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USO DO HABITAT POR URUBUS (FAMÍLIA CATHARTIDAE LAFRESNAYE, 1839) EM ÁREAS URBANAS E NATURAIS EM MANAUS – AMAZONAS

WEBER GALVÃO NOVAES

Manaus, Amazonas

Setembro, 2013

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USO DO HABITAT POR URUBUS (FAMÍLIA CATHARTIDAE LAFRESNAYE, 1839) EM ÁREAS URBANAS E NATURAIS EM MANAUS – AMAZONAS

ORIENTADOR: Dr. RENATO CINTRA

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BANCA EXAMINADORA DO TRABALHO ESCRITO:

Nome (instituição)	Parecer
Dr. Caio Graco (Universidade Estadual de Feira de Santana)	Aprovado
Dra. Tania Sanaiotti (Instituto Nacional de Pesquisas da Amazônia)	Aprovado
Dr. Fabrizio Sergio (Estacion Biologica de Doñana)	Aprovado
Dr. Fernando Abad-Franch (Fundação Oswaldo Cruz)	Aprovado com correções
Dr. Leonardo França (Universidade Federal do Semi-Árido)	Necessita revisão

BANCA EXAMINADORA DA DEFESA PUBLICA DA TESE:

Nome (instituição)	Parecer
Dra. Cintia Cornelios (Universidade Federal do Amazonas)	Aprovado
Dr. Marcelo Menin (Universidade Federal do Amazonas)	Aprovado
Dr. Fernando Abad-Franch (Fundação Oswaldo Cruz)	Aprovado

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Sinopse:

Investigou-se o uso do ambiente urbano por urubus-de-cabeça-preta (*Coragyps atratus*) e urubus-de-cabeça-vermelha (*Cathartes aura*) na cidade de Manaus, Estado do Amazonas. Aspectos como estruturas urbanas influenciando a ocorrência dos urubus e a seleção de dormitórios comunitários foram avaliados.

Palavras-chave: Ambientes urbanos, Ecologia, Manaus, Uso do habitat, Urubus

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Urubu (mestre do voo)

“Perdoa a mão que te apedreja
Perdoa quem não te perdoa
Perdoa a pedra que te alveja
Perdoa o preconceito e voa
Quem come o podre que ele deixa
Não pode ser inútil à toa
Gari de terno preto e asas
Perdoa o preconceito e voa

Mestre do voo, divino réu
Anjo de cor, gari do céu
No imenso azul e branco véu
Cumpre, urubu, o teu papel

Perdoa a voz que te pragueja
Quem simplesmente te caçoa
Perdoa o chute que te aleija
Perdoa a estupidez e voa
Para que todo homem veja
Que teu agouro é coisa boa
Que todo azar é uma trapaça
Do próprio ego das pessoas
Gari de terno preto e asa
Perdoa a estupidez e voa”

Eudes Fraga e Joãozinho Gomes (2005)

RESUMO

A expansão de áreas urbanas tem favorecido o estabelecimento e o crescimento de populações de algumas espécies de urubus (Família Cathartidae) em ambientes altamente antropizados. Isto tem gerado conflitos com os seres humanos, tais como ataques a animais de criação, incômodo causado por ninhos e dormitórios e aumento significativo do risco de colisões com aeronaves. Neste estudo foi mostrado: (1) como determinados componentes urbanos favorecem a ocorrência de urubus-de-cabeça-preta (*Coragyps atratus*) e urubus-de-cabeça-vermelha (*Cathartes aura*); (2) os fatores ecológicos que influenciam a seleção de dormitórios comunitários por urubus-de-cabeça-preta; e (3) o uso de fontes artificiais de calor como auxílio de voo por urubus na área urbana de Manaus, Amazonas, Brasil. Os resultados demonstraram claramente dois padrões de uso do habitat por essas duas espécies de urubus. Urubus-de-cabeça-preta estavam associados a componentes que fornecem grande quantidade de alimento, tais como lixeiras e riachos (igarapés) poluídos. Por outro lado, urubus-de-cabeça-vermelha estavam altamente associados aos remanescentes florestais, porém evitaram locais com grande concentração de urubus-de-cabeça-preta (ex. feiras-livres). A seleção de locais para uso como dormitórios por urubus-de-cabeça-preta também foi diretamente influenciada pela proximidade de áreas onde há grande oferta de alimento. Outro interessante resultado, relacionado à ecologia comportamental, foi a demonstração do uso do calor liberado por chaminés de usinas termelétricas como um artifício para ascensão do voo por urubus, auxiliando o movimento dessas aves entre dormitórios e locais de alimentação, bem como aumentando o tempo de atividade diária dessas aves. Com base nos resultados é possível sugerir medidas de manejo que minimizem os problemas causados pelos urubus. As medidas de manejo para urubus-de-cabeça-preta devem se concentrar nas estruturas que oferecem grande oferta de alimento (ex. substituição de lixeiras abertas por lixeiras com tampa e revitalização de igarapés), enquanto que as ações voltadas para urubus-de-cabeça-vermelha podem ser concentradas nos locais em que estes causem problema (ex. ambientes aeroportuários) através da retirada de carcaças de animais. Medidas de manejo como o bloqueio de acesso a poleiros, remoção de ninhos e medidas de inquietação podem ser utilizadas para ambas as espécies nos locais que eles utilizam para nidificar e/ou como dormitórios.

ABSTRACT

Urban expansion has favored the establishment and population growth of some vulture species (Family Cathartidae) in highly anthropic environments. The positive relationship between vultures and anthropogenic landscapes has generated conflicts with humans, including livestock predation, nest- and roost-associated nuisance, and a significant increase of the risk of collision with aircrafts. In this study we showed: (1) how some urban structures influence the occurrence of Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*); (2) ecological factors influencing communal roost site selection by Black Vultures; and (3) the use of artificial thermal sources by vultures in Manaus, Amazonas, Brazil. The results clearly demonstrated two different patterns of habitat use by the two species. Black Vultures were associated with urban structures which provided large amounts of food, such as open garbage containers and polluted streams. Turkey Vultures were strongly associated with forest remnants and avoided sites with large numbers of Black Vultures (e.g., street markets). Communal roost site selection by Black Vultures also was directly influenced by proximity to areas with higher food availability. Another interesting finding, related to behavioral ecology, was that the vultures are using air thermals from vent pipes of thermal power plants as an aid for soaring, assisting the movements between roosts and foraging sites, as well as extend their daily activities. Based on our results it is possible to suggest management measures aimed at reducing the problems caused by vultures. For Black Vultures, management should focus on urban structures which provide large amounts of food (e.g., the replacement of open with closed garbage containers and the ecological recovery of polluted streams). For Turkey Vultures, interventions could concentrate on areas where these birds are causing problems (e.g., airport environments), and should include the elimination of animal carcasses. Further management measures, such as blocking access to roosts and perches, nest removal, or harassment could also be used for both vulture species.

SUMÁRIO

LISTA DE TABELAS

Capítulo 1

Patterns of habitat use by two New World Vultures in an urban area of Central Amazon.

Capítulo 2

Factors influencing the selection of communal roost sites by the Black Vulture *Coragyps atratus* (Aves: Cathartidae) in an urban area in Central Amazon.

Capítulo 3

The use of thermal power plants by New World Vultures as an artifice for lift: a potential hazard for aircrafts.

LISTA DE FIGURAS

LISTA DE APÊNDICES

LISTA DE ANEXOS

INTRODUÇÃO GERAL

A estrutura do habitat exerce grande influência sobre populações e comunidades de aves, principalmente com relação à sua organização e estruturação (MacArthur *et al.*, 1966). Componentes do habitat como a disponibilidade de alimento, poleiros e refúgio contra predadores são elementos importantes do nicho ecológico das aves (Wiens *et al.*, 1987). Um dos aspectos importantes para compreender a ecologia das espécies é entender como o habitat é selecionado (Kristan *et al.*, 2007). A seleção do habitat por aves geralmente ocorre através de um processo de decisões hierárquicas dependente da habilidade de um indivíduo perceber características do ambiente em diferentes escalas espaciais (Marzluff *et al.*, 2007). Variações espaciais e temporais nas condições desse habitat poderão gerar forte pressão na seleção do mesmo, a qual poderá influenciar na reprodução, sobrevivência e regulação de populações de aves (Johnson, 2007). A escolha de um determinado habitat deve refletir a qualidade do mesmo, demonstrando uma correlação positiva entre o habitat preferido e a qualidade desse habitat (Kristan *et al.*, 2007).

Alterações do ambiente natural são fatores importantes que influenciam o *fitness* de algumas espécies (Kristan *et al.*, 2007). Dentre esses fatores está a urbanização, que é a transformação do ambiental natural em paisagens compostas de uma mistura de remanescentes de ambientes naturais e habitats antropizados. O estudo da ecologia urbana pode fornecer novas ideias sobre os mecanismos e consequências da seleção do habitat por aves, seu sucesso reprodutivo, e o relacionamento desses fatores com a predação, competição e uso do habitat (Marzluff *et al.*, 2007). Nas últimas décadas as áreas urbanas se expandiram tanto em tamanho como em número (Melles *et al.*, 2003); embora essa expansão urbana resulte na conversão de áreas de cultivo, pastagens e florestas em ambientes com construções, os efeitos da urbanização nos diversos níveis de organização biológica ainda é pouco conhecido (Blair, 2004). Tradicionalmente os estudos têm focado em ambientes menos alterados e tem falhado em não incorporar o homem e suas atividades como um agente no funcionamento dos ecossistemas terrestres (Blair, 2004).

A urbanização tem alterado radicalmente os habitats de muitas espécies, principalmente pela perda e fragmentação de habitats naturais devido às atividades humanas (Morrison e Chapman, 2005), o que afeta a heterogeneidade natural dos ambientes e, consequentemente, a distribuição e abundância dos recursos que as aves utilizam (Blair, 2004; Devictor *et al.*, 2007). Em aves de rapina, a urbanização, a fragmentação e a redução de florestas tendem a reduzir a diversidade (Bosakowski e Smith, 1997). Porém, algumas espécies rapineiras podem prosperar em ambientes modificados pelo homem, desde que este habitat possua algumas características ecológicas fundamentais. Espaços abertos com muita vegetação e com quantidade suficiente de presas podem suportar uma considerável população de aves de rapina (Berry *et al.*, 1998). Embora a presença de espécies de aves seja comum em paisagens urbanas, esses ambientes são pouco conhecidos com relação ao efeito que exercem sobre o padrão de seleção de habitat. Essas informações são relevantes devido ao aumento da urbanização nas últimas décadas e da necessidade de elaboração de ações de conservação e manejo de muitas espécies que são afetadas positiva ou negativamente pela urbanização (Fernández-Juricic, 2001).

Dentre as aves que respondem positivamente aos ambientes altamente antropizados estão duas espécies de urubus, o urubu-de-cabeça-preta (*Coragyps atratus* (Bechstein, 1793)) e o urubu-de-cabeça-vermelha (*Cathartes aura* (Linnaeus, 1758)), pertencentes à Família Cathartidae Lafresnaye, 1839. Estas duas espécies têm se destacado pelo uso dos ambientes urbanos (Novaes, 2007), diferentes da espécie urubu-rei (*Sarcoramphus papa* (Linnaeus, 1758)) que é restrito a áreas naturais (Sick, 1997). Em florestas de terra firme e reservas florestais ao redor de Manaus pode ser encontrado o urubu-da-mata (*Cathartes melambrotus* Wetmore, 1964), enquanto que o urubu-de-cabeça-amarela (*Cathartes burrovianus* Cassin, 1845) ocorre em áreas de várzea, praias dos rios e em áreas de floresta (Cintra e Naka, 2012). O condor-dos-andes [*Vultur gryphus* Linnaeus, 1758] tem sua ocorrência restrita à região andina, com poucos registros no Pantanal.

Os urubus-de-cabeça-preta e urubus-de-cabeça-vermelha experimentaram nos últimos anos um significativo crescimento populacional. De acordo com dois institutos que monitoram as populações de aves nos Estados Unidos, o Christmas Bird Count (CBC) e o Breeding Bird Survey (BBS), entre 1990 e 2002 as taxas de crescimento anual foram de 1,8-2,0% para o urubu-de-cabeça-vermelha e de 5,0-5,9% para o urubu-de-cabeça-preta (Avery, 2004). Do mesmo modo que essas aves estão apresentando significativo crescimento populacional, elas estão também ampliando sua distribuição para localidades onde anteriormente suas ocorrências não eram registradas. Anteriormente limitados a algumas partes das Américas, recentemente esses urubus tem avançado progressivamente até regiões mais ao norte da América do Norte e por toda a América do Sul (Buckley, 1999; Blackwell *et al*., 2007; Carrete *et al.*, 2010).

O sucesso dessas espécies de urubus tem se tornado um grande desafio para os especialistas em manejo de fauna devido ao consequente aumento das interações negativas com os seres humanos. Dentre os maiores conflitos estão problemas causados a animais de criação (Lowney, 1999; Avery e Cummings, 2004) ou o incômodo causados por ninhos e poleiros próximos a residências (Hill e Neto, 1991; Lowney, 1999); atualmente, um dos maiores problemas se refere ao risco de colisões com aeronaves (DeVault *et al*., 2005; Blackwell e Wright, 2006; Avery *et al*., 2011). O risco que as aves colocam às aeronaves, chamado no Brasil de Risco Aviário ou Risco da Fauna, é comum em todo o mundo (Linnell *et al.*, 1996; Sodhi, 2002). No entanto, as espécies, a situação e a severidade das colisões entre animais e aviões são diferentes (Sodhi, 2002). Desde o primeiro registro de colisão, em 1912, até os dias atuais foram milhares de colisões, resultando em grandes prejuízos financeiros e a morte de cerca de 350 pessoas (Dolbeer *et al.*, 2000; Sodhi, 2002). Estima-se que o prejuízo anual decorrente de incidentes causado por animais à aviação seja em torno de US$ 1,2 bilhão (Allan, 2002). Os urubus-de-cabeça-preta e os urubus-de-cabeça-vermelha estão entre as espécies que mais causam dano às aeronaves, tanto na aviação civil (Dolbeer *et al*., 2000) como na militar (Zakrajsek e Bissonette, 2005) dos Estados Unidos. Segundo estimativas da Força Aérea dos Estados Unidos, prejuízo com urubus-de-cabeça-preta já totalizaram mais de US$ 25 milhões e urubus-de-cabeça-vermelha causaram mais de US$ 27 milhões em prejuízos. No Brasil, os urubus são as espécies de aves que mais colidiram com aeronaves entre 2000 e 2011. Neste período foram registradas 7.079 colisões envolvendo animais e aeronaves, das quais 980 foram com urubus (CENIPA, 2012). Com base em dados de efeitos no voo e danos causados às aeronaves, além do peso médio dessas aves, os urubus foram ranqueados como o grupo de aves mais perigoso para a aviação brasileira (T. Abreu, dados não publicados).

A expansão de áreas degradadas e com deficiência de saneamento básico próximo aos aeroportos são fatores que propiciam a incidência e permanência de aves, principalmente urubus. Esses problemas levaram à necessidade de legislação específica que proteja as áreas do entorno dos aeródromos quanto à implantação de atividades que sirvam como foco de atração de aves. Em 1995, o Conselho Nacional de Meio Ambiente - CONAMA resolveu que é considerada "Área de Segurança Aeroportuária - ASA" um raio de 20 km ao redor dos aeroportos. Dentro da ASA não é permitida a implantação de atividades de natureza perigosa e foco de atração de aves. Entre estes, matadouros, curtumes, vazadouros de lixo e culturas agrícolas que atraem aves. Segundo esta normativa, as atividades já existentes dentro da ASA devem adequar suas operações de modo a minimizar seus efeitos atrativos e/ou de risco, em conformidade com as exigências normativas de segurança e/ou ambientais (CONAMA, 1995). Em 2012 foi sancionada pela Presidência da República a lei Nº 12.725, que tem os mesmos objetivos da resolução CONAMA Nº 4 de 1995 (BRASIL, 2012).

Essas decisões buscam a mitigação do problema causado por animais à aviação, no entanto, é comum a busca por soluções rápidas, que muitas vezes passam pelo simples abate dos animais, de forma ilegal e pouco eficiente. Muitos problemas causados por aves, dentre elas os urubus, são resolvidos utilizando métodos não letais (Avery *et al*., 2002, Seamans, 2004). Porém, para que medidas eficientes sejam elaboradas e implantadas, é fundamental o conhecimento básico sobre como e quais estruturas do ambiente estão afetando a ocorrência dessas espécies, para que essas estruturas sejam manipuladas, e assim elaborar medidas eficazes de manejo.

Este estudo teve como objetivo estudar como estruturas urbanas afetam a ocorrência de urubus em diversos habitats presentes na cidade de Manaus, sendo dividido em três capítulos. O primeiro capítulo teve como objetivo avaliar o efeito de estruturas urbanas (feiras-livres, lixeiras, igarapés, poleiros e fragmentos florestais) na ocorrência de urubus-de-cabeça-preta e urubus-de-cabeça-vermelha. O segundo capítulo objetivou identificar os fatores que determinam a seleção de poleiros comunitários por urubus-de-cabeça-preta na área urbana de Manaus, e o terceiro descreveu o uso de usinas termelétricas por urubus como auxílio na ascensão do voo.

OBJETIVOS

Objetivo Geral

Investigar o efeito de estruturas urbanas nos padrões de uso da área urbana e suburbana de Manaus por urubus.

Objetivos Específicos

- Estimar os efeitos de estruturas urbanas nas probabilidades de ocorrência de urubus-de-cabeça-preta e urubus-de-cabeça-vermelha;
- Estimar os efeitos de estruturas urbanas nas probabilidades de detecção de urubus-de-cabeça-preta e urubus-de-cabeça-vermelha;
- Identificar os fatores ambientais que influenciam a seleção de locais para o estabelecimento de dormitórios comunitários de urubus-de-cabeça-preta;
- Investigar o uso de térmicas artificiais produzidas por usinas termelétricas como auxílio à ascensão do voo por urubus;
- Propor medidas de manejo que possam reduzir os problemas causados por urubus.

Capítulo 1

Novaes, W.G. & Cintra, R. Patterns of habitat use by two New World Vultures in an urban area of Central Amazon. Manuscrito em preparação para *Wilson Journal of Ornithology*.

PATTERNS OF HABITAT USE BY TWO NEW WORLD VULTURES IN AN URBAN AREA OF CENTRAL AMAZON

WEBER GALVÃO NOVAES [1,3] AND RENATO CINTRA[2]

[1] Instituto Nacional de Pesquisas da Amazônia, Graduate Program in Ecology, André Araújo Avenue 2936, Petrópolis, zip code 69080-971, Manaus, Amazonas, Brazil

[2] Instituto Nacional de Pesquisas da Amazônia, Coordenação de Biodiversidade, André Araújo Avenue 2936, Petrópolis, zip code 69080-971, Manaus, Amazonas, Brazil

[3] Corresponding author; e-mail: webernovaes@gmail.com

ABSTRACT.--- Recent increases in Black (*Coragyps atratus*) and Turkey Vulture (*Cathartes aura*) numbers, particularly in urban-periurban settings, have led to more frequent human–vulture interactions, including vulture–aircraft strikes. This highlights the need for vulture population management, but the determinants of habitat use by these species remain poorly understood. We investigated the effects of selected urban-landscape structures on the patterns of habitat use by Black and Turkey Vultures in urban-periurban Manaus, in Central Amazon. We repeatedly surveyed 80 sites (3-9 visits/site in 2009-2010) and used detection histories to derive maximum-likelihood estimates of (i) vulture occurrence and detection probabilities, and (ii) environmental covariate effects on such probabilities. Hierarchical logistic models showed that Black Vulture occurrence was positively associated with open garbage containers, and that both garbage containers and polluted urban streams independently increased detection probability. For Turkey Vultures, proximity to forest fragments increased both occurrence and detection probabilities, whereas street markets and, to a lesser extent, garbage containers negatively affected detection. These results suggest that Black Vultures select environments where the food supply is abundant, whereas Turkey Vultures are associated with forest remnants, a habitat for which they have specific foraging adaptations, and may tend to avoid Black Vulture gathering sites. Black Vulture management should therefore focus on reducing the amounts of solid waste available to the birds in urban open garbage containers and streams, whereas that of Turkey Vultures could contemplate the removal of animal carcasses and perhaps also nests/roosts from forest remnants, especially near airfields.
Key words.--- Black Vulture, Brazil, *Cathartes aura*, *Coragyps atratus*, urban habitat, Turkey Vulture, vulture–aircraft strike.

Factors such as food abundance, vegetation cover, roost-site availability, and morphological characteristics regulate the habitat use of birds of prey and scavenger birds (Schnell 1968, Preston 1990, Kirk and Curral 1994). Understanding the relationships between species and their environment is crucial for effective population management and conservation (O'Neil and Carey 1986). The urban environment can be of superior quality to some raptors (Chace and Walsh 2006) and bird communities tend to be dominated by a few species (Blair 2004). Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*) have adapted well to landscapes fragmented by human activities, and this has resulted in population growth and range expansion in recent years (Avery 2004, Blackwell et al. 2007, Carrete et al. 2010).

The occurrence of Black and Turkey Vultures in urban centers is considered detrimental to humans because of problems such as nuisance related to roosts (Avery et al. 2002), property damage (Hill and Neto 1991, Lowney 1999), problems for communication-tower operators (Avery et al. 2002), and, particularly, collisions with aircraft (DeVault et al. 2005, Blackwell and Wright 2006, Avery et al. 2011). According to the bird strike database of the United States Air Force (USAF), Turkey and Black Vultures ranked third and fourth, respectively, with regard to losses caused (USAF 2009); they ranked as the second most hazardous wildlife group to civil aircraft, and the first to military aircraft in the United States (Dolbeer et al. 2000, Zakrajsek and Bissonette 2005). In Brazil, according to the bird strike database of the Aeronautical Accidents Investigation and Prevention Center (CENIPA), vultures are responsible for the highest number of wildlife strikes with aircraft, with more than 980 strikes recorded in the twelve years from 2000 to 2011. In Manaus, more than 65 vulture–aircraft strikes occurred between 2000 and 2012. Only one strike with two Turkey

Vultures at Manaus International Airport in 2012 cost US$ 750,000.00 (data from CENIPA 2012).

To compound the problems caused by vultures, little information is available concerning the influence of urban structures on Black and Turkey Vulture occurrences. Previous ecological studies with these two vulture species were conducted only in natural areas, including agricultural and forested landscapes (Rabenold 1986, Coleman and Fraser 1989, Kirk and Currall 1994, DeVault et al. 2004). Understanding the environmental factors influencing the occurrence of each species will contribute substantially to the development of protocols to manage Black and Turkey Vulture populations. Unlike previous studies, our study focused on a typically urban environment, using the quantification of vulture occurrence and detection probabilities and modeling these probabilities as a function of environmental covariates. Our study provides information about the relationship between vultures and the urban environment. The data demonstrate clearly that both Black and Turkey Vultures are present in, and are intensively utilizing, the urban landscape.

We aimed to answer two types of questions in this study. First, we asked about the major determinants of habitat use by urban vultures, which have not been examined thus far. Second, we asked about the potential benefits of changing certain management practices that may benefit large avian scavengers such as our focal species. This second, practical, question is immediately relevant because vultures may represent a risk for civil and military aviation. In this regard, we were interested in quantifying the propensity of urban vultures to use sites similar to those surrounding Eduardo Gomes International Airport and the Ponta Pelada Air Base, both of which are located within a large forest fragment, and the Flores Aerodrome, located in a highly urbanized area.

Although it is clear from everyday experience that Black Vultures are easily observed throughout the study region, we hypothesized that this highly synanthropic, gregarious species would preferentially use sites where food is often available in large amounts. Such sites were represented by sampling points in which large, open, garbage containers were present. Food is also easily accessible in street markets, and we predicted a positive effect on the occurrence of vultures at such sites, independent of the presence of garbage containers. In addition, we thought that the presence of water sources (streams) would also have a positive effect on occurrence; urban streams in Manaus are, in addition, usually highly polluted, and solid garbage and dead animals are often also available for the vultures on their banks. We also expected to find a positive effect of perches, both natural (i.e., dead trees) and anthropogenic (such as mobile phone, radio, and television communication towers), which are often used by vultures for resting and roosting. On the other hand, we thought that sites in the vicinity of forest fragments would be less frequently used because food and water should be more difficult for Black Vultures to locate and access in forest patches than in open sites (Houston 1986).

We predicted that Black Vulture detection probabilities (*p*) would vary with the time of day at which observations were made – i.e., that Black Vultures would be easier to detect in the morning and at midday, when they rest and feed at the sites more often, and that they would be harder to detect later in the afternoon when they are more likely to be moving to their communal roosts. As we were not observing discrete sampling sites within which populations are demographically closed, our *p* values estimate the probability that at least one individual was present and detected. Therefore, higher *p* values were expected when the sites were used more frequently and individuals were easier to detect. This led us to model *p* as a function of the presence of all the site-specific covariates (urban structures).

We predicted that Turkey Vultures would utilize forest fragments more frequently because their adaptations for foraging in forested areas (Houston 1986, Wallace and Temple 1987, Lemon 1991) might lead to a local competitive advantage over the more common Black Vulture. We also predicted that urban structures with large amounts of food availability (i.e., garbage containers) would have a negative effect on Turkey Vulture occurrence because of the high densities of Black Vultures competing for food at such sites. We also predicted a positive effect of streams and perches on the occurrence of this species. With regard to detection, we expected Turkey Vulture detection probabilities to be higher at sites near forest fragments. The time of day at which observations were made was predicted to affect Turkey Vulture detection in the same manner as described above for Black Vultures.

Thus, our general goal was to examine how urban structures affect the presence of Black and Turkey Vultures, and to offer suggestions for the development of management plans regarding urban vulture populations.

METHODS

Study Area.--- The study was conducted in the urban and suburban area of Manaus (03º08' S, 60º01' W), in the Central Amazon, Northern Brazil. The mean annual precipitation in Manaus is 2,286 mm. The rainy season is between December and May and the dry season runs from June to November. The city has an area of 377.4 km^2 and is predominantly surrounded by Amazon Terra Firme rain forest. The urban area is covered by a dense hydrographic network (Couceiro et al. 2006) and more than 50 urban forest fragments that vary in size from 3 to 578 ha (Gontijo 2008). Manaus has grown rapidly in recent decades. Between 1991 and 2010 the human population grew from 1 million to 1.8 million inhabitants (IBEG 2010). Consequently, there are increasing disturbances in the complex system of urban environments, such as deforestation and water pollution, resulting in constant changes in the local ecosystem. Furthermore, garbage collection is not adequate in several areas of the city, mainly in street markets, where large amounts of solid waste are left in the open. Such places provide ample feeding opportunities for vultures.

Sampling design.--- The sampling design was aimed at estimating vulture occurrence and detection, which is the probability of a species of interest occurring in a site for the duration of the sampling period (MacKenzie et al. 2002). In 2009 we selected 48 sampling sites located approximately 3 km from one another throughout the urban/periurban area of Manaus. To widen our study area and to investigate the influence of structures such as streams and street markets on the occurrence of vultures, in 2010 we incorporated an additional 32 sites with these structures into our study. To select these additional sites, we identified all street markets and stream reaches present in the urban area and randomly selected 32 of them, keeping a minimum distance of 1 km between sites. Therefore, our site set was comprised of 80 sites covering an area of 457 km^2 in the urban and suburban areas of Manaus (Fig. 1).

Sampling consisted of up to four visits to each of the initial 48 sites between July and October 2009 and up to five visits to each of the 80 sites between September and November 2010; overall, 38 sites were visited nine times, 23 sites eight times, ten sites five times, eight sites four times, and one site three times, for a total of 572 visits. In each visit, an observer recorded the number of vultures present in a ~200 m-radius area around the same sampling point. Sampling was concentrated in the dry season because heavy rainfall between December and May in Manaus complicates the gathering of evidence in the field. At each site and visit, vulture sampling lasted five minutes and was conducted by a single observer between 0800 and 1700. This corresponds to the period in which Black and Turkey Vultures are most active (Avery et al. 2011); however, the timing of vulture activities (roosting, feeding, and resting) varies throughout the day, and site visits were planned at varying times in order to incorporate this variation.

Although all vultures detected by the observer were recorded, only vultures that were perching or flying immediately above the site were considered for the modeling of occurrence and detection probabilities. We used these criteria because vultures could be next to the site (i.e., soaring on a thermal or moving from one place to another) but not be using the structures present in the sample radius. However, we used the abundance data of all vultures observed to provide an illustrative map demonstrating city areas with higher concentrations of each vulture species and the proximity of these areas to airports.

Based on the biology and behavior of Black and Turkey Vultures, five site covariates and two sampling covariates were chosen to build occurrence and detection models. These covariates included urban structures that were potentially attractive to vultures as feeding and resting sites, and time variables. The urban structures considered were: 1) street markets, where large amounts of solid waste are often available; 2) urban streams, locally called *igarapés*, most of which are essentially open sewers with large amounts of solid waste; 3) garbage containers, which are usually and almost daily filled to capacity, with much of the garbage being organic in origin; 4) perches, both natural (such as dead trees) and anthropogenic (for example mobile phone, radio, and television communication towers), which are often used by vultures for resting and roosting; and 5) forest fragments, which are suitable for roosting or nesting. We also analyzed the influence of time variables: 1) year of sampling, to investigate variations in vulture occurrence and detection over two study years; and 2) time of sampling, divided into three periods: morning (0800–1100); midday (1100–1400); and afternoon (1400–1700) to investigate the influence of time of day in vulture detection.

Data Analysis.--- We first conducted descriptive and exploratory analyses, including the distribution of covariate values among sites. We also used observed vulture abundance data of both species to create illustrative maps demonstrating how these birds are distributed throughout the urban and peri-urban area of Manaus, thus indicating the areas with a high abundace of vultures, mainly in the proximity of urban airports. To create the map, we used the ArcGIS Software 10.1.

Second, we used a likelihood-based method for estimating site occupancy rates and detection probabilities similar to that proposed by MacKenzie et al. (2002), in which the investigators repeatedly sample discrete sites and record the detection/non-detection of the species of interest. Thus, for each sampling site we had a vector of 1s and 0s, denoting detection and non-detection, respectively, for the number of occasions at which the site was sampled. For example, if a site was visited eight times (out of the maximum of nine visits, with the seventh visit not carried out because of logistical constraints) and the species was detected only during the first and fourth visits, its detection history is 100100-00. This approach takes into account that the target species will not always be detected within a site that is currently being used. Non-detection may be due to true detection failure (i.e., the species was present at the site, but the observer did not see it) or to temporary absence of the species from the site (i.e., all individuals were in another part of their home range at the time of sampling). In some circumstances, as in the example above, it may not be possible to survey all sites in all sampling occasions; these missing observations are also accommodated in the model: if sampling does not take place at site *i* at time *t*, then, on that occasion, no information is contributed to the model likelihood for that site (MacKenzie et al. 2002).

We estimated the parameter Ψ_i, which is the probability that a species is present at site *i*, and p_{it}, which is the probability that a species is detected at site *i* at time *t*, conditional on the presence of at least one individual at that site. Following MacKenzie (2006), here we interpret Ψ as the probability that a site is used by Black or Turkey Vultures, and p as the probability of detecting each species at site i at time t, given the site is used. Both parameters may be expressed as a logistic function of site-specific covariates (e.g., habitat type, patch size) time-varying covariates (e.g., time, temperature, weather) (MacKenzie et al. 2002, Bailey et al. 2004). To understand which urban structures and time variables contributed to explaining the observed variation in vulture occurrence, we modeled p as a function of two time variables (year and time of day), and Ψ and p in relation to the presence/absence of five urban structures (street markets, garbage containers, streams, forest fragments, and perches) within a 200 m radius of the observation point at each site. We tested the importance of each covariate separately for Black and Turkey Vultures using different model specifications using variations in the basic model parameters: Ψ_{i} and p_{it}. First, we kept the proportion of sites used constant, Ψ(.), and allowed species detection to vary with time, p(time), and each site-specific covariate, p(covariate), separately for a total of seven models. Next, we kept the species detection probability constant, p(.), and varied Ψ with each covariate (urban structures) separately, Ψ(covariate), for five models. In each set of models we used a constant model, Ψ(.), p(.), which represents the hypothesis of no predictable variation.

We built models using the software PRESENCE, which provides maximum-likelihood estimates of parameters and their standard errors (SE). The models were ranked according to Akaike's Information Criterion corrected for a small sample size (AIC_c). AIC is used to select the most parsimonious model within a given set of models, i.e., the one that provides a better fit to the data while keeping the number of estimable parameters to the minimum (Burnham and Anderson 2002). The model with the lowest AIC_c value (i.e., $\Delta\mathrm{AIC}_c = 0$) is therefore the one that is best supported by the data; alternative models with $\Delta\mathrm{AIC}_c \leq 2$ are considered to fit the data nearly as well as the model with the lowest AIC_c value (Burnham and Anderson 2002). The best ranked models ($\Delta AIC_c \leq 2$) of the two model sets (Ψ(.), *p*(covariate) and Ψ(covariate), *p*(.)) were combined in a Ψ(covariate), *p*(covariate) model to investigate whether including covariates in both parameters (Ψ and *p*) improved model performance.

RESULTS

Descriptive Results: observed vulture occurrence.--- The total number of visits per point ranged from between 3 and 9, with an average of 3.9 visits in 2009 and 4.8 visits in 2010. Black Vultures were detected at 66 sites (82.2%) and Turkey Vultures at 31 sites (38.75%) (Table 1). Apparently, Black Vultures occur throughout the city in an almost random distribution. With the illustrative maps it is possible to observe the widespread distribution of Black Vultures in the urban area of Manaus; however, it is also possible to observe that there is a higher concentration of this species in some areas of the city, particularly the southern and eastern zones (Fig. 2). The illustrative map of Turkey Vulture numbers shows that these vultures are less abundant than Black Vultures, and that they occurred mainly on the outskirts of the city, where there is a higher concentration of continuous primary forest areas (Fig. 3).

Modeling Vulture Occurrence and Detection Probabilities.--- We analyzed the importance of time variables and urban structures in Black and Turkey Vulture occurrence and detection estimates by comparing AIC_c values for a set of models. The best models from the occurrence and detection model sets showed that: the structure that ranked best for explaining the occurrence of Black Vultures was the garbage container (Table 2); the urban structures that ranked best for explaining the Black Vulture detection probabilities was the garbage container and streams (Table 2); forest fragments were the urban structures that best explained the occurrence of Turkey Vultures (Table 3); and models with forest fragments and street markets best explained the Turkey Vulture detection probabilities (Table 3). The model with time period (year) and time of day (hour) as detection covariates did not rank well, indicating that these time covariates did not influence the detection of vultures as much as other site-specific covariates. When the best model was combined in models with covariates in both parameters (Ψ(covariate), p(covariate)), the model performances were improved for both species (Table 2 and 3).

As shown in Table 1, Black Vultures were detected at least once in each of the sites that had a garbage container, resulting in quasi-complete data separation; in such cases, the maximum likelihood estimate of the covariate effect does not exist (Allison 2008). We therefore were not able to estimate the effects of garbage containers, even if the data (see Table 1) indicate that they are likely important for Black Vultures. As suggested by the map in Fig. 2 , and model set (Table 2), Black Vultures had a wide distribution throughout the city, and their occurrence was not strongly affected by any particular urban structure. However, applying the Laplace/DeMorgan correction to the Black Vulture data we get an estimate of the odds ratio OR = 2.96 (approx. 95% CI 0.34, 25.66) and a conditional maximum likelihood estimate of the odds ratio CML-OR = 2.89 (mid-*P* exact 95% CI 0.43, 68.42) for garbage container (see Greenland et al. 1999). In other words, has almost three times more chance to find a Black Vulture in a location that has a garbage container than in a place that has not.

Based on best models for Black and Turkey Vultures, we assessed the effect of each covariate on vulture occurrence and detection through the β estimates. As mentioned previously, we were unable to estimate the effect of garbage containers in Black Vulture occurrence. We were however able to identify important urban structures affecting Black Vulture detection. As expected, garbage containers and stream had a positive effect on Black Vulture detection (Fig. 4). Forest fragments had a positive effect on Turkey Vulture occurrence, as well as a positive effect on Turkey Vulture detection (Fig. 5). On the other hand, street markets had a negative effect on Turkey Vulture detection (Fig. 5).

DISCUSSION

Although Black and Turkey Vultures share some important features, most notably eating carrion, their biology and behavior differ markedly. Black Vultures find food by sight, whereas Turkey Vultures have a well-developed sense of smell that enables them to efficiently find food in forested environments (Houston 1986, Kirk and Mossman 1998, Buckley 1999). For this reason, Black Vultures prefer foraging in open areas (Coleman and Fraser 1989), where they often congregate in large groups around carcasses (Buckley 1996). On the other hand, Turkey Vultures are less gregarious and, despite their ability to find food first, they are often displaced by later-arriving Black Vultures. Probably for this reason, Turkey Vultures prefer small food items that they can consume quickly before Black Vultures take them (Buckley 1996). Black Vultures can re-use a given feeding site for several days, whereas Turkey Vultures use a large number of feeding sites and return to the same feeding site less often than Black Vultures (Coleman and Fraser 1989).

These differences in vultures' biology and behavior can help explain their distinct use of urban sites in Manaus. Most of the garbage containers we studied were large, open containers that can accumulate large amounts of waste. Our data show that these structures are frequently used by Black Vultures as a food source; we often observed large numbers (even approaching hundreds of individuals) of them fighting over food scraps in such containers. In a simple analogy, these garbage containers may function as large carcasses, which Black Vultures seem to prefer over smaller ones (Buckley 1996). As with large carcasses, the aggregation of aggressive Black Vultures in sites with garbage containers may have contributed to their apparent avoidance by Turkey Vultures. In addition, container locations do not change and thus become predictable food sources that Black Vultures can use regularly; as has been reported for other scavenger guilds (e.g., Monsarrat et al. 2103), this could also help explain why Turkey Vultures were only rarely seen at sites with garbage containers.

Turkey Vultures were more common in sites next to forest fragments. This strong effect may be attributed to the fact that this species efficiently finds food in forested environments using olfactory cues (Houston 1986, Wallace and Temple 1987, Lemon 1991). In the city of Manaus there are more than 50 tropical rain forest remnants, 27 of which are larger than 30 ha (Gontijo 2008). Although we do not have data about food availability in these forest fragments, it is possible that they represent both foraging areas and roosting or breeding sites for Turkey Vultures.

Even if Black Vulture occurrence did not seem to be affected by the urban structures we investigated, detection models with the same covariates ranked substantially better. According to Bailey et al. (2004), multiple factors can affect the detection probability of a species. These factors include local population density of the species, seasonal or behavioral patterns, the size of the species, weather and environmental variations, or even sampling effort (i.e., the number of visits to each site). Additionally, MacKenzie (2006) argues that, in many situations, it seems reasonable to expect that the target species will not always be detected within a unit that is currently being used, particularly with cryptic or low-density species; in addition, the species may be temporarily absent from the site, e.g., using another part of its home range at the time of sampling.

Both Black and Turkey Vultures are large black birds, and it is not difficult to detect them in a site where they occur. Therefore, we believe that non-detection of a vulture in one of our sampling sites is a combination of a few true detection failures and, more frequently, the absence of the vulture from the site at the time of sampling (e.g., the vulture was in another part of its range). Thus, a detection history recorded as {111111010} would be expected at a site frequently by vultures and where detection probability is high, whereas a detection history {000010001} suggests that, although vultures occur at this site, they visit it or are detected less frequently, and the detection probability is therefore small.

Our detection models demonstrated that the presence of garbage containers and streams increased the probability of detection of Black Vultures, whereas forest fragments increased, and street markets decreased, the probability of detection of Turkey Vultures. We believe that local density and the frequency of use of a site are the factors that influence the detection probability of Black Vultures in sites with garbage cans and streams. On the other hand, the behavioral patterns of Turkey Vultures may increase detection probability near forest fragments: because Turkey Vultures primarily find food by using their sense of smell, they soar at low altitudes immediately above the forest canopy in order to detect carcasses. When Turkey Vultures are performing this type of flight, they are easily observed. Finally, the behavioral dominance of Black over Turkey Vultures probably explains the negative effect of street markets on Turkey Vulture detection (Wallace and Temple 1987). Most street markets in our study area are in poor hygienic conditions, with organic waste scattered throughout the surrounding streets. Black Vultures often feed on this waste, and their presence may drive Turkey Vultures away from these sites. This would explain the negative influence of street markets (and, to a lesser extent, garbage containers) on the detection of Turkey Vultures in our study.

The occurrence of these two large bird species near airports in urban areas represents a serious hazard to aircraft. Observing the illustrative maps of each vulture species, it is possible to note how the difference in the use of the urban habitat influences the distribution pattern of Black and Turkey Vultures throughout the city. Black Vultures are more concentrated in the southern and eastern zones of the city, whereas Turkey Vultures occur mainly on the outskirts of town. Downtown Manaus is located in the southern zone of the city. In this region there are many sites where there are a lot of garbage containers, as in fishing terminals, and most streams located in this region are used as drainage. In these streams a large amount of sewage is dumped daily, helping to attract more vultures. The distribution map allows us to observe that higher concentrations of Turkey Vultures occur near green areas on the outskirts of the city and in large forest fragments within the urban area.

Regarding the proximity of areas with high densities of vultures to airports, both Black and Turkey Vultures occurred in greater numbers near to the military air base because it is located in the southern zone of the city and its runway is surrounded by forest remnants. Manaus International Airport is not close to areas with higher concentrations of Black Vultures; however, the occurrence of Turkey Vultures is common in the region surrounding it because this aerodrome is also surrounded by forest remnants. On the basis of the different habitat use and behavior of Black and Turkey Vultures, it is possible understand more about the problems caused by these vultures to aviation.

For example, from January 2011 to May 2013 there were twelve vulture strikes at Manaus International Airport, six of which were with Turkey Vultures and three involved Black Vultures. On three occasions the vulture species was not identified (CENIPA 2012). All of the strikes involving Turkey Vultures occurred below 150 m, when the aircraft was in the Airport Operation Area (AOA). On the other hand, two of the three collisions with Black Vultures occurred outside the airport boundary, at a height of above 450 m. Whereas Black

Vultures are associated with the environment surrounding the airport, as they are attracted by the solid waste accumulated in the city, Turkey Vultures are commonly seen flying or foraging at Manaus International Airport itself. Turkey Vultures are attracted by the airport environment because it comprises an area of 980 ha of forest fragments. Furthermore, Turkey Vultures are attracted by large areas with freshly cut grass at the airport as it enables them to feed on small animals (e.g., rodents, frogs, snakes, lizards, and insects) that were killed during the mowing as well as animals struck by aircraft (WGN, pers. obs).

Consequently, population management programs for Black Vultures, at least for some Brazilian Cities, should focus on places with structures that provide a large amount of organic residue, such as garbage cans, open dumps, and polluted streams. Thus, the reduction of food resources by improvements in public sanitation is fundamental. Actions such as increasing the frequency of garbage collection, the replacement of uncovered garbage cans with those with covers, replacing open dumps with controlled landfills, and recovering polluted rivers and streams would be an important step towards reducing the number of Black Vultures in cities.

In contrast, because of their lower flying altitudes, management actions for Turkey Vultures can be concentrated at AOAs. An integrated management approach could include measures such as: 1) reducing the amount of food available, particularly the carrion of small animals (e.g., animals killed by grass mowing along air fields); 2) reducing the availability of perches by removing or blocking access to trees and navigation instruments at AOAs; 3) identifying and removing nests; 4) non-lethal harassment in roosting spots; and, if necessary, 5) lethal control of adults, which would be dependent upon the initial size of the population. Furthermore, some methods have been identified as being effective in vulture management, such as 6) suspending vulture carcasses or taxidermic effigies to keep vultures away from roosts (Avery et al. 2002, Ball 2009); and 7) relocating vultures some distance away to where their subsequent behavior is not expected to conflict with human activities (Humphrey et al. 2000).

We demonstrated that Black and Turkey Vultures are intensely utilizing the urban environment, but that the habitat structures influencing the presence of these birds are different, highlighting a need for different management practices. Our study will provide a valuable contribution to wildlife managers in their efforts to manage vulture populations, particularly in several cities in Central and South America that have similar problems with vultures, even though there may be some variation in the intrinsic characteristics of each urban habitat.

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FIG. 1. Spatial distribution of the 80 sampling sites within the urban and suburban area of Manaus, Amazonas, Brazil. From north to south are the airports: International Airport of Manaus; Flores Aerodrome; and Manaus Air Base.

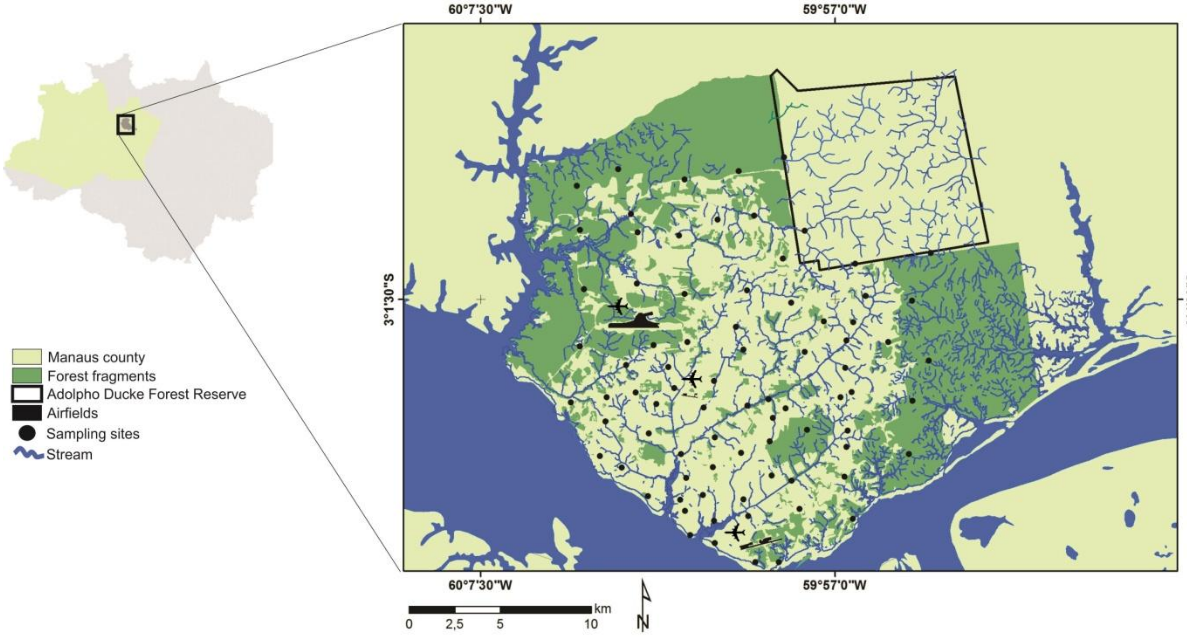
FIG. 2. Illustrative map representing the average of Black Vultures (*Coragyps atratus*) observed in each sampling sites within urban and suburban area of Manaus, Amazonas, Brazil.

FIG. 3. Illustrative map representing the average of Turkey Vultures (*Cathartes aura*) observed in each sampling sites within urban and suburban area of Manaus, Amazonas, Brazil.

FIG. 4. Estimates of the effect (β coefficient) of urban structures on the occurrence and detection of Black Vultures (*Coragyps atratus*) according best ranked models in the urban/peri-urban area of Manaus, Amazonas, Brazil. When 95% confidence bounds do not overlap the zero line, the effect was considered as significant.

FIG. 5. Estimates of the effect (β coefficient) of urban structures on the occurrence and detection of Black Vultures (*Coragyps atratus*) according best ranked models in the urban/peri-urban area of Manaus, Amazonas, Brazil. When 95% confidence bounds do not overlap the zero line, the effect was considered as significant.

FIG. 1.



60°7'30"W
59°57'0"W
3°1'30"S
3°1'30"S
60°7'30"W
59°57'0"W
Manaus county
Forest fragments
Adolpho Ducke Forest Reserve
Airfields
Sampling sites
Stream
0
2,5
5
10
km
N

FIG. 2.

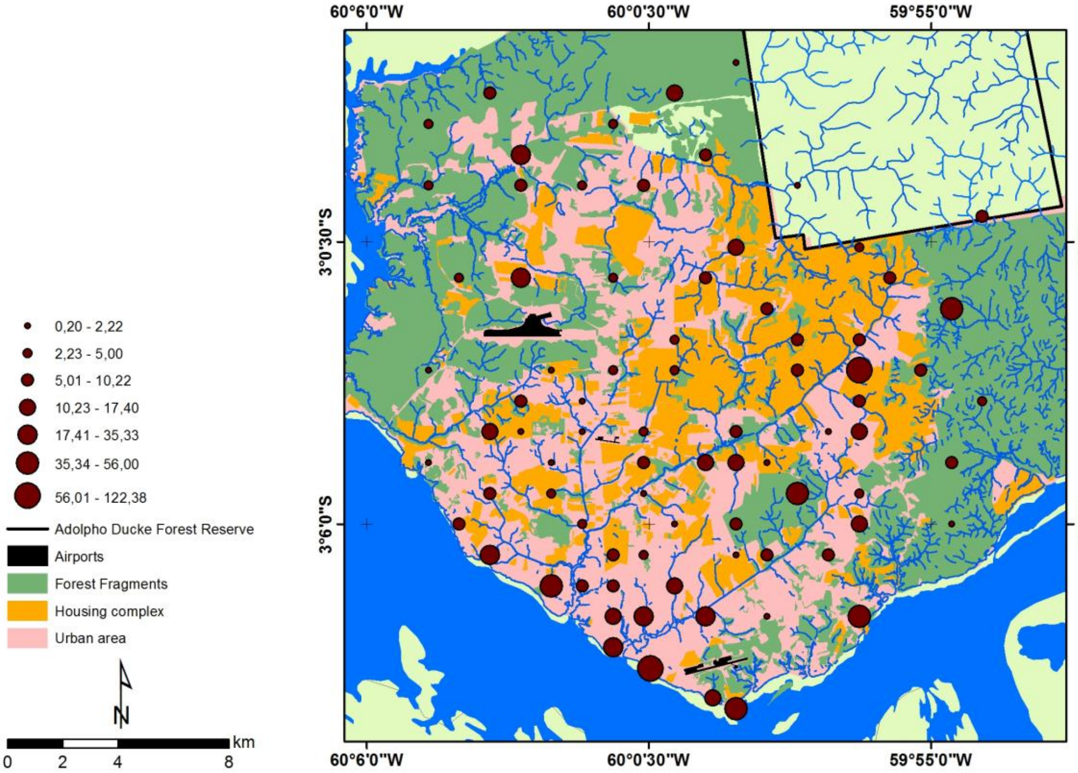

60°6'0"W
60°0'30"W
59°55'0"W
3°0'30"S
3°6'0"S
0,20 - 2,22
2,23 - 5,00
5,01 - 10,22
10,23 - 17,40
17,41 - 35,33
35,34 - 56,00
56,01 - 122,38
Adolpho Ducke Forest Reserve
Airports
Forest Fragments
Housing complex
Urban area
N
0
2
4
8
km

FIG. 3.

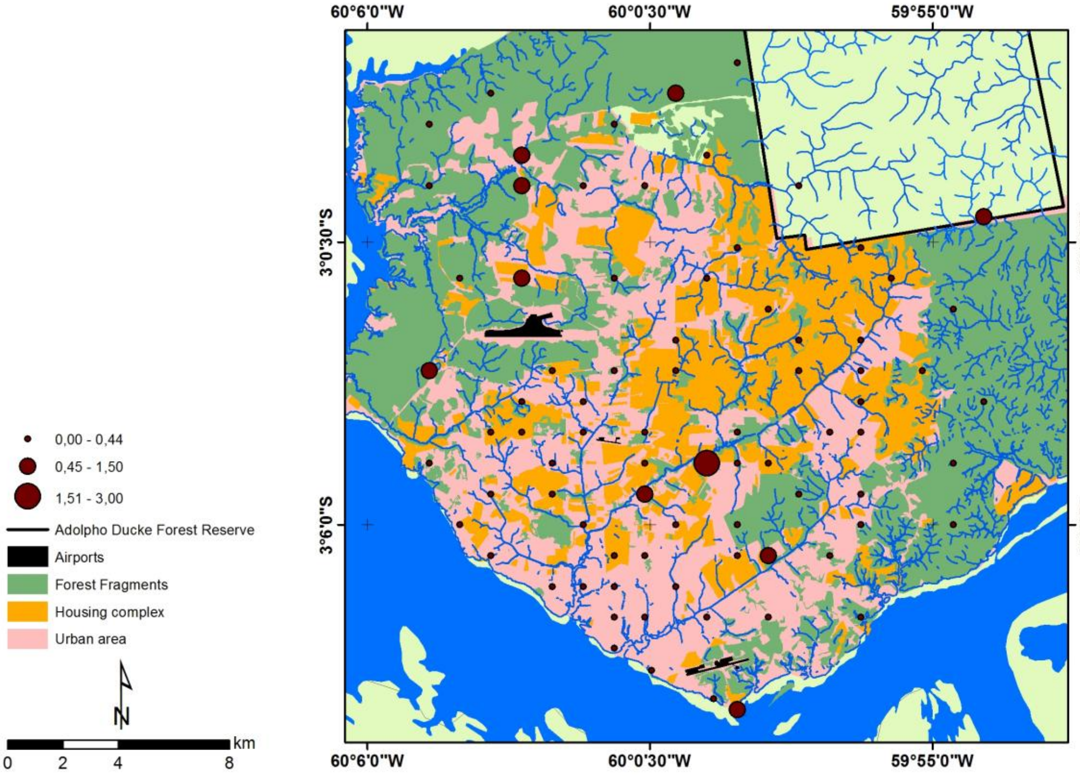
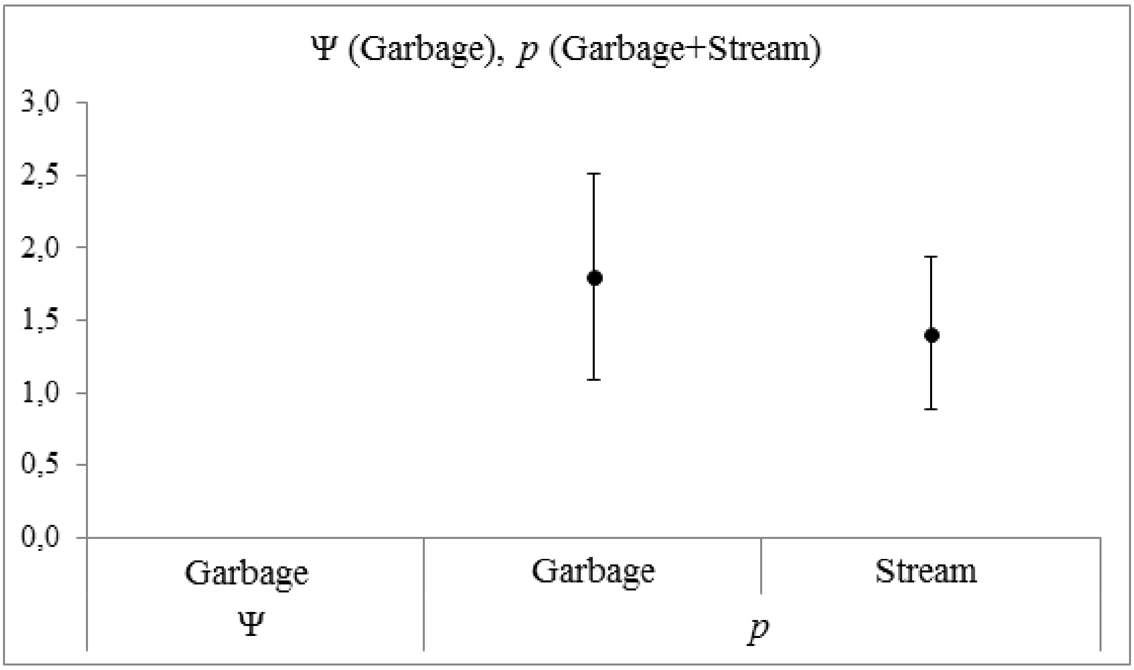

60°6'0"W
60°0'30"W
59°55'0"W
3°0'30"S
3°6'0"S
0,00 - 0,44
0,45 - 1,50
1,51 - 3,00
Adolpho Ducke Forest Reserve
Airports
Forest Fragments
Housing complex
Urban area
N
km
0
2
4
8

FIG. 4



Ψ (Garbage), p (Garbage+Stream)
3,0
2,5
2,0
1,5
1,0
0,5
0,0
Garbage
Ψ
Garbage
Stream
p

FIG. 5

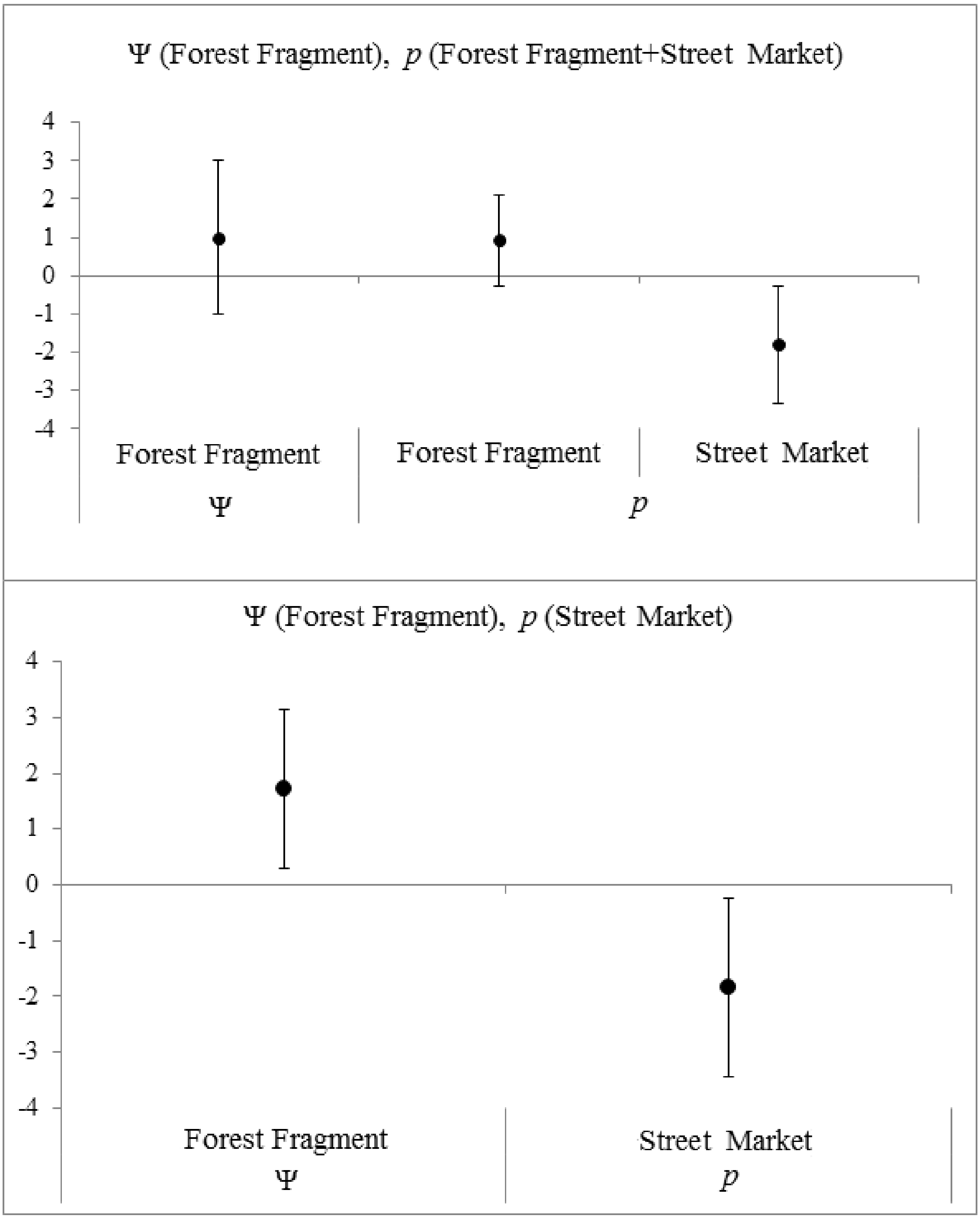

Ψ (Forest Fragment), p (Forest Fragment+Street Market)
4
3
2
1
0
-1
-2
-3
-4
Forest Fragment
Ψ
Forest Fragment
Street Market
p
Ψ (Forest Fragment), p (Street Market)
4
3
2
1
0
-1
-2
-3
-4
Forest Fragment
Ψ
Street Market
p

TABLE 1. Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*) occurrence according to urban structures during 2009-2010 in Manaus, Amazonas, Brazil.

Urban structure		Black Vultures		Turkey Vultures		Total[a]
		Yes	No	Yes	No	
Forest Fragment	Yes	52	12	29	35	64
	No	14	2	2	14	16
Street market	Yes	18	3	2	19	21
	No	48	11	29	30	59
Stream	Yes	16	3	8	11	19
	No	50	11	23	38	61
Garbage Can	Yes	11	0	2	9	11
	No	55	14	29	40	69
Perch	Yes	41	7	22	26	48
	No	25	7	9	23	32

[a] Number of sites (sampling points) with presence/absence of the urban structures.

TABLE 2. Set of models to estimate occurrence and detection probability of Black Vultures (Coragyps atratus) during 2009-2010 in the urban and suburban areas of Manaus, Amazonas, Brazil.

Model[a]	AIC_c[b]	ΔAIC_c[c]	w_i[d]	K[e]
Modeling Ψ				
Ψ(garbage),p(.)	714,06	0	0,5417	3
Ψ(.),p(.)	716,34	2,28	0,1732	2
Ψ(perch),p(.)	717,93	3,87	0,0782	3
Ψ(forest frag.),p(.)	717,97	3,91	0,0767	3
Ψ(street market),p(.)	718,2	4,14	0,0683	3
Ψ(stream),p(.)	718,4	4,34	0,0618	3
Modeling *p*				
Ψ(.),p(garbage)	689,34	0	0,6337	3
Ψ(.),p(stream)	690,46	1,12	0,362	3
Ψ(.),p(perch)	700,27	10,93	0,0027	3
Ψ(.),p(street market)	702,34	13	0,001	3
Ψ(.),p(year)	702,91	13,57	0,0007	3
Ψ(.),p(.)	716,34	27	0	2
Ψ(.),p(forest frag.)	718	28,66	0	3
Ψ(.),p(hour)	718,41	29,07	0	3
Modeling Ψ and *p*				
Ψ(garbage),p(garbage+stream)	658.12	0.00	1	5
Ψ(garbage),p(garbage)	687.20	29.08	0.0000	4
Ψ(garbage),p(stream)	688.23	30.11	0.0000	4

Ψ(.),p(.)	716.34	58.22	0.0000	2

[a] Models include different combinations of covariates of Black Vultures occurrence (Ψ) and detection (*p*). The operators '+' indicate additive models.
[b] Corrected Akaike's Information Criterion.
[c] Variation in AIC_c values relative to the best model.
[d] Akaike weight, a normalized likelihood of the model.
[e] Number of model parameters.

TABLE 3. Set of models to estimate occurrence and detection probability of Turkey Vultures (*Cathartes aura*) during 2009-2010 in the urban and suburban area of Manaus, Amazonas, Brazil.

Model	AIC_c	ΔAIC_c	w_i	k
Modeling Ψ				
Ψ(forest frag.),p(.)	349,75	0	0,8148	3
Ψ(street market),p(.)	352,88	3,13	0,1704	3
Ψ(.),p(.)	360,09	10,34	0,0046	2
Ψ(garbage),p(.)	360,26	10,51	0,0043	3
Ψ(perch),p(.)	360,3	10,55	0,0042	3
Ψ(stream),p(.)	362,05	12,3	0,0017	3
Modeling *p*				
Ψ(.),p(forest frag.)	349,62	0	0,4964	3
Ψ(.),p(street market)	349,68	0,06	0,4817	3
Ψ(.),p(garbage)	357,71	8,09	0,0087	3
Ψ(.),p(year)	358,53	8,91	0,0058	3
Ψ(.),p(.)	360,09	10,47	0,0026	2
Ψ(.),p(hour)	360,37	10,75	0,0023	3
Ψ(.),p(perch)	361,15	11,53	0,0016	3
Ψ(.),p(stream)	362,05	12,43	0,001	3
Modeling Ψ and *p*				
Ψ(forest frag.),p(forest frag.+street market)	345.36	0.00	0.5439	5
Ψ(forest frag.),p(street market)	345.98	0.62	0.3990	4

Ψ(forest frag.),p(forest frag.)	349.88	4.52	0.0568	4
Ψ(.),p(.)	360.09	14.73	0.0003	2

[a] Models include different combinations of covariates of Turkey Vultures occurrence (Ψ) and detection (*p*). The operators '+' indicate additive models.
[b] Corrected Akaike's Information Criterion.
[c] Variation in AIC_c values relative to the best model.
[d] Akaike weight, a normalized likelihood of the model.
[e] Number of model parameters.

Capítulo 2

Novaes, W.G. & Cintra, R. Factors influencing the selection of communal roost sites by the Black Vulture *Coragyps atratus* (Aves: Cathartidae) in an urban area in Central Amazon. Manuscrito aceito para publicação na revista *Zoologia*.

Factors influencing the selection of communal roost sites by the Black Vulture *Coragyps atratus* (Aves: Cathartidae) in an urban area in Central Amazon

Weber G. Novaes[1,3] & Renato Cintra[2]

[1]Graduate Program in Ecology, Caixa Postal 2223, Instituto Nacional de Pesquisas da Amazônia, CEP 69080-971, Manaus, Amazonas, Brazil.

[2]Coordenação de Biodiversidade, Caixa Postal 2223, Instituto Nacional de Pesquisas da Amazônia, CEP 69080-971, Manaus, Amazonas, Brazil.

[3]Corresponding author. E-mail: webernovaes@gmail.com

ABSTRACT. Increasing populations of Black Vultures, *Coragyps atratus* (Bechstein, 1793) and their capacity to adapt to living near humans has resulted in vulture-human conflicts. These conflicts enhance the need for effective management of vultures. Improved understanding of communal roosting dynamics is a key aspect of vulture biology provides information for effective management that can mitigate such conflicts. Here we investigated factors influencing roosting site selection by Black Vultures in Manaus. We monitored 40 vegetation remnants (VRs), visiting each VR twice (two independent observers) between 17:00 and 18:00 once every two-three months from June to November 2011. Using maximum-likelihood analysis and information-theoretic multimodel inference, we investigated the effects of VR covariates (size, shape, and location relative to feeding sites, to thermal power plants, and to other VRs) on VR occupancy by roosting Black Vultures. Distance to feeding sites (mainly garbage-dumping sites) was identified as the most important covariate (model-averaged $\beta=-0.62$, SE=0.26) and the other variables had no significant effects. Our results indicate that Black Vultures adjusted to the nearest possible roost to the food source to reduce the cost of movement. This suggests that reducing Black Vulture access

to food through simple waste management and sanitation policies, including public education, may help reduce vulture-human conflicts in Manaus.

KEY WORDS: Aircraft; bird strikes; Chathartidae; vulture-human conflicts.

Black Vultures, *Coragyps atratus* (Bechstein, 1793), are common in urban environments (Novaes 2007), and its populations have increased significantly in recent years (Avery 2004, Blackwell *et al*. 2007). As a result, several vulture-human conflicts have arisen such as nuisance roosts (Avery *et al*. 2002), property damage (Hill & Netto 1991), livestock depredations (Lowney 1999, Avery & Cummings 2004), and collisions with aircrafts (Blackwell & Wright 2006, Avery *et al*. 2011). In the United States alone, air strikes with Black Vultures represented a cost of over US$25 million to the US Air Force (USAF 2009). In Brazil, aircraft strikes are considered the main problem caused by vultures from the aviation industry's perspective. The Aeronautical Accidents Investigation and Prevention Center (CENIPA) recorded more than 980 strikes involving vultures between 2000 and 2011 (CENIPA 2012). In Manaus, a total of 65 vulture–aircraft strikes were recorded from 2000 to 2012 (CENIPA 2012).

These problems illustrate the increasing need for effective management of vulture populations to reduce vulture-human conflicts, which, by its turn requires a sound understanding of key aspects of the biology and behavior of this species. Communal roosting (defined as the "aggregation of more than two birds that sleep together"; Beauchamp 1999, p. 677) is one such key aspect (Rabenold 1986, McVey *et al*. 2008, Lambertucci *et al*. 2008) as it has been hypothesized to aid thermoregulation, reduce predation risk, and/or increase foraging efficiency (Ward & Zahavi 1973, Eiserer 1984, Hatchwell *et al*. 2009; see also beauchamp 1999).

Among the main benefits attributed communal roosting, are opportunities for social interaction and information exchange (Rabenold 1986, 1987, Buckley 1999), and facilitation of group foraging (Buckley 1996, 1997, Stolen & Taylor 2003). Communal roosts are complex and comprise a series of spatially closed roosts used by a local population of vultures that alternates among such roosts in a given area, forming a roosting system (Rabenold 1986, Buckley 1999, Stolen & Taylor 2003). These complex communal roosts have been the subject of several studies that address habitat characteristics (Wright *et al*. 1986, Thompson *et al*. 1990), social behavior (Rabenold 1986, 1987, Buckley 1998, Evans & Sordahl 2009), movements between roosts (Stolen & Taylor 2003), seasonal and daily use patterns (McVey *et al*. 2008), and population dynamics (Lambertucci *et al*. 2008). However, one key question remains poorly investigated: what drives the selection of communal roosting sites by urban Black Vultures at the landscape scale?

Manaus is a good study site to investigate the selection of communal roost sites by the Black Vulture. This unplanned and fast growing city has experienced increased environmental disturbances such as deforestation, water pollution, and shortage of basic sanitation in the last decades. Black Vulture populations have likely benefited as foraging opportunities have been enhanced by the large amounts of organic residues available. Moreover, there are several native vegetation remnants (VR) (mainly forest fragments) that are potential communal roost sites for Black Vultures. Furthermore, there are three airports in the urban area of Manaus; the Eduardo Gomes International Airport, the Ponta Pelada Air Base, and the Flores Aerodrome. The establishment of a vulture communal roost close to one of these aerodromes poses a serious risk to aviation.

In this study, we investigated the effects of five VR covariates on VR occupancy by roosting Black Vultures. Two related VR sites: size and shape, and three related VR location:

distance to feeding sites; distance to thermal power plants; and distance to the nearest VR. Black Vultures normally use roosts in protected areas where human activities are limited and taking off or landing is possible (Coleman & Fraser 1989, Thompson *et al*. 1990). We hypothesized that the larger and more rounded shaped VR harbor more isolated and protected sites devoid of human activities that facilitate arrivals and departures of Black Vultures. As Black Vultures can form communal roosts near predictable food sources (Coleman & Fraser 1989), we expected that VRs near areas with larger amounts of organic residues could increase the probability of these VRs be vulture roosts. Roosts also are often located near structures that generate upward-flowing air that facilitate early-morning flights (Thompson *et al.*1990). In Manaus, thermal power plants attracted vultures to their vent pipes (vultures use the mass of expelled heat as an aid to soar and fly) (Novaes, unpublished data) Similar behavior was observed in Turkey Vultures (Mandel & Bildstain 2007), which suggests that the proximity to thermal power plants might be favorable for the establishment of a communal roost. As Black Vultures form a complex of communal roosts comprised of a series of nearby roosts (Rabenold 1997), the proximity to other VRs (potential ancillary roosts) may influence the probability of a VR be used as a roost.

Our objectives were to investigate how structural features and the spatial location of VRs contribute to the probability that a VR be used as a Black Vulture communal roost. Based on the results, we propose management actions to keep vultures away from airports.

METHODS

Study area. – Manaus (03º 08' S and 60º 01' W) is one of the main cities in the Brazilian Amazon. It has an urban area of 377.4 km^2 surrounded by the Amazon Forest, and about 1.8 million inhabitants. The climate is tropical, warm and humid, with a local rainy season between December and May and a dry season from June to November.

Sampling design. Several types of roosting substrates, such as trees, cell towers or tall buildings can be used as a roost by vultures. However, in our study area, vulture roosts in sites other than VRs are rare probably due to the large availability of VRs. Therefore, our study concentrated on VRs only. Our sampling consisted of multiple visits to VRs of different sizes, shapes, and locations (Fig. 1). All VRs present in the urban area of Manaus that had from small tree aggregations (< 1 ha) to a large forest fragment (> 500 ha) were identified. We identified 197 VRs and for each VR a number in ascending order from north southwards was assigned. The function sample (replace = FALSE) in the R software was used to randomly select 40 VRs. The number of observation points within each VR varied according to size as follows: < 10 ha (N = 21), one observation point per VR; 10–150 ha (N = 15), two points; 151–300 ha (N = 2), three points, and > 300 ha (N = 2), four observation points per VR.

We monitored five communal roosts of Black Vultures before establishing observation time and length at each observation point. These sites are characterized by large numbers of individuals (Rabenold 1986, Wright *et al.* 1986, Buckley 1998). Our previous observations identified a continuous arrival of vultures to communal roosts, therefore we established 10 min observations periods near sunset (between 17:00 and 18:00 h) for our study.

Observations were carried out at the edges of the VRs, which were usually on the streets bordering these areas. VRs were considered occupied if vultures were observed roosting and/or arriving from at least one observation point during each observation period. Larger VRs, i.e. with two, three or four observation points, were considered occupied if vultures were observed roosting in only one point even for VRs with two or more points.

Our sampling design was based on estimating the proportion of sites occupied by a species of interest as proposed by MacKenzie *et al.* (2002). This approach explicitly accommodates detection failures and makes the following assumptions: (i) population closure: sites do not change their occupancy status during the length of the survey; (ii) no false-positive detections: individuals of other similar species are not misidentified as individuals of the focal species; (iii) independence of detection events: detection during one visit does not affect detection during any other visit to the same site; (iv) independence of sites with regard to occupancy. To fulfill this premise, we surveyed the VRs within a short period of time (four months and a half) assuming that the VR occupancy did not change during our survey period. Based on MacKenzie & Royle (2005) and considering the high detection probability (> 0.9) of vultures in the communal roost sites chosen, our sampling consisted of two observers simultaneously visiting VR observation points twice between 16 Jun and 1 Nov 2011, with intervals varying between two and three months between each visit. Observers positioned themselves at least 30m from each other. Altogether, there were three trained observer conducting observations during this study. Due to logistical constraints, some VRs were not surveyed during all sampling occasions. These missing observations were accommodated using the proposed likelihood model (MacKenzie *et al*. 2002).

We measured VR sizes using images from Google Earth (images from 2 August 2010) and the GEPath 1.4.6 software (Sgrillo 2012). To estimate VR shapes or deviation from a circle (a circular VR assuming a shape index, SI = 1.0, and all other shapes assuming higher values), the Patton shape index (SI) (Patton 1975) below was used:

$$SI = \frac{P}{200} (\pi * A)^{0.5}$$

where SI = VR shape index; P = perimeter of the VR in km; π = 3.1416; A = VR area in km^2.

To estimate distance to food source, we identified vulture feeding sites using sampling points across urban and suburban areas of Manaus between 2009 and 2010. The sampling consisted of four visits to 48 sites between July and October 2009 and five visits to 80 sites between September and November 2010. The addition of 32 more sites in 2010 made it possible to increase the study area and include structures such as street markets, dumps, and polluted streams in the sample. At each site, vulture sampling lasted five minutes and was conducted by a single observer between 08:00 and 17:00 h. We considered feeding sites as those where Black Vultures were observed foraging for at least 80% of the observations.
To investigate the use of thermal power plants by vultures, we monitored six of the 11 thermal power plants in the urban area of Manaus from February to September 2012. We observed that all thermal power plants were used by vultures and were visited more often in the early morning and/or late afternoon. To estimate distance to other VRs, we considered the distance from the sampled VR to the nearest VR in the urban area of Manaus. Distances to the nearest VR, to the feeding sites and to thermal power plants were measured using Google Earth 6.1.

Data analysis. Our data analysis consisted of two steps. Firstly, we used descriptive analysis to assess the number of VRs occupied, their size and shape, variations in the distance of occupied VRs to feeding sites, thermal sources and other VRs. Secondly, we used a procedure of parameter estimation and multimodel inference (Burnham & Anderson 2002). Each model tested has two components: one to estimate the probability that a VR would be occupied by Black Vultures (Ψ) (a biologic component) and other expressed the probability that we would detect Black Vultures in a VR where they actually occur (p) (a sample component). Both components can incorporate covariates, where it is possible to evaluate the effect of the covariates on psi and p.

We inputted a complete set of additive logistic regression model for the five variables, estimating the weighted mean effect sizes, and the relative importance of each variable based on the set of models. Using the PRESENCE software (Hines 2006), we built models that provided the maximum-likelihood estimates of parameters and their standard errors (SE). The models were compared using Akaike's Information Criterion corrected for small sample sizes (AICc). The AIC is a theoretic information measure used to select a parsimonious model that considers data variation and the number of parameters (Burnham & Anderson 2002). The relative importance of each variable (*w*) was estimated, within model set, as the sum of Akaike weights over all models in which the variable was present; the w_{max}=1 and variables with $w \leq 0.35$ were considered unimportant. The weighted mean effect size (βs) was estimated for each variable in the model set as the sum of model-specific effect sizes times model-specific Akaike weights. The model set included a null model representing the hypothesis that none of the variables influenced the probability of Black Vultures occupying VRs as communal roosts. We were also interested in measuring the effect of observers and VR size with the probability of roost detection, for doing so we tested models with these variables as detections covariates.

RESULTS

Descriptive results

Each observation point was visited 3.34 times on average (range 2-4 times). Overall, we detected Black Vulture roosting in 17 of the 40 VRs sampled (42.5%). Among 17 roosts identified, 14 (82%) were less than 2 km from feeding sites, 9 (53%) were less than 1 km, and 7 (41%) were less than 0.5 km. Only 3 (17%) were farther than 2 km from feeding sites (Fig 2; see also Appendix 1). We observed vultures roosting in VRs of different sizes, from very small (0.31 ha) to large forest fragments (773 ha) (Appendix 1). Similarly, Black Vultures used both rounded and irregular shaped VRs (Appendix 1). The use of VRs seems not to be influenced by either distance to other VRs or to thermal power plants, since both VRs close or far from other VR and thermal power plants had vultures roosting (Appendix 1).

Multimodel inference

As expected, the null model did not provide an adequate explanation of the data (Appendix 2). The effect of the observer´s presence (Observer 1 = 0.97, Observer 2 = 0.96, and Observer 3 = 0.97) and of the VR size (varied from 0.96 to 0.97) showed no significant variations on detection probabilities. Therefore, we considered the detection probability as constant in our model set. The occupancy estimates for each VR by Black Vultures was 0.42 (SE = 0.07; $CI_{95\%}$ 0.28 - 0.58) and the probability of detecting Black Vultures in the VRs in which they occurred was 0.97 (SE = 0.02; $CI_{95\%}$ 0.88 - 0.99).

Our model set comprised 32 models with all possible combinations of the variables and one null model (Appendix 2). The best-performed models (ΔAIC $\leq$ 2) are provided in Table I. In terms of relative importance, the variables rank as follows: distance to feeding sites, w=0.91; distance to thermal power plants, w=0.35; shape of VR, w=0.30; size of VR, w=0.26; and distance to other VRs, w=0.23. The distance between VRs and the nearest feeding site was the most important predictor of VR occupancy by roosting Black Vultures (Fig. 3), with a strong negative effect on occupancy (β=−0.62); although the precision of this estimate is somewhat low (SE=0.26), it is significantly different from zero at α=0.05 (95%CI −1.13, −0.11; see Fig. 4). The other variables had either little or no significant effect on VR use by Black Vultures as communal roost (Fig. 4).

DISCUSSION

We found that among the variables investigated in this study, distance to feeding sites was the most important factor for roost site selection. The closer a VR was to sites with available food, the greater the chance the VR was used as a communal roost (an increase of 1% per meter; see Fig. 3). In Manaus, the location of food sources for Black Vultures was already known (i.e., street markets, dump garbage, open sewer) and they used these feeding sites extensively. Black Vultures are able to adjust their home ranges, movement patterns, and flight behavior to local features (DeVault *et al*. 2004). Therefore, these birds may have adjusted to use the nearest possible roost to the food source to reduce the cost of movement.

Although the other variables could represent more safety (size), accessibility of roosts (shape), facilitated early-morning flight (proximity to thermal power plants), and potential ancillary roosts (proximity to other VRs), none of these variables were significant in our study. Coleman & Fraser (1989) demonstrated that Black Vultures can roost communally in small to medium sized woodlots when roosts are near feeding sites. We observed Black Vultures roosting in very small VRs (i.e., 0.3 ha) in areas of intense human activity (i.e., street markets), but theses roosts were near large garbage containers used as feeders by vultures. It seems that Black Vultures tolerate use of small areas (theoretically less protected) when they find advantages in such areas, in this case, food supply. Closeness to thermal power plants had little influence upon roost site selection. This is probably due to the fact that when food location was known to Black Vultures, they approached feeding sites flapping rather than gliding (Buckley 1997), demonstrating less dependence from thermals. Finally, the distances to other VRs varied little (from 0.01 to 1.39 km) due o the large availability of these structures in Manaus, which may explain the lack of influence of this variable in our study.

When vulture communal roosts are located near human activity sites, vulture-human conflicts (Lowney 1999, Seamans 2004, Avery *et al*. 2006), including vulture-aircraft strikes, may arise (Ball 2009). For example, two of the three most abundant roosts that we identified (129 and 92 Black Vultures on average arriving within a 10 min period) were 1 and 0.7 km away from Ponta Pelada Military Air Base. Normally, the strategies employed to minimize problems caused by vulture roosts include dispersal of the birds through suspending vulture carcasses and use of hand-held lasers and pyrotechnics in the roost (Avery *et al*. 2002, Seamans 2004, Ball 2009). Although locally efficient, actions implemented only in one roost does not solve the problem because birds repelled from a roost simply relocated to adjacent roosts and maintained the activity in that area (Stolen & Taylor 2003, Avery *et al*. 2006). For the efficient management of Black Vulture communal roosts, integrative measures are necessary. The number and composition of individuals in a roost may be influenced by factors such as roost location, roosting site and abundance of birds in the roost (Rabenold 1986, Lambertucci 2013). Therefore, the characterization of those sites regarding use and composition variations can provide tools to determine priorities for the management of the main roosts (i.e., more abundant and greater variation in age classes).

However, as previously stated, roost dispersal does not reduce Black Vulture activity in an area. Our results suggest that effective management for preventing vulture-human conflicts include removal and proper disposal of food to reduce the attractiveness of the site for vultures. A management plan to control the problems caused by Black Vulture communal roosts in urban areas should be based on significantly reducing food supply through: improving the quality of garbage collection, installing and/or adjusting the sewage collection systems, replacing open garbage cans with closed garbage cans to prevent vulture access, and, environmental education campaigns to reduce indiscriminate garbage disposal by local communities.

Nonetheless, we suggest caution before starting management of vultures. The radical reduction of food does not necessarily mean that vultures will leave the area. These birds probably will feed on other resources, which can result in attacks to livestock, poultry, and domestic animals (Avery & Cummings 2004). Competition for key resources with other bird species can also arise (Carrete *et al*. 2010). It is important to consider translocation of birds to other places were human-vulture interactions are not negative (Humphrey *et al*. 2000). On the other hand, it is important to consider that Black Vultures play an important role as cleaners in the environment. The drastic reduction of scavenger bird populations can have socio-economic, cultural, and biodiversity impacts (Markandia *et al*. 2008).

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Figure legends:

Figure 1. Spatial distribution map of the 40 vegetation remnants investigated for occupancy by communal roost of Black Vultures (*Coragyps atratus*) in the urban area of Manaus, Amazonas, Brazil.

Figure 2. Box plot with median and quartiles feeding site distances from vegetations remnants that are occupied and unoccupied by Black Vultures as communal roosts, Manaus, Amazonas, Brazil.

Figure 3. Estimate of occupancy probability of vegetation remnants as communal roosts of Black Vultures (*Coragyps atratus*) for each covariate, with error bars showing 95% confidence bounds.

Figure 4. Model-averaged effect-size (β coefficients) of variables from the 32-model set. Error bars show 95% confidence limits, where they do not intersect the dotted line, we consider the effect of the variables on vegetation remnant occupancy to be significant.

Figure 1.

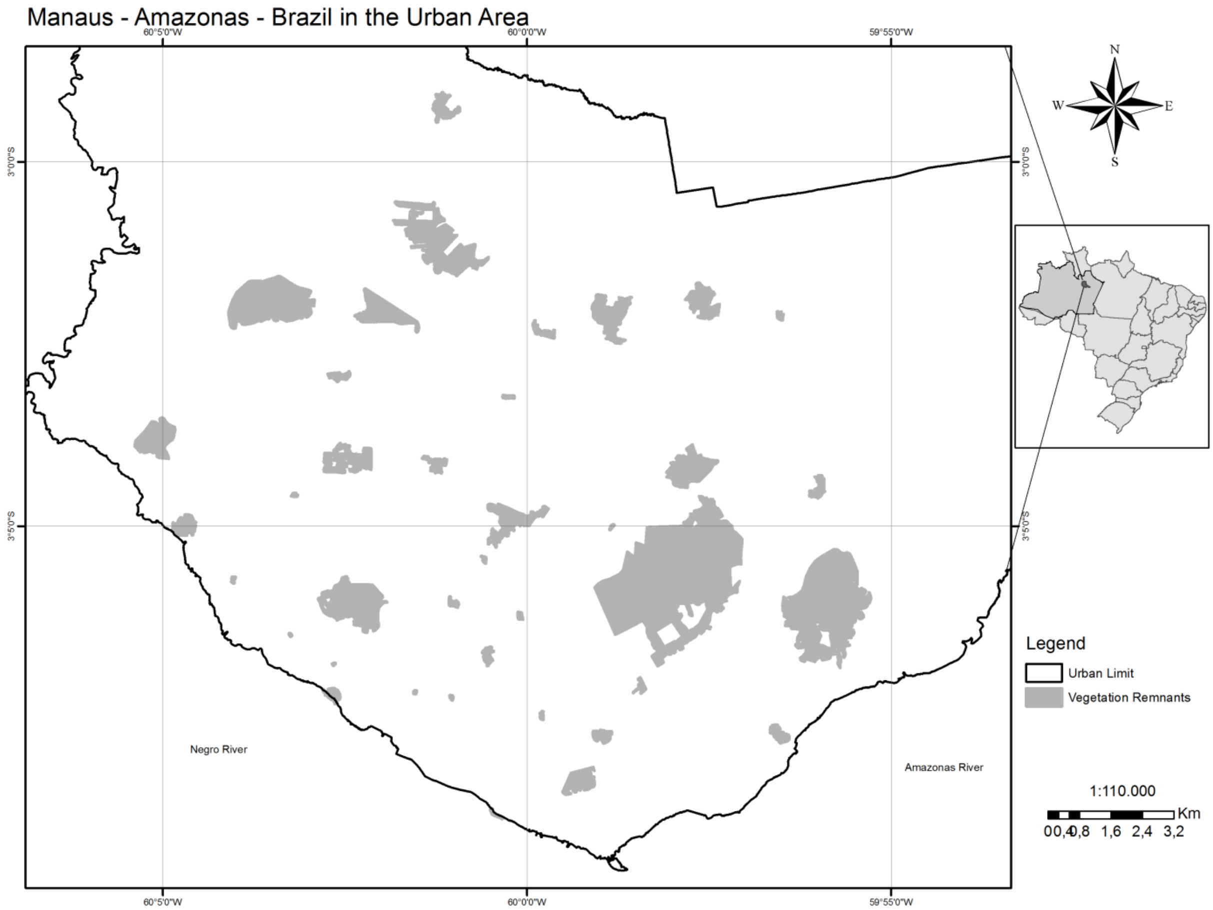
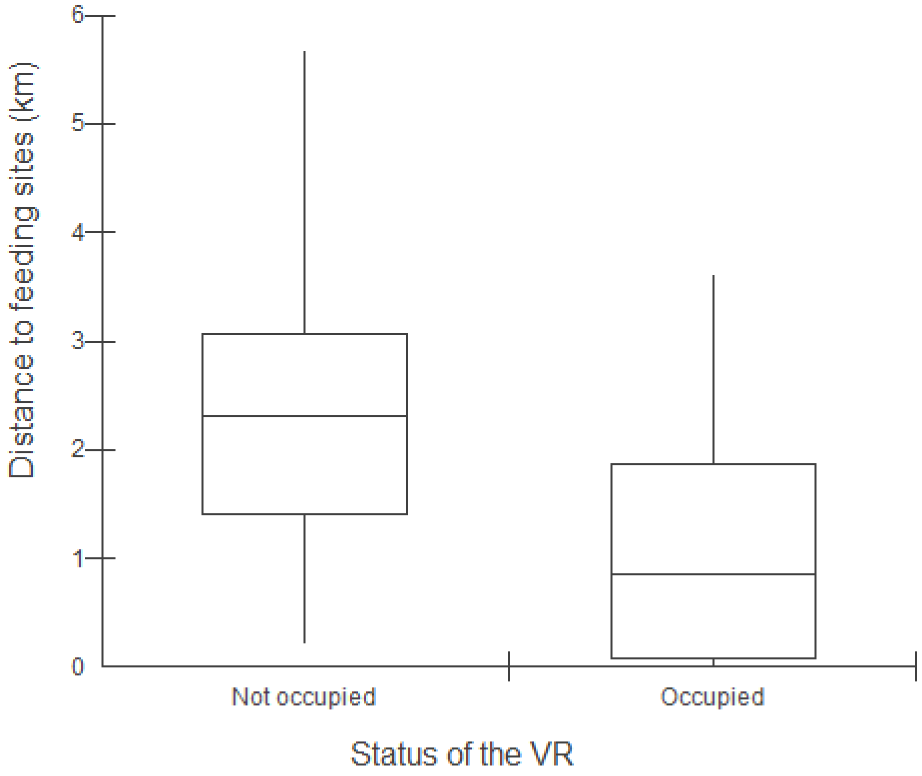
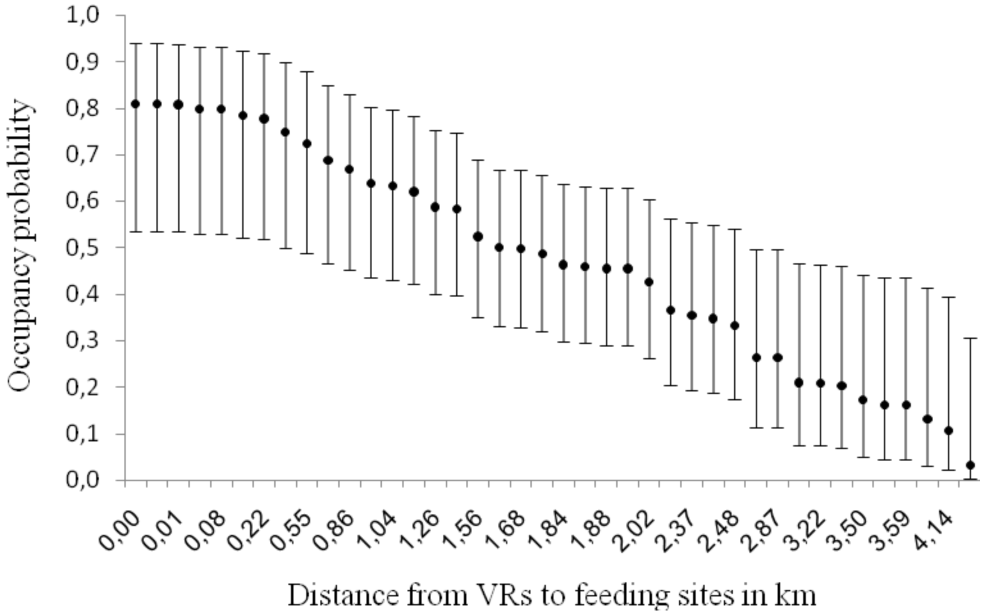

Manaus - Amazonas - Brazil in the Urban Area
60°5'0"W
60°0'0"W
59°55'0"W
3°0'0"S
3°5'0"S
N
W
E
S
Negro River
Amazonas River
Legend
Urban Limit
Vegetation Remnants
1:110.000
Km
0 0,4 0,8 1,6 2,4 3,2

Figure 2.



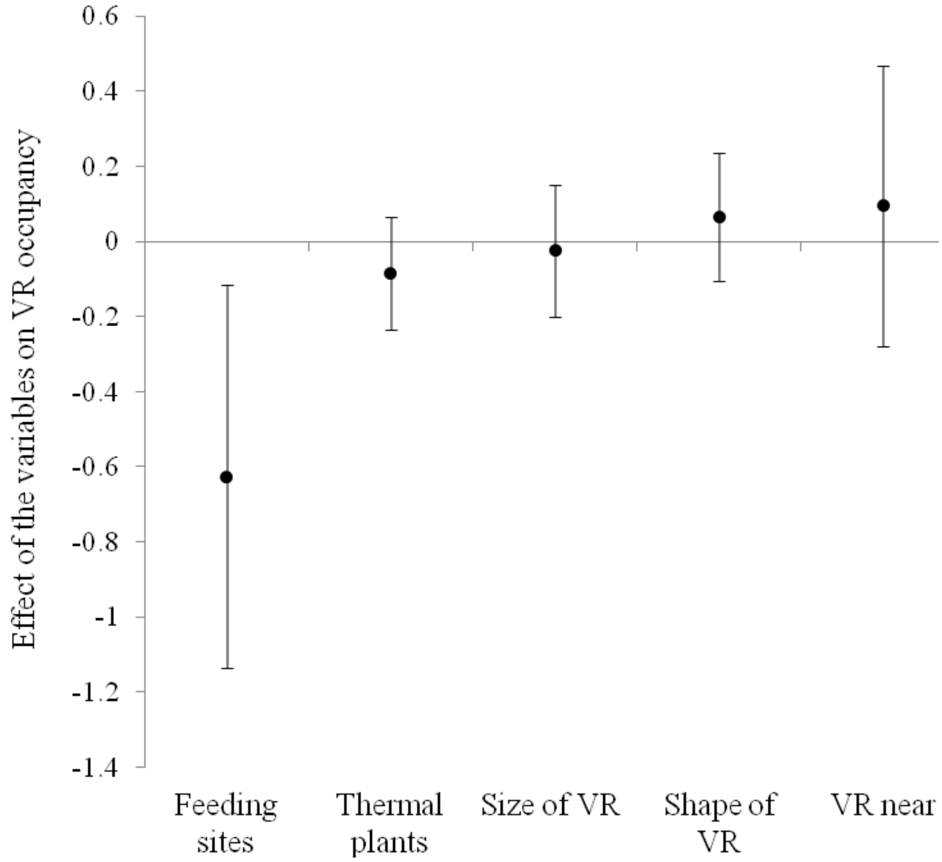
Distance to feeding sites (km)
0
1
2
3
4
5
6
Not occupied
Occupied
Status of the VR

Figure 3.



Occupancy probability
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0,00
0,01
0,08
0,22
0,55
0,86
1,04
1,26
1,56
1,68
1,84
1,88
2,02
2,37
2,48
2,87
3,22
3,50
3,59
4,14
Distance from VRs to feeding sites in km

Figure 4.



Effect of the variables on VR occupancy
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
Feeding sites
Thermal plants
Size of VR
Shape of VR
VR near

Table I – The subset of best models ($\Delta AIC \leq 2$) of vegetation remnant (VR) occupancy by communal roosts of Black Vultures (*Coragyps atratus*) in the urban area of Manaus – Central Amazon – Brazil.

Model	AIC_c	ΔAIC_c	w_i	k
Ψ(Feeding), p(.)	71.91	0	0.2195	3
Ψ(Feeding+Thermal), p(.)	72.89	0.98	0.1345	4
Ψ(Feeding+Shape), p(.)	73.20	1.29	0.1152	4
Ψ(Feeding+Size), p(.)	73.79	1.88	0.0858	4

Models include different combinations of variables of VR occupation. “Feeding” denotes the distance of VRs to Feeding sites. “Thermal” denotes the distance of VRs to thermal power plants. “Shape” denotes the shape of VR. “Size” denotes the size of VR. AIC_c is the Akaike Information Criterion corrected for small sample size; ΔAIC_c is the variation in Akaike Information Criterion values relative to the best model; w_i is the Akaike weight, a normalized likelihood of the model; and K is number of model parameters.

Capítulo 3

Freire, D. A.; Novaes,W. G.; Gomes, F. B. & Cintra, R. The use of thermal power plants by New World Vultures as an artifice for lift: a potential hazard for aircrafts. Manuscrito em preparação para *Wilson Journal of Ornithology*.

THE USE OF THERMAL POWER PLANTS BY NEW WORLD VULTURES AS AN ARTIFICE FOR LIFT: A POTENTIAL HAZARD FOR AIRCRAFTS

DAVI ALMEIDA FREIRE,[1] WEBER GALVÃO NOVAES,[2,4] FELIPE BITTIOLI RODRIGUES GOMES,[2] RENATO CINTRA [3]

[1] Universidade Federal do Amazonas, Instituto de Ciências Biológicas, Av. Rodrigo Otávio 3000, Coroado, zip code 69077-000, Manaus, Amazonas, Brazil

[2] Instituto Nacional de Pesquisas da Amazônia, Graduated Program in Ecology, Av. André Araújo 2936, Petrópolis, zip code 69080-971, Manaus, Amazonas, Brazil

[3] Instituto Nacional de Pesquisas da Amazônia, Coordenação de Biodiversidade, Av. André Araújo 2936, Petrópolis, zip code 69080-971, Manaus, Amazonas, Brazil

[4] Corresponding author; e-mail: webernovaes@gmail.com

ABSTRACT.--- Natural and artificial ascending thermals are intensively used by vultures to gain height and reduce effort in flight. The concentration of large numbers of vultures flying in thermals represents a great hazard to aircrafts due the risk of collisions with these birds. We investigated the use of six thermal power plants by vultures in the urban and suburban area of Manaus in Central Amazon, Brazil. All the plants sampled were used by vultures as an artifice to rise up in flight. More vultures were recorded in plants near to communal roosts and feeding sites. Early morning and late afternoon were the times with a greater concentration of vultures. The results demonstrate that vultures frequently use the thermal power plants, especially at times when they are moving between roosts and feeding sites, and the proximity of these plants to airports endangers aircraft safety. Certain management actions can reduce this hazard, such as not permitting the building of thermal plants close to airports; avoiding flight routes that pass too close to power plants; and the harassment of vultures at plants.

Key words.--- artificial thermal, Black Vultures, bird strike, Brazil, *Cathartes aura*, *Coragyps atratus*, Turkey Vultures.

Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*) are birds that use intensively thermal air currents to gain height and reduce effort in flight, the foraging energy cost, and to move between roosts and foraging sites (Newman 1958, Pennycuick 1983, Kirk and Mossman 1998). Vultures can use the natural thermals close to escarpments, mountains and canyons, updrafts along hills, and storm fronts as ascending currents (Kirk and Mossman 1998, Buckley 1999), or artificial thermals generated by anthropogenic activities (Mandel and Bildstain 2007).

Black and Turkey Vulture populations have increased in the last years (Avery 2004, Blackwell et al. 2007), and interactions with human activities have become a problem. One of these conflicts is collisions with aircraft (DeVault et al. 2005, Blackwell and Wright 2006, Avery et al. 2011). Only vultures caused losses of over US$ 57 million to the United States Air Force (USAF), and in Brazil, from 2000 to 2011, more than 980 vulture-aircraft strikes were reported (CENIPA 2012). Due to their heavy weight and flight behavior, vultures are considered one of the most hazardous birds to aircraft (Dolbeer et al. 2000, Zakrajsek and Bissonette 2005).

The recent Brazilian law No. 12.725 (BRASIL 2012) provides a stringent requirement on certain land uses that have the potential to attract hazardous wildlife, such as solid waste landfill, wetlands, agricultural activities, and commercial fishing, of a minimum distance of 20 km from the airport. However, thermal power plants (TPPs) have never been reported as structures frequently used by vultures and only one study has described a similar behavior in Turkey Vultures, which gain altitude while soaring in thermals above flared methane vents at a landfill site (Mandel and Bildstain 2007). The purposes of this study were to report the use of thermals produced in TPPs by vultures and understand the correlation of usage and the variables of time of day.

METHODS

We assessed the use of TPPs by vultures from February to August 2012 in the urban and rural zones of Manaus (03º 08' S and 60º 01' W), Central Amazon, Brazil. Manaus has an area of 377.4 km^2 and about 1.8 million inhabitants. The region has a rainy season from December to May, and a dry season from June to November. The annual mean precipitation is 2286 mm and the annual mean air temperature is 26.5 ºC.

In Manaus, according to the energy company, 82.2% of electrical energy is generated by 11 TPPs. We sampled 6 of the 11 TPPs. Five of these were widely distributed over the city area: Jaraqui TPP (02º 59' 12" S and 60º 01' 39" W); São José TPP (3º 03' 30" S and 59º 56' 51" W); Flores TPP (3º 04' 29" S and 60º 01' 25" W); Ponta Negra TPP (3º 05' 34" S and 60º 04' 23" W); and Aparecida TPP (3º 07' 48" S and 60º 01' 59" W); and one was in the rural zone: Cristiano Rocha TPP (2º 53' 31" S and 60º 01' 59" W). We selected these six TPPs so that all regions of the city were included in the sample. Each TPP was visited six times, in three periods of the day: early morning (0600 to 0800); midday (1100 to 1300); and late afternoon (1600 to 1800), throughout the rainy season (February to April) and dry season (June to August). Each sampling lasted 2 hr, with five counts every 30 min, conducted by a single observer at a point count located between 100 and 200 m from the vent pipes. All birds that approached the vents in flapping flight and then circle-soared above the vents were counted. To assess whether there were significantly variation in the numbers of vultures among the UTEs and certain times of the day, we used the Friedman rank sum test, a nonparametric version of the oneway ANOVA with repeated measures.

RESULTS

We observed vultures using the vent pipes of all TPPs (Fig. 1). Black Vultures and Turkey Vultures were observed using the thermals of vents at TPPs; however, Black Vultures were more numerous, representing more than 95% of the birds counted. Although uncommon, the Lesser Yellow-headed Vultures (*Cathartes burrovianus*) were observed at Cristiano Rocha TPP, located in a forested area. Other birds, such as the Yellow-headed Caracara (*Milvago chimachima*) and Swallow-tailed Kite (*Elanoides forficatus*) were also seen flying with vultures at the thermals. Despite the fact that we started recording the birds from 0600 to 1800, we initiated our observations before sunrise and extended them after sunset. We observed that vultures began to arrive at TPPs 30–40 min before sunrise and were present up to 20–30 min after sunset. On one occasion when the Flores TPP was not under operation in the morning, we observed that vultures flew toward the vent pipes, but promptly they went away, different from when the plants are running.

The number of vultures was significantly different between the TPPs (Friedman chi-squared = 52.0328, $P < 0.001$). We observed a higher number and concentration of vultures at Jaraqui and Aparecida TPPs than the other TTPs (Fig. 1). The highest vulture concentration was in the late afternoon in three UTEs (Table 1). However, at the Aparecida TPP, the highest concentration occurred at midday, but the difference to this concentration was not significant (Table 1).

DISCUSSION

Our results demonstrated an intensive use of thermals released in the vent pipes of TPPs by vultures. These birds are known for their extensive use of the ascending air currents produced by natural thermals to reduce the energetic costs of flight while foraging or moving between roosting and feeding areas (Pennycuick 1983, Kirk and Mossman 1998). Our study showed that beside natural thermals, the vultures used the thermals produced by anthropogenic activities, similar to those reported by Mandel and Bildstein (2007). However, unlike the results presented by Mandel and Bildstein (2007), which showed that Black Vultures did not soar in artificial thermals, we observed that Black Vultures soared and in much higher numbers than Turkey Vultures. Thus, it is very clear that Black Vultures are also able to take advantage of the turbulent thermals above the vents. An explanation for the highest number of Black Vultures at vent pipes could be the greater abundance of these birds in Manaus, concomitant with the constant increase in sites with organic residues. In addition, Black Vultures have a higher wing loading than Turkey Vultures, so must flap their wings more often to stay aloft (Buckley 1999). For this reason, they may have greater need for this type of aid to soar than Turkey Vultures.

We observed significant differences in the number of vultures among the TPPs. These differences can be due to the location of the TPPs. The Jaraqui TPP, which had the highest number of vultures, is located near forest remnants with several vulture roosts, and the Aparecida TPP, the second most used, is in downtown Manaus, with a higher availability of vulture feeding sites along the harbor area and around the fish markets. Nevertheless, it is very clear from the location of these TPPs that these structures are used to help vultures move between roosting and feeding areas.

The early morning and late afternoon were the periods in which more vultures used the vent pipes, demonstrating an increase in flight activity at this time. Normally, vultures stay perched for several hours in the morning and late afternoon, or fly at low altitudes, due to the smaller existence of natural thermal at these time (Coleman and Fraser 1989, Kirk and Mossman 1998). However, on windy days or when thermal currents remain strong, the vultures may leave the communal roost to forage as early as before sunrise and return to the roost after sunset (Kirk and Mossman 1998). In Manaus, we found similar patterns of behavior. Thus, we are reasonably convinced that the TPPs are spots that provide artificial thermals for vultures to extend their daily activity period.

Normally, vultures circle-soar in groups of many individuals, which means that any site that attracts these birds are extremely hazardous to aircraft. It is clear that all the TPPs investigated in our study pose a threat to the safety of aircraft in Manaus, since all of them are within a 20 km radius of airports. Certain management actions can reduce the hazard of the TPPs to aircraft, such as: only permitting the building of TPPs with a minimum safe distance and isolation from the airports, or not permitting the construction of an airport near to any existing TPPs. In cases where an airport is close to a TPP, air traffic control should avoid flight routes that pass too close to TPPs in times of an increased concentration of vultures; and harassment of the vultures at the TPPs.

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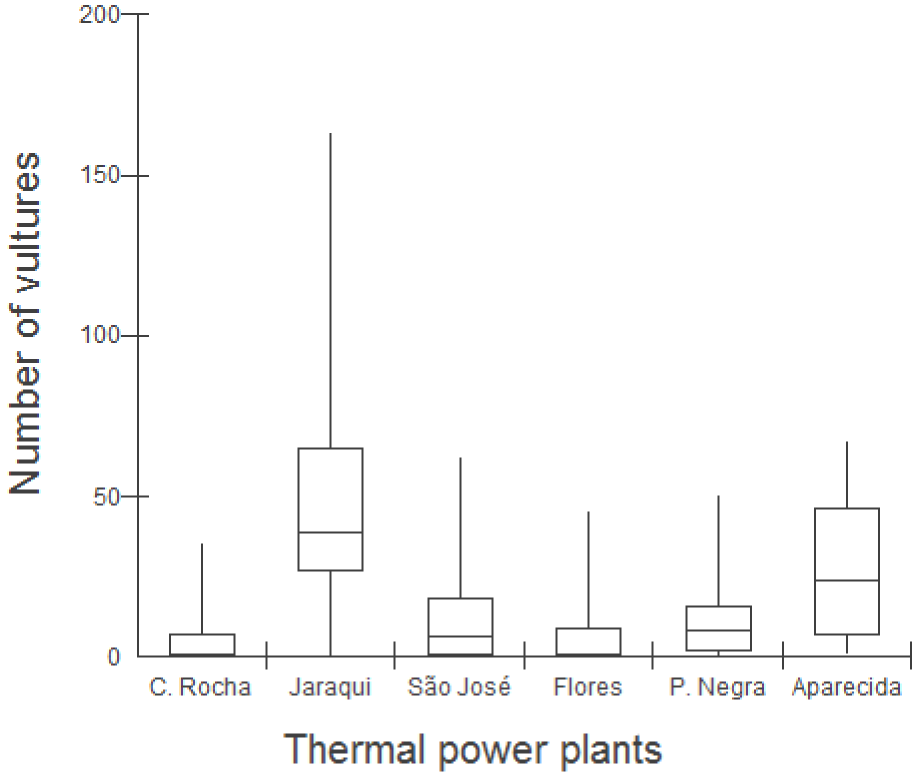
FIG. 1. Box plot with number of vultures observed at six thermal power plants in Manaus, Amazonas, Brazil, 2012. For each box plot, top bar is maximum observation, lower bar is minimum observation, top of box is upper or third quartile, bottom of box is lower or first quartile, middle bar is median value.

FIG. 1.



200
150
100
50
0
Number of vultures
C. Rocha
Jaraqui
São José
Flores
P. Negra
Aparecida
Thermal power plants

TABLE 1. Number of vultures using artificial thermal of thermal power plants according to the time of day in Manaus, Amazonas, Brazil, 2012.

Thermal Power Plant	Time of day			Friedman χ^2	*P*
	Morning	Midday	Afternoon		
	Mean	Mean (SD)	Mean (SD)		
C. Rocha	2.3	1.6	14.8	12.88	**0.001**
Jaraqui	48.7	22.6	66.3	3.8	0.14
São José	11.5	7.7	17.4	3.48	0.17
Flores	5.3	0.7	12.8	11.11	**0.003**
P. Negra	12.6	3.3	18.5	14	**0.0001**
Aparecida	15.0	34.9	31.2	1.4	0.496

SÍNTESE

Os resultados deste estudo demonstraram que urubus-de-cabeça-preta e urubus-de-cabeça-vermelha são espécies que estão utilizando o ambiente urbano, no entanto esse uso é influenciado por diferentes estruturas urbanas. Considerando que ambas as espécies de urubus tem causado sérios transtornos, dentre eles o risco de colisões com aeronaves, que causam elevados prejuízos financeiros e colocam em risco a vida de centenas de pessoas a bordo de uma aeronave, é fundamental o conhecimento das estruturas que afetam a ocorrência dessas espécies. Esse tipo de conhecimento é a base para elaboração de medidas de manejo eficientes.

Foi demonstrado neste estudo que urubus-de-cabeça-preta estão altamente associados a locais que ofertam grandes quantidades de alimentos, principalmente resíduos de origem orgânica. A proximidade para áreas com grande oferta de alimento também é um fator importante para a seleção de locais que sirvam como dormitórios comunitários de urubus-de-cabeça-preta. Os urubus-de-cabeça-preta são beneficiados pela falta de qualidade na coleta dos resíduos sólidos na área urbana, bem como do saneamento básico precário na cidade de Manaus. Portanto, o manejo eficiente das populações de urubus-de-cabeça-preta passa fundamentalmente pela drástica redução da oferta de alimento para essas aves, através de políticas de melhoria na coleta e destinação dos resíduos.

Por outro lado, os urubus-de-cabeça-vermelha estiveram associados aos fragmentos florestais urbanos. Mesmo com muitos problemas de crescimento desordenado, Manaus ainda possui grande quantidade de remanescente de floresta tropical em sua área urbana. Como os urubus-de-cabeça-vermelha são bem adaptados para encontrar carcaças de animais nesse tipo de ambiente, é provável que esses fragmentos florestais representem fontes de recurso alimentar, além de serem áreas favoráveis para reprodução e descanso. Como essa espécie de urubu tem comportamento de voo mais baixo que urubus-de-cabeça-preta, o risco de colisão com aeronaves é mais acentuado quando estes se encontram próximos dos aeroportos. Assim, ações no próprio ambiente aeroportuário pode reduzir o risco de colisões com essa espécie de urubu, dentre elas a redução de animais mortos nas áreas próximas das pistas de pouso e decolagem. Por fim, ações integradas como remoção de ninhos e inquietação podem ser utilizadas para ambas as espécies nos locais onde elas nidificam e/ou utilizam como dormitórios.

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APÊNDICE

Apêndice A - Descriptive data of vegetation remnants (VR) Black Vulture (*Coragyps atratus*) occupation status as a communal roost, Manaus, Central Amazon, Brazil.

VRs	Size (ha)	Shape	Nearest VR	Feeding sites	Thermal	Status
1	20.49	2.4	0.12	3.21	0.8	Occupied
2	152.62	3.4	0.07	3.59	2.53	Occupied
3	190.67	1.4	0.02	4.14	5.46	Not occupied
4	60.89	1.9	0.01	2.4	4	Not occupied
5	7.72	1.6	0.07	2.48	3.43	Not occupied
6	61.63	1.3	0.02	5.66	5	Not occupied
7	0.94	2.0	0.46	3.87	3.22	Not occupied
8	47.54	4.4	0.02	1.68	1.34	Not occupied
9	10.22	3.0	0.03	0.86	0.52	Occupied
10	20.9	1.8	0.01	3.59	0.95	Not occupied
11	8.46	1.9	0.11	1.26	5.54	Not occupied
12	59.01	2.0	0.08	0.01	3.95	Occupied
13	40.45	1.8	0.03	1.86	2.84	Occupied
14	2.2	1.8	0.02	1.01	2.54	Not occupied
15	2	1.8	0.01	0.75	3.06	Occupied
16	68.86	1.5	0.03	1.73	1.49	Occupied
17	0.68	1.4	0.09	0	4.68	Occupied
18	54.91	3.0	0.04	1.67	0.71	Occupied
19	0.92	2.4	0.08	1.88	1.93	Not occupied
20	2.03	1.2	0.09	1.88	3.04	Occupied

21	129.75	2.1	0.02	1.1	2.7	Not occupied
22	0.31	2.2	0.58	0.08	2.17	Occupied
23	0.27	1.5	0.56	0.55	1.45	Not occupied
24	8.65	1.8	0.12	0.08	2.88	Occupied
25	3.46	1.5	0.31	3.5	3.23	Not occupied
26	1.5	1.9	0.13	2.87	3.09	Not occupied
27	6.52	2.5	0.08	1.84	1.87	Not occupied
28	0.65	1.6	0.08	1.56	2.22	Not occupied
29	1.2	1.7	0.01	3.26	3.28	Not occupied
30	1.98	1.8	1.39	0.41	4	Occupied
31	2.06	1.1	0.14	2.31	1.25	Not occupied
32	0.46	2.1	0.1	2.02	2.34	Not occupied
33	773.89	2.5	0.02	0	2.11	Occupied
34	10.82	2.0	0.27	3.22	0.77	Occupied
35	359.57	2.0	0.01	2.86	3.1	Not occupied
36	3.94	2.0	0.11	2.37	3.98	Not occupied
37	1.41	1.4	0.29	0.22	3.02	Not occupied
38	10.42	1.6	0.03	1.04	1	Not occupied
39	11.11	2.0	0.03	0.17	3.1	Occupied
40	32.02	1.7	0.01	1.28	1.69	Occupied

Details about shape see methods section. VR nearest is the distance of VRs to the nearest VR in km. Feeding sites is the distance of VRs to Feeding sites in km. Thermal is the distance of VRs in km to thermal power plants.

Apêndice B – The complete set of 32 models of vegetation remnant (VR) occupancy by communal roosts of Black Vultures (*Coragyps atratus*) in the urban area of Manaus – Central Amazon – Brazil.

Model	AIC_c	ΔAIC_c	w_i	k
Ψ(Feeding), *p*(.)	71.91	0	0.2195	3
Ψ(Feeding+Thermal), *p*(.)	72.89	0.98	0.1345	4
Ψ(Feeding+Shape), *p*(.)	73.2	1.29	0.1152	4
Ψ(Feeding+Size), *p*(.)	73.79	1.88	0.0858	4
Ψ(Feeding+VR near), *p*(.)	74.32	2.41	0.0658	4
Ψ(Feeding+Size+Thermal), *p*(.)	74.85	2.94	0.0505	5
Ψ(Feeding+Shape+Thermal), *p*(.)	74.99	3.08	0.0471	5
Ψ(Feeding+Thermal+VR near), *p*(.)	75.33	3.42	0.0397	5
Ψ(Feeding+Size+Shape), *p*(.)	75.48	3.57	0.0368	5
Ψ(Feeding+Shape+VR near), *p*(.)	75.67	3.76	0.0335	5
Ψ(Feeding+Size+VR near), *p*(.)	76.24	4.33	0.0252	5
Null	76.85	4.94	0.0186	2
Ψ(Feeding+Size+Thermal+VR near), *p*(.)	77.3	5.39	0.0148	6
Ψ(Feeding+Size+Shape+Thermal), *p*(.)	77.33	5.42	0.0146	6
Ψ(Feeding+Shape+Thermal+VR near), *p*(.)	77.55	5.64	0.0131	6
Ψ(Thermal), *p*(.)	77.72	5.81	0.012	3
Ψ(Feeding+Size+Shape+VR near), *p*(.)	78.02	6.11	0.0103	6
Ψ(Shape), *p*(.)	78.1	6.19	0.0099	3
Ψ(Size), *p*(.)	78.59	6.68	0.0078	3
Ψ(VR near), *p*(.)	78.61	6.7	0.0077	3

Ψ(Thermal+VR near), *p*(.)	79.39	7.48	0.0052	4
Ψ(Size+Thermal), *p*(.)	79.5	7.59	0.0049	4
Ψ(Shape+VR near), *p*(.)	79.78	7.87	0.0043	4
Ψ(Shape+Thermal), *p*(.)	79.8	7.89	0.0042	4
Ψ(Feeding+Size+Shape+Thermal+VR), *p*(.)	79.92	8.01	0.004	7
Ψ(Size+VR near), *p*(.)	80.17	8.26	0.0035	4
Ψ(Size+Shape), *p*(.)	80.21	8.3	0.0035	4
Ψ(Size+Thermal+VR near), *p*(.)	80.95	9.04	0.0024	5
Ψ(Shape+Thermal+VR near), *p*(.)	81.52	9.61	0.0018	5
Ψ(Size+Shape+VR near), *p*(.)	81.79	9.88	0.0016	5
Ψ(Size+Shape+Thermal), *p*(.)	81.91	10	0.0015	5
Ψ(Size+Shape+Thermal+VR near), *p*(.)	83.48	11.57	0.0007	6

Models include different combinations of variables of VR occupation. “Feeding” denotes the distance of VRs to Feeding sites. “Thermal” denotes the distance of VRs to thermal power plants. “VR near” denote de distance of VRs to the nearest VR. “Shape” denotes the shape of VR. “Size” denotes the size of VR. AIC_c is the Akaike Information Criterion corrected for small sample size; ΔAIC_c is the variation in Akaike Information Criterion values relative to the best model; w_i is the Akaike weight, a normalized likelihood of the model; and K is number of model parameters.

ANEXOS

ANEXO A – Parecer da banca examinadora de qualificação.

PG·ECO·INPA
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AULA DE QUALIFICAÇÃO

PARECER

Aluno(a): WEBER GALVÃO NOVAES
Curso: ECOLOGIA
Nível: DOUTORADO
Orientador(a): RENATO CINTRA SOARES

Título:

"Uso de habitat por espécies de urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus-AM"

BANCA JULGADORA:

TITULARES:
Albertina Pimentel Lima (INPA)
Camila Ribas (INPA)
Eduardo Martins Venticinque (UFAM)
Gonçalo Ferraz (PDBFF)
Paulo Bobrowiec (INPA)

SUPLENTES:
Regina Luizão (INPA)
Claudia Keller (INPA)

EXAMINADORES	PARECER		ASSINATURA
Albertina Pimentel Lima (INPA)	( ) Aprovado	( ) Reprovado	
Camila Ribas (INPA)	(X) Aprovado	( ) Reprovado	
Eduardo Martins Venticinque (UFAM)	(X) Aprovado	( ) Reprovado	
Gonçalo Ferraz (PDBFF)	(X) Aprovado	( ) Reprovado	Gonçalo Ferraz
Paulo Bobrowiec (INPA)	(x) Aprovado	( ) Reprovado	Paulo Bobrowiec
Regina Luizão (INPA)	(X) Aprovado	( ) Reprovado	
Claudia Keller (INPA)	( ) Aprovado	( ) Reprovado	

Manaus(AM), 20 de novembro de 2009

OBS: O aluno discorreu a aula de forma bem didática e no prazo regulamentar o que levou a sua aprovação. Entretanto, a banca recomenda fortemente que o aluno reveja o delineamento amostral com base em uma definição de objetivos mais claros/focados.

PROGRAMA DE PÓS-GRADUAÇÃO EM BIOLOGIA TROPICAL E RECURSOS NATURAIS – PIPG BTRN
PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA PPG-ECO/INPA
Av. Efigênio Sales, 2239 – Bairro: Adrianopolis – Caixa Postal: 478 – CEP: 69.011-970, Manaus/AM.
Fone: (+55) 92 3643-1909 Fax:(+55) 92 3643-1909
site: http://pg.inpa.gov.br e-mail: pgeco@inpa.gov.br

ANEXO B – Parecer do avaliador do trabalho escrito, Dr. Caio Graco.

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Programa de Pós-graduação em Ecologia

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INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA

Avaliação de tese de doutorado

Título: **Uso do habitat por urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus, AM**

Aluno: Weber Galvão Novaes

Orientador: Renato Cintra   Co-orientador: -

Avaliador: **Caio Graco Machado**

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(x)	( )	( )	( )
Revisão bibliográfica	( )	(x)	( )	( )
Desenho amostral/experimental	(x)	( )	( )	( )
Metodologia	(x)	( )	( )	( )
Resultados	(x)	( )	( )	( )
Discussão e conclusões	( )	(x)	( )	( )
Formatação e estilo texto	(x)	( )	( )	( )
Potencial para publicação em periódico(s) indexado(s)	(x)	( )	( )	( )

PARECER FINAL

(x) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

( ) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

( ) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Feira de Santana,   **01/07/2013**
Local   **Data**   **Assinatura**

Comentários e sugestões podem ser enviados como uma continuação desta ficha, como arquivo separado ou como anotações no texto impresso ou digital da tese. Por favor, envie a ficha assinada, bem como a cópia anotada da tese e/ou arquivo de comentários por e-mail para pgecologia@gmail.com e flaviacosta001@gmail.com ou por correio ao endereço abaixo. O envio por e-mail é preferível ao envio por correio. Uma cópia digital de sua assinatura será válida.

Endereço para envio de correspondência:

Flávia Costa
DCEC/CPEC/INPA
CP 478
69011-970 Manaus AM
Brazil

ANEXO C – Parecer da avaliadora do trabalho escrito, Dra. Tânia Sanaiotti.

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Avaliação de tese de doutorado

Título: **Uso do habitat por urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus, AM**

Aluno: Weber Galvão Novaes

Orientador: Renato Cintra Co-orientador: -

Avaliador:

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	( )	(X)	( )	( )
Revisão bibliográfica	(X)	( )	( )	( )
Desenho amostral/experimental	( )	(X)	( )	( )
Metodologia	(X)	( )	( )	( )
Resultados	( )	(X)	( )	( )
Discussão e conclusões	( )	(X)	( )	( )
Formatação e estilo texto	(X)	( )	( )	( )
Potencial para publicação em periódico(s) indexado(s)	(X)	( )	( )	( )

PARECER FINAL

(X) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

( ) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

( ) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Manaus, 11 Julho/2013, Tânia Margarete Sanaiotti
Local, Data, Assinatura

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Endereço para envio de correspondência:

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69011-970 Manaus AM
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Anexo D - Parecer do avaliador do trabalho escrito, Dr. Fabrizio Sergio.

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Avaliação de tese de doutorado

Título: **Uso do habitat por urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus, AM**

Aluno: Weber Galvão Novaes

Orientador: Renato Cintra Co-orientador: -

Avaliador: **Fabrizio Sergio**

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(X)	( )	( )	( )
Revisão bibliográfica	( )	(X)	( )	( )
Desenho amostral/experimental	( )	(X)	( )	( )
Metodologia	( )	(X)	( )	( )
Resultados	( )	(X)	( )	( )
Discussão e conclusões	(X)	( )	( )	( )
Formatação e estilo texto	(X)	( )	( )	( )
Potencial para publicação em periódico(s) indexado(s)	(X)	( )	( )	( )

PARECER FINAL

(X) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

( ) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

( ) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

SEVILLA (ESPAÑA), 15/07/2013, Fabrizio Sergio

Local Data Assinatura

Comentários e sugestões podem ser enviados como uma continuação desta ficha, como arquivo separado ou como anotações no texto impresso ou digital da tese. Por favor, envie a ficha assinada, bem como a cópia anotada da tese e/ou arquivo de comentários por e-mail para pgecologia@gmail.com e flaviacosta001@gmail.com ou por correio ao endereço abaixo. O envio por e-mail é preferível ao envio por correio. Uma cópia digital de sua assinatura será válida.

Endereço para envio de correspondência:

Flávia Costa
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Brazil

ANEXO E - Parecer do avaliador do trabalho escrito, Dr. Fernando Abad-Franch.

Instituto Nacional de Pesquisas da Amazônia - INPA
Programa de Pós-graduação em Ecologia

Avaliação de tese de doutorado

Título: **Uso do habitat por urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus, AM**

Aluno: Weber Galvão Novaes

Orientador: Renato Cintra Co-orientador: -

Avaliador: **Fernando Abad-Franch**

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(x)	( )	( )	( )
Revisão bibliográfica	( )	(x)	( )	( )
Desenho amostral/experimental	( )	(x)	( )	( )
Metodologia	( )	( )	(x)	( )
Resultados	( )	( )	(x)	( )
Discussão e conclusões	( )	( )	(x)	( )
Formatação e estilo texto	( )	( )	(x)	( )
Potencial para publicação em periódico(s) indexado(s)	( )	(x)	( )	( )

PARECER FINAL

( ) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

(x) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

( ) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Manaus ,	**22 Julho 2013,**	
Local	**Data**	**Assinatura**

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Endereço para envio de correspondência:

Flávia Costa
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CP 478
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ANEXO F - Parecer do avaliador do trabalho escrito, Dr. Leonardo Fernandes França.

Instituto Nacional de Pesquisas da Amazônia - INPA
Programa de Pós-graduação em Ecologia

Avaliação de tese de doutorado

Título: **Uso do habitat por urubus (Família Cathartidae Lafresnaye, 1839) em áreas urbanas e naturais em Manaus, AM**

Aluno: Weber Galvão Novaes

Orientador: Renato Cintra Co-orientador: -

Avaliador: **Leonardo Fernandes França**

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	( )	(X)	( )	( )
Revisão bibliográfica	( )	( )	(X)	( )
Desenho amostral/experimental	( )	(X)	( )	( )
Metodologia	( )	( )	(X)	( )
Resultados	( )	( )	(X)	( )
Discussão e conclusões	( )	( )	(X)	( )
Formatação e estilo texto	( )	(X)	( )	( )
Potencial para publicação em periódico(s) indexado(s)	( )	(X)	( )	( )

PARECER FINAL

( ) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

( ) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

(X) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Mossoró RN, **01 de Agosto de 2013,** Leonardo Fernandes França
Local **Data** **Assinatura**

Comentários e sugestões podem ser enviados como uma continuação desta ficha, como arquivo separado ou como anotações no texto impresso ou digital da tese. Por favor, envie a ficha assinada, bem como a cópia anotada da tese e/ou arquivo de comentários por e-mail para pgecologia@gmail.com e flaviacosta001@gmail.com ou por correio ao endereço abaixo. O envio por e-mail é preferível ao envio por correio. Uma cópia digital de sua assinatura será válida.

Endereço para envio de correspondência:

Flávia Costa
DCEC/CPEC/INPA
CP 478
69011-970 Manaus AM
Brazil

ANEXO G – Ata da defesa pública da tese.

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BRASIL
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ATA DA DEFESA PÚBLICA DA TESE DE DOUTORADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA DO INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA

Aos 18 dias do mês de setembro do ano de 2013, às 09:00 horas, na sala 2 do Programa de Pós-Graduação em Ciências de Florestas Tropicais - CFT, Campus 3 do INPA., reuniu-se a Comissão Examinadora de Defesa Pública, composta pelos seguintes membros: o(a) Prof(a). Dr(a). **Cintia Cornelius Frische**, da Universidade Federal do Amazonas - UFAM, o(a) Prof(a). Dr(a). **Marcelo Menin**, da Universidade Federal do Amazonas - UFAM e o(a) Prof(a). Dr(a). **Fernando Abad-Franch**, da Fundação Oswaldo Cruz - FIOCRUZ, tendo como suplentes o(a) Prof(a). Dr(a). Ronis Da Silveira, da Universidade Federal do Amazonas - UFAM e o(a) Prof(a). Dr(a). George Henrique Rebêlo, do Instituto Nacional de Pesquisas da Amazônia - INPA, sob a presidência do(a) primeiro(a), a fim de proceder a argüição pública do trabalho de **TESE DE DOUTORADO** de **WEBER GALVÃO NOVAES**, intitulado "Uso do habitat por urubus (*Família Cathartidae Lafresnaye*, 1839) em áreas urbanas e naturais em Manaus – Amazonas", orientado pelo(a) Prof(a). Dr(a). Renato Cintra, do Instituto Nacional de Pesquisas da Amazônia – INPA.

Após a exposição, o(a) discente foi argüido(a) oralmente pelos membros da Comissão Examinadora, tendo recebido o conceito final:

- [X] APROVADO(A) — [ ] REPROVADO(A)
- [X] POR UNANIMIDADE — [ ] POR MAIORIA

Nada mais havendo, foi lavrada a presente ata, que, após lida e aprovada, foi assinada pelos membros da Comissão Examinadora.

Prof(a).Dr(a). Cintia Cornelius Frische ____________________

Prof(a).Dr(a). Marcelo Menin ____________________

Prof(a).Dr(a). Fernando Abad-Franch ____________________

____
Coordenação PPG-ECO/INPA