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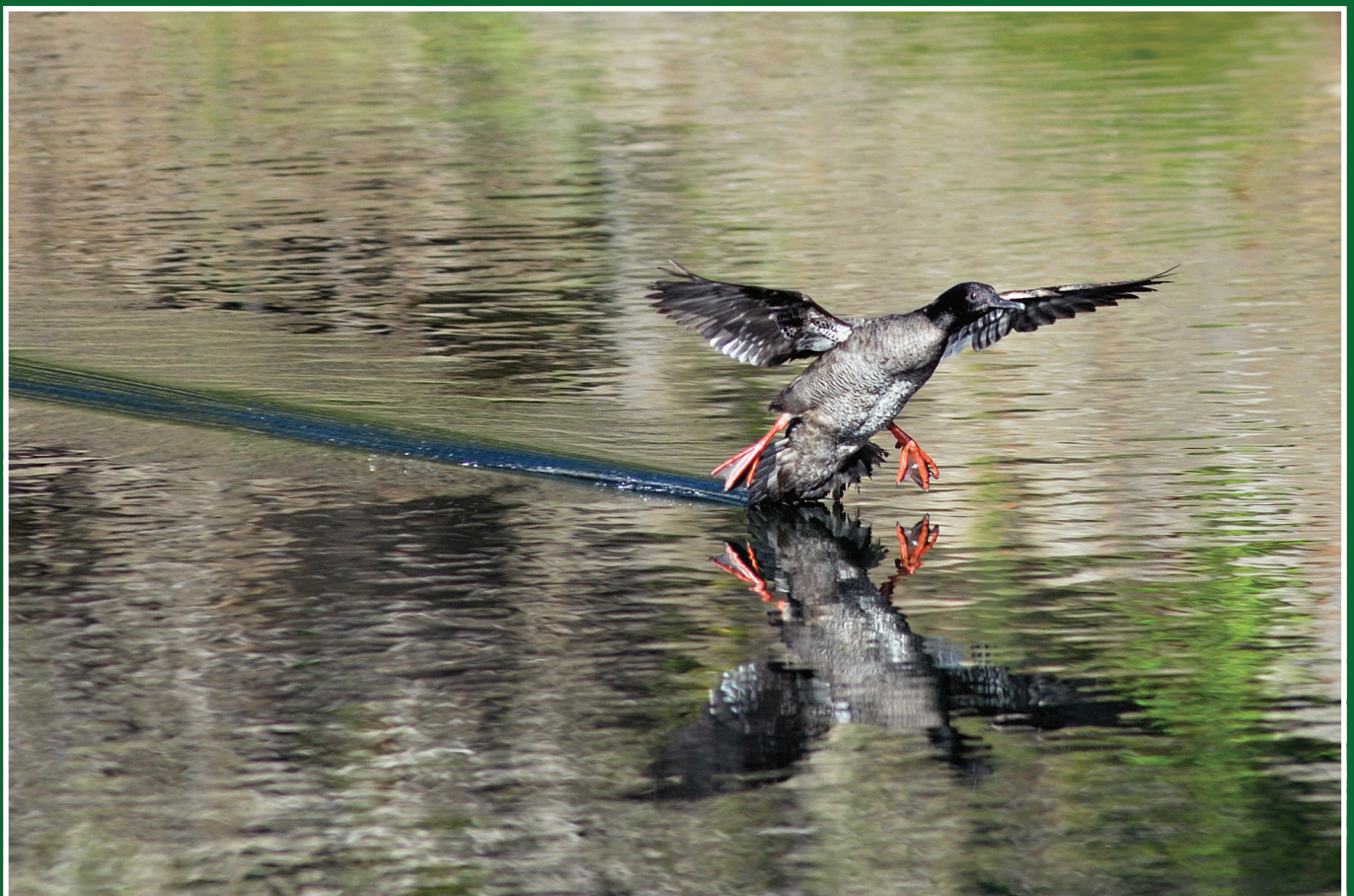
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Density estimates of the Bare-faced Curassow (*Crax fasciolata*) in the Brazilian Pantanal

Arnaud Léonard Jean Desbiez^{1,2} and Christine Steiner São Bernardo³

¹ Royal Zoological Society of Scotland, Murrayfield, Edinburgh, EH12 6TS, Scotland.

² Escola Superior de Conservação Ambiental e Sustentabilidade (ESCAS-IPÊ). Rodovia Dom Pedro I, km 47, Caixa Postal 47, CEP 12960-000, Nazaré Paulista, SP, Brasil. E-mail: adesbiez@hotmail.com

³ Departamento de Ciências Biológicas, Universidade Estadual do Sudoeste da Bahia, Campus Jequié. Rua José Moreira Sobrinho, s/n, Jequié, CEP 45206-190, Jequié, BA, Brasil. Author for correspondence. E-mail: christinesteiner@yahoo.com

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RESUMO: Estimativas de densidade de mutum-do-penacho (*Crax fasciolata*) no Pantanal brasileiro. O Pantanal brasileiro é uma das maiores áreas alagadas do mundo e está localizado no centro do continente sul-americano. Utilizando transecções lineares, a densidade populacional do mutum-do-penacho *Crax fasciolata* foi estimada em três paisagens diferentes (Floresta, Cerrado e Planície inundável), na região central do Pantanal brasileiro. Este estudo fornece uma oportunidade rara para obter densidade desta ave em uma paisagem onde impactos antrópicos, como a destruição de habitat e caça, são pouco frequentes. A densidade populacional de mutuns-de-penacho foi maior na floresta (4,66 indivíduos/km²) e menor na planície inundável (0,43 indivíduos/km²). Habitats florestados são habitats-chave para mutuns-de-penacho. Aves solitárias foram encontradas com maior frequência (51%, n = 96) ou em pares macho/fêmea (39%, n = 74) e foram raramente observadas em grupos grandes (10%, n = 20). Contudo, em quatro ocasiões foi observado o que pareceu ser comportamento de leque. Revisamos estudos com densidades populacionais de cracídeos, mas não encontramos estudos com *Crax fasciolata* em nenhum bioma. Resultados deste estudo predizem que a atual intensificação e mudança no uso da terra no Pantanal será prejudicial para mutuns-de-penacho.

PALAVRAS-CHAVE: Cracídeos; Pantanal brasileiro; Densidade populacional; Áreas alagadas.

ABSTRACT: Density estimates of the Bare-faced Curassow (*Crax fasciolata*) in the Brazilian Pantanal. The Brazilian Pantanal is one of the world's largest wetland and is located in the center of the South American Continent. Using line transects the population density of Bare-faced Curassow, *Crax fasciolata* was estimated in three landscapes (Forest, Cerrado and Floodplain) in the central region of the Brazilian Pantanal. This study provides a rare opportunity to obtain densities for this bird in a landscape where anthropogenic impacts such as habitat destruction and hunting are low. The population density of Bare-faced Curassows was highest in the forest landscape (4.66 individuals/km²) and lowest in the floodplain landscape (0.43 individuals/km²). Forested habitats are key habitats for the Bare-faced Curassows. The birds were mostly encountered alone (51%, n = 96) or in male/female pairs (39%, n = 74) and were rarely observed in larger groups (10%, n = 20). However, on four occasions what appeared to be classical lekking behaviour was observed. We reviewed studies on cracids population densities but we found no studies with *Crax fasciolata* in any biome. Results from this study predict that current intensifications and changes in land use practices in the Pantanal will be detrimental to Bare-faced Curassows.

KEY-WORDS: Cracids; Brazilian Pantanal; Population density; Wetland.

The Bare-faced Curassow, *Crax fasciolata* is widespread throughout South America and can be found from northern Brazil, to northern Argentina (BirdLife International 2009). Three subspecies are recognised for this taxon: the *pinima* of north-east Brazil, *grayi* in east Bolivia and the nominate in central and south-west Brazil, Paraguay and north Argentina (Clay and Oren 2006, BirdLife International 2009). Although the species occupies a relatively large range, it has disappeared from parts of its former range as a result of habitat destruction and hunting (del Hoyo 1994). Even though overall population trends appears to be decreasing, this species has an extremely large range, and hence does not approach the thresholds for vulnerable and is currently listed as least

concern (IUCN 2009). However, the species is listed as being of "High conservation priority" in the IUCN Cracid Action Plan, and more information on population size trends and habitat loss are needed, especially for the core range in Brazil (BirdLife International 2009).

This paper presents the first population density estimates for the Bare-faced Curassow in the central region of the Brazilian Pantanal. Located in of the centre of South American continent, the Pantanal is an immense floodplain that concentrates the headwaters of the upper Paraguay River and its tributaries and covers an area of about 160 000 km². Vegetation types in the Pantanal are highly influenced by the nearby Cerrado, Chaco and Amazonian forest biomes (Prance and Schaller 1982). Most of the

land in the Pantanal are privately owned and are exploited as extensively managed cattle ranches (Harris *et al.* 2005). The Pantanal is considered one of the very few examples of sustainable management of a tropical ecosystem (Junk and de Cunha 2005). Due to the low soil fertility and annual floods low cattle densities are maintained over large areas that can stretch over thousands of hectares of undisturbed landscape. In addition, in the central region of the Pantanal native mammals are seldom hunted as the introduced feral pig (*Sus scrofa*) is the main hunting target in the region (Desbiez *et al.* 2011). The Bare-faced Curassow, which is widely hunted throughout its distribution (del Hoyo 1994) is rarely killed by local people (Desbiez *et al.* 2011). Therefore this study of Bare-faced Curassow in the central region of the Pantanal is a rare opportunity to obtain densities for this bird in a landscape where anthropogenic impacts such as habitat destruction and hunting are low.

MATERIAL AND METHODS

Study area

This study took place in a 200 km² area which included six traditionally managed cattle ranches in central Pantanal (18°59'S, 56°39'W). Traditionally managed ranches are mostly comprised of native vegetation, cattle range freely within large grazing areas, and human densities and anthropogenic impacts are considered low. The study area contained three different landscapes characteristic of the region: (1) floodplains, dominated by seasonally flooded grasslands; (2) forests, characterized by strips and patches of semi-deciduous forest, and (3) Cerrado, covered by scrub forest and open scrub grasslands. Further details of the study area are provided in Desbiez (2007) and Soriano *et al.* (1997).

Density estimations

Twenty one transects ranging from three and a half to five km and marked at 50 m intervals were randomly placed within the study area with no previous knowledge of animal distribution: Seven in the forest landscape, six in the cerrado landscape and eight in the floodplain. Survey took place between July 2002 and October 2004. Transects were walked alone by the same observer (AD), except for the ones in the floodplains, 200 km of which were walked alone by another trained observer. Transects were cleaned bi-monthly to ensure detection of animals on the line and to avoid noise while walking. Transect census began at sun rise; no nocturnal surveys were conducted. In both the forested and cerrado landscape, transects were walked out at a pace of approximately 1-2 km

per hour, followed by a minimum one hour wait in a location 500 m from the end of the transect, and then walked back. In the floodplain, transects were walked out at 2-4 km per hour and, at the end of the trail, the observer stopped data collection, walked to a parallel transect distant 1 km, and walked back along it collecting data. For detections to remain independent events, Bare-faced Curassows were grouped into clusters and group sightings were considered as single detections. Date, time of the day, species, perpendicular distance from the transect to the center of the group, habitat type, group size and activity were registered for each sighting. Perpendicular distances were estimated to the nearest meter with a measuring tape or using a GPS. A total of 2 174 km of transects were walked (848 km in the forest landscape, 906 in the cerrado landscape and 420 in the floodplain landscape).

Densities were estimated using DISTANCE software (Thomas *et al.* 2006). Multiple Covariates Distance Sampling (MCDS) methods (Marques and Buckland 2003) were applied to estimate densities because the Pantanal is an extremely heterogeneous environment, where landscapes are composed of a mosaic of exceptionally different habitats. This means that, on the same line-transect, the observer may walk through a forested environment with a maximum visibility of 25 m and later find him(her)self in open grasslands, where the maximum visibility is well over 250 m. In MCDS, the detection function is modeled as a function of both distance and one or more additional covariates, in this case habitat visibility. Habitat types were grouped in two categories: closed and open, according to the visibility within the habitat and entered as factorial covariates. Closed habitats included vegetated habitats such as semi-deciduous forests or scrub forests where visibility was restricted by the vegetation. Open habitats included grasslands and scrub grasslands where visibility was greater. Effort in each habitat type on each trail was quantified. The study area was divided into three strata based on landscape: floodplain, forest, cerrado. A global detection function and strata specific encounter rates were used to obtain density estimates for each landscape. Distance data from repeat transect visits were pooled. The detection function for was modeled using the half-normal, key function and cosine series adjustments. The Akaike's Information Criterion (AIC) was used to select the combination that produced the best fit. Model fit and the fit of the estimated detection functions to the empirical histograms of distance data were assessed through the Qq-plot and the Chi-sq goodness-of-fit, Kolmogorov-Smirnov and Cramer-von Mises tests reported by DISTANCE.

RESULTS

A total of 190 sightings of Bare-faced Curassow individuals (n = 96) or groups (n = 94) occurred from the

TABLE 1: Density estimates (individuals/km²), standard error and coefficient of variation calculated using the half-normal, key function and cosine series adjustments in DISTANCE of Bare-faced Curassow from central Pantanal between July 2002 and October 2004.

Landscape	Density (individuals/km ²)	Standard error	% Coefficient of variation
Whole study area	3.67	0.82	22.37
Forest	4.66	1.26	27.15
Cerrado	2.90	0.63	21.67
Floodplain	0.43	0.19	43.68

line transects. In the forest landscape they were sighted 112 times, in the cerrado landscape they were sighted 72 times and in the floodplain landscape they were sighted only 6 times. The density of Bare-faced Curassows was highest in the forest landscape (4.66 individuals/km²) and lowest in the floodplain landscape (0.43 individuals/km²) (Table 1). Most of the sightings of the Bare-faced Curassows were made in closed forested habitats (72%, n = 137) and few were made in open grasslands (28%, n = 53). When Bare-faced Curassows were sighted in the open grasslands they were usually near the forest edge. In the floodplain landscape they were only seen in the small pockets of forest. Forested habitats appear to be key habitats for the Bare-faced Curassows.

The birds were mostly encountered either alone (51%, n = 96) or in male/female pairs (39%, n = 74) and were rarely observed in larger groups (10%, n = 20) (Table 2). The birds were almost always sighted on the ground (93%, n = 176), but occasionally they were seen resting in trees (7%, n = 14). Bare-faced Curassows are noisy birds and pairs communicate constantly while travelling together in the forest on the ground. The pair usually stays close together (< 20 m). Bare-faced Curassows were observed eaten fallen fruit and invertebrates in the leaf litter.

Observations of large groups of Bare-faced Curassows were rare, but on four occasions what appeared to be classical lekking behaviour was observed. On January 22nd 2003 eleven male Bare-face Curassows were observed in a grand formation in a grassland at the edge of a forest near a small stream. Males were evenly spaced about 15 to 20 meters from each other. All animals were visible to each other as the grass was lower than their heads. One female was observed near a male at the edge of the formation. Unfortunately, the observer (AD) disturbed the birds and was unable to fully register the behaviour. The next day, in the same place a similar formation of 6 males was observed, but no females were seen. On two other occasions March 8th 2003 and October 6th 2004 similar formation were observed. In the March observation 6 males and five females were sighted and in the October observation 8 males and no females were observed. All these leks were observed during the height of the fruiting season (October to March).

TABLE 2: Frequency of encounter of Bare-faced Curassow group sizes (N = 190).

Number of birds in group	Frequency of sightings
1	0.51
2	0.39
3	0.05
4	0.01
5	0.01
6	0.01
7	0.01
8	0
9	0
10	0
11	0.01
12	0.01

DISCUSSION

The Bare-faced Curassow is widely hunted throughout its distribution (del Hoyo 1994). Although it is not under threat of extinction, density estimates are required throughout the species range, to monitor population changes over time and estimate potential impact of harvest and other potential anthropogenic impacts. A review of population densities for 14 cracid species reveals no such information currently exists for the species in any biome (Table 3). Brooks (2006) as well as Clay and Oren (2006), did not include density estimates as recommendations for Bare-faced Curassows. However, reliable estimates of population sizes are needed to plan, implement and evaluate land management strategies or conservation measures (Sutherland 2000). Vegetation in the Pantanal biome is influenced by the neighbouring Atlantic forest, Cerrado, Amazon and Chaco biomes and the mosaic of landscapes offer a diversity of habitats for Bare-faced Curassows. This study provides the first data on this species population density in three different landscapes of the Pantanal. Furthermore, results from this study provide a rare insight into potential population sizes this bird can reach when unaffected by anthropogenic impacts. Therefore this information is extremely valuable as it can potentially be used to contribute estimated densities of Bare-faced Curassows in some landscapes of the neighbouring biomes in the absence of biome specific data. It may also be used for comparative purposes to evaluate densities in landscapes from these neighbouring biomes which are heavily impacted by anthropogenic impacts.

In general, arboreal cracids (*e.g.*, genus *Penelope* and *Aburria*) present higher densities in comparison to the terrestrial cracids species (*e.g.*, genus *Crax*) (Table 3). Bertch and Barreto (2008) reported the highest densities for *Crax daubentoni* (Table 3) suggesting it could represent the maximum values in optimal conditions at a high quality environment and low hunting pressure. This is the highest estimate for the species in Amazonia. This

TABLE 3: Review of cracids population densities, based upon the review by Setina (2009).

Species	Study site	Predominant habit	Individuals/km ²	Reference
<i>Ortalis guttata</i>	El Pinche, Peruvian Amazon	Arboreal	5.95	Begazo and Bodmer 1998
<i>Penelope perspicax</i>	Santuario de Fauna y Flora, Colombia	Arboreal	88	Rios <i>et al.</i> 2008
<i>Pipile cumanensis</i>	Samiria, Peruvian Amazon	Arboreal	6.79	Begazo and Bodmer 1998
<i>Penelope jacquacu</i>	Lago Uauaçu, Brazilian Amazon	Arboreal	0.63	Haugaasen and Peres 2008
<i>Penelope jacquacu</i>	Samiria, Peruvian Amazon	Arboreal	5.46	Begazo and Bodmer 1998
<i>Penelope jacquacu</i>	Yanayacu, Peruvian Amazon	Arboreal	5.46	Begazo and Bodmer 1998
<i>Penelope jacquacu</i>	Lago Uauaçu, Brazilian Amazon	Arboreal	4.45	Haugaasen and Peres 2008
<i>Pipile cumanensis</i>	Yanayacu, Peruvian Amazon	Arboreal	9.37	Begazo and Bodmer 1998
<i>Ortalis guttata</i>	Lago Uauaçu, Brazilian Amazon	Arboreal	1.44	Haugaasen and Peres 2008
<i>Pipile cumanensis</i>	El Pinche, Peruvian Amazon	Arboreal	0.44	Begazo and Bodmer 1998
<i>Ortalis guttata</i>	Samiria, Peruvian Amazon	Arboreal	3.28	Begazo and Bodmer 1998
<i>Penelope jacquacu</i>	El Pinche, Peruvian Amazon	Arboreal	0.22	Begazo and Bodmer 1998
<i>Chamaepetes goudotii</i>	Otún Quimbaya, Central Andes of Colombia	Arboreal	13.7	Londoño <i>et al.</i> 2007
<i>Penelope jacquacu</i>	Lago Uauaçu, Brazilian Amazon	Arboreal	0.19	Haugaasen and Peres 2008
<i>Ortalis guttata</i>	Yanayacu, Peruvian Amazon	Arboreal	3.6	Begazo and Bodmer 1998
<i>Oreophasis derbianus</i>	El Triunfo, Montane rainforest of Mexico	Arboreal	4.4	Abundis 2006
<i>Pauxi pauxi</i>	Henri Petier, Venezuela	Arboreal	8	Silva and Strahl 1991
<i>Ortalis guttata</i>	Lago Uauaçu, Brazilian Amazon	Arboreal	1.05	Haugaasen and Peres 2008
<i>Pauxi pauxi</i>	Yacambu, Venezuela	Arboreal	5	Silva and Strahl 1991
<i>Crax fasciolata</i>	Central Pantanal of Brazil (cerrado)	Terrestrial	2.90	This study
<i>Aburria aburri</i>	Otún Quimbaya, Central Andes of Colombia	Terrestrial	0.87	Rios <i>et al.</i> 2005
<i>Crax fasciolata</i>	Central Pantanal of Brazil (whole study area)	Terrestrial	3.67	This study
<i>Crax fasciolata</i>	Central Pantanal of Brazil (forest)	Terrestrial	4.66	This study
<i>Crax alberti</i>	Noroste Antioqueño, Colombia	Terrestrial	1.66	González 2004
<i>Mitu tuberosa</i>	Samiria, Peruvian Amazon	Terrestrial	1.65	Begazo and Bodmer 1998
<i>Mitu tuberosa</i>	Lago Uauaçu, Brazilian Amazon	Terrestrial	1.63	Haugaasen and Peres 2008
<i>Crax globulosa</i>	Lago Uauaçu, Brazilian Amazon	Terrestrial	0.56	Haugaasen and Peres 2008
<i>Mitu tuberosa</i>	Lago Uauaçu, Brazilian Amazon	Terrestrial	3.45	Haugaasen and Peres 2008
<i>Crax fasciolata</i>	Central Pantanal of Brazil (floodplain)	Terrestrial	0.43	This study
<i>Crax globulosa</i>	Bajo rio Caquetá, Colombia	Terrestrial	29	Alarcon 2008
<i>Mitu tuberosa</i>	Lago Uauaçu, Brazilian Amazon	Terrestrial	1.11	Haugaasen and Peres 2008
<i>Pauxi pauxi</i>	Tamá, Eastern Andes of Colombia	terrestrial	4.8	Setina 2009
<i>Crax alberti</i>	Reserva natural El Paujil, Colombia	Terrestrial	2.8	Rodríguez 2008
<i>Mitu tuberosa</i>	Yanayacu, Peruvian Amazon	Terrestrial	2.08	Begazo and Bodmer 1998
<i>Crax globulosa</i>	Rio Negro river, Bolivian Amazon	Terrestrial	3.4	Hill <i>et al.</i> 2008
<i>Crax rubra</i>	Costa Atlántica, Guatemala	Terrestrial	4	Eiserman 2004
<i>Mitu tuberosa</i>	El Pinche, Peruvian Amazon	Terrestrial	0.02	Begazo and Bodmer 1998
<i>Crax daubentoni</i>	Central Andes of Venezuela	Terrestrial	8-12.5	Bertch and Barreto 2008
<i>Crax globulosa</i>	Pacaya Samiria, Peruvian Amazon	Terrestrial	3-4	Yahuarcani <i>et al.</i> 2009
<i>Crax daubentoni</i>	Central Andes of Venezuela	Terrestrial	28-43	Bertch and Barreto 2008
<i>Crax daubentoni</i>	Central Andes of Venezuela	Terrestrial	39-160	Bertch and Barreto 2008
<i>Crax rubra griscomi</i>	Cozumel island, Tropical forest	Terrestrial	0.91 (1995)	Martínez-Morales <i>et al.</i> 2009
<i>Crax rubra griscomi</i>	Cozumel island, Tropical forest	Terrestrial	1.02 (2005)	Martínez-Morales <i>et al.</i> 2009

biome presents high densities of cracids except in heavily hunted areas (Begazo and Bodmer 1998).

In our study densities varied between the landscapes and this is probably due to resource availability. Densities of Bare-faced Curassow were highest in the landscape with the highest forest cover (forest landscape) and lowest in the landscape with lowest forest cover (floodplain landscape). Bare-faced Curassows are mostly frugivorous (Muñoz and Kattan 2007) and fruits are mostly produced in the forested habitats in the Pantanal (Desbiez 2007).

The absence of *Crax fasciolata* in the region of southern Amazon Basin (Mato Grosso state) is an intriguing question (Sick 1997, Trinca and Ferrari 2007). It is known that cracids play important role on the seed dispersal and seed predation, and their declines probably have negative impacts on the forest structure (Begazo and Bodmer 1998).

In the central region of the Pantanal Bare-faced Curassows are rarely hunted. However in two ranches we saw a male bird kept as a pet. On both occasions eggs had been collected in the field and incubated by chickens. In

one of the ranches they had to get rid of the male Curassow as it became aggressive towards children.

In this study, the birds were mostly encountered either alone or in male/female pairs as reported by Clay and Oren (2006). The occasional records of groups of males were similar to lekking behaviour. In other cracids species, some groups were observed making similar types of displays and were considered as reproductive group (leks), and have been reported for *Aburria aburri* (Rios *et al.* 2005), *Ortalis vetula* (Brooks, com. pers. *apud* Rios *et al.* 2005) and *Mitu tuberosa* (Jiménez com.pers. *apud* Rios *et al.* 2005). This is the first published report of potential lekking behaviour for the Bare faced Curassow. Furthermore during the period of low fruit availability, guans *Penelope perspicax* have been reported to congregated in large numbers at a Chinese ash (*Fraxinus chinensis*) plantation (Muñoz *et al.* 2007). However, in our study area, no noticeable source of food was noted near the group of birds and the observations were made during the period of high fruit availability. Several cracid species are frequently associated with riparian habitats (Bernardo *et al.* 2011) and in this study eleven male Bare-face Curassows were observed near a small stream. However, population density of the species in this study was lowest in the floodplain habitat.

In the Pantanal, cattle ranching is becoming increasingly competitive and many land owners are now either selling their properties or intensifying ranching practices (Seidl *et al.* 2001, Santos *et al.* 2002). Since the early 1970s, ranchers are clearing land and planting pastures of exotic grasses to increase the carrying capacity for livestock. Ranchers tend to plant pastures on the highest grounds available in their ranch since these are not subject to regular flooding and these areas are usually forested (Comastri Filho and Pott 1996, Seidl *et al.* 2001). Deforestation in the Pantanal is on the increase, more than 40% of the forests and savanna habitats have already been altered for cattle ranching through the introduction of exotic grass species (Padovani *et al.* 2004). Forested landscapes had the highest densities of Bare-faced Curassows. However these habitats have the lowest carrying capacity for cattle (Santos 2001). For this reason, they are the primary targets for deforestation. Results from this study predict that current intensifications and changes in land use practices throughout the Pantanal will be detrimental to populations of Bare-faced Curassows. Since this study occurred in an area with very low anthropogenic impacts, results from this study can be used as baseline data to gauge the impact of land use practice changes on populations of Bare-faced Curassows.

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