (BVLOS) ou acima de 400 pés ou 120 metros acima do nível do solo (AGL).
This inscription certificate is not valid for unmanned aircraft of more than 25 kg maximum takeoff weight, or flying beyond visual line of sight (BVLOS) or over 400 feet or 120 meters above ground level (AGL).

Anexo 2

GOVERNO DO ESTADO
RIO GRANDE DO SUL
Secretaria do Ambiente e Desenvolvimento Sustentável

AUTORIZAÇÃO PARA PESQUISA EM UNIDADE DE CONSERVAÇÃO

02/2019

A Central de Autorizações, com base na Instrução Normativa SEMA nº 06/2014 e com base no Parecer nº 136/2019- DUC autoriza **o projeto de pesquisa a seguir identificado**, nas condições constantes neste documento.

Título do Projeto: Onde moram as águias? Investigação de nidificação de Harpia harpya e Spizaetus spp. no sul do Brasil.

Número de cadastro do projeto na DUC: 672

Responsável: Dante Andres Meller

Instituição a que o projeto se vincula: Universidade Federal do Pampa

Tipo de material a ser coletado: Não há coletas

Unidade de Conservação em que será desenvolvido o projeto: Parque Estadual do Turvo

Condições gerais:

1. Este documento não dispensa a exigência de autorização de Ingresso para o Pesquisador.
2. Mediante decisão motivada, a Divisão de Unidades de Conservação poderá suspender ou cancelar esta Autorização, caso ocorra descumprimento das normas da Instrução Normativa SEMA nº 06/2014 e legislação vigente.
3. O pesquisador deverá realizar uma apresentação dos resultados ao final do projeto, que será posteriormente planejado com o gestor da Unidade.

Validade da Autorização: 01 (um) ano

Porto Alegre, 10 de abril de 2019.

Coordenadora Central de Autorizações
Marilaine Silva de Lima

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