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Activity Patterns, Sex Ratio, and Social Organization of the Bare-Faced Curassow (*Crax fasciolata*) in the Northern Pantanal, Brazil

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Simple Summary: For the majority of tropical birds, basic life history information is still missing and holds mostly for tropical forest species. Among these are the members of guans, chachalacas, and curassows, a New World avian family known as cracids. In our study, conducted in a protected area in the northeastern Pantanal of Brazil, where human impacts were low, we investigated the seasonal activity, social organization, and sex ratio of the Bare-faced Curassow using camera traps. Strong seasonal inundation pulses are characteristic of the study area and influence vegetation, resource, and water seasonality, causing differences in seasonal activity behavior patterns. The daily activity of the Bare-faced Curassow differed between forest- and savanna-dominated areas but did not differ by sex, seasonal period, or presence of offspring. Such population studies in protected areas may serve as a "template" to plan more appropriate conservation and area management strategies that are applicable locally and beyond.

Abstract: Among Neotropical cracids (Galliformes), many taxa are declining rapidly in population size and facing local extinction. However, in the Brazilian Pantanal, several species occur sympatrically and in abundant numbers to allow for long-term studies. Therefore, the study was intended to collect data and statistically evaluate the life history patterns of Bare-faced Curassow (*Crax fasciolata*), a high-conservation-priority species. Additionally, the effect of applying commonly used independence filters on camera trap data was evaluated. The study was conducted in the SESC Pantanal, Baía das Pedras, Mato Grosso, Brazil, a private protected area of approximately 4200 ha. Between July 2015 and December 2017 (4768 sampling days), 37 sampling locations were monitored with camera traps placed in a regular grid with a spacing of 1 km. *Crax fasciolata* was detected at 26 (70.27%) of them, with 357 independent captures (554 individuals). Capture success differed among the four seasonal periods, being highest during the receding and lowest during the high-water period. The seasonal difference was more pronounced in the savanna, with significantly lower activity during the rising period and higher activity during the receding period, while it was more uniform in forest-dominated areas. Groups with offspring were more active during the period of receding water, indicating the peak of reproductive activity in the months before. The daily activity of the species followed a bimodal pattern, with peaks between 06:00 and 07:00 and 16:00 and 17:00. Daily activity rhythms were similar when compared between seasonal periods, sexes, and adults with or without offspring and differed between two habitats (more homogeneous in the forest). The mean detected group size was 1.55 ± 0.81 SD, with four animals exhibiting the largest observed aggregation. Larger unisexual aggregations of adults were not observed. The offspring sex ratio was significantly female-skewed at 0.51:1.00, while the adult sex ratio was considered equal at 1.05:1.00 (male:female).

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The use of different independence filters did not alter the BFC general activity pattern estimates. Cracids can be considered important bioindicators of habitat quality. The results of this study outline the importance of the Pantanal as a stronghold for this species and the privately protected areas with low anthropogenic activity as highly beneficial to its populations.

Keywords: camera trapping; capture success; Cracidae; daily activity; independence filters; Pantanal; seasonal activity; social organization

1. Introduction

Cracidae (Galliformes) comprises 56 species of medium-to-large-sized birds. These include 16 species of Curassows found only in the Neotropical region [1], of which 12 (75.0%) are globally threatened or near-threatened and one species is already extinct in the wild (6.25%). Populations of all 15 species still found in the wild are declining [2] but are also at risk of local extinction due to habitat destruction and hunting pressure [3,4]. The Bare-faced Curassow (*Crax fasciolata*), the species under study, is classified as "vulnerable" in its global conservation status and is considered a "high conservation priority" species [5,6]. It has already been extirpated from many parts of its original range [7], while its estimated range has recently declined by 6.57% to 4,410,000 km^2 [6]. However, it is still distributed over a large area in Central South America, with the highest abundance in the Pantanal [8–10], which can be considered a stronghold.

The Bare-faced Curassow is a large-bodied (male: 2700–2800 g, female: 2200–2700 g), polytypic, and dimorphic bird that occurs in Neotropical lowland forests and woodland edges near water sources and is predominantly terrestrial and frugivorous [9,11–13]. It is active during the day, with peaks around dusk and dawn [9,13–15], and is usually seen alone or in pairs of males and females [10,13,14,16]. Larger groups of more than two adult birds are not common. Previous camera-trap-based studies [13,14] reported up to 5 individuals, while in transect-based studies, large groups of up to 6 [17] and 12 individuals [10] were observed. Larger groups of males and possible (but not conclusive) classic lekking behavior have also been reported [9,10,12]. A recent study by Senič et al. [18] reported Bare-faced Curassow family groups with offspring, which always occurred in formation with single or male–female paired adults, territorial overlap between different family groups, and biparental care.

In previous reports, the adult sex ratio in the *Crax* genera was usually male-skewed [14,19–24] but could also be female-skewed [13,25]. Data for Great Curassow (*Crax rubra*) suggest a strong female-skewed sex ratio in offspring [19].

The Pantanal hosts one of the largest concentrations of inland birds in the world. It is an important refuge for many endangered species and has the potential to harbor even more species than we know, as many parts of this ecosystem are poorly known due to limited accessibility [26–28]. Tubelis and Tomas [26] stated that 463 endemic bird species occur in the Pantanal. This number was recently updated to 617 species [29].

There is still a large knowledge gap about the life history of forest-dwelling birds present in the whole Neotropical region [11], while camera-trap-based studies are particularly useful for conducting research on large ground-dwelling birds such as cracids [30]. Worldwide, the use of camera traps has become an indispensable, noninvasive tool for wildlife monitoring [31] and has been shown to be a powerful method for studying the life history of the Bare-faced Curassow [13–15,17,18,32] and other closely related species, such as the Red-billed Curassow (*Crax blumenbachii*; [21,22]) and the Great Curassow (*Crax rubra*; [23,24,33,34]). Regardless of the high population densities of the Bare-faced Curassow in the Pantanal, the species has been little studied. Only a few systematized studies have been conducted in the area [10,15,18], and information on some basic aspects of the life history of the species is missing. Phalan et al. [35] made important recommendations in their recent ex situ assessment for integrated conservation planning for Galliformes and

Tinamiformes in Brazil. One of these is the importance of collaborating with mammologists and other researchers conducting camera trap and autonomous recorder studies, as there are many studies that do not primarily address these groups, while data on them are collected but not used for future assessments. This study on the Bare-faced Curassow is based on field observations and camera trap data from the Northern Pantanal and is part of the long-term biodiversity assessment project "Sounds of the Pantanal" of the National Institute for Science and Technology in Wetlands (INAU), Federal University of Mato Grosso (UFMT), and National Council for Scientific and Technological Development (CNPq). The data used in the present study were obtained during a study focused on the biodiversity of mammals, which provided a sufficient amount of data for expanded research on the Bare-faced Curassow. The present study complements previously reported information by addressing daily and seasonal activity patterns and providing additional insights into Bare-faced Curassow social organization, parental care, adult sex ratio, and offspring sex ratio for the same study area and time period. The study also considers the potential effects of strong seasonal flood pulses in the area [36] on these patterns, as the movements of different cracids are known to be related to the seasonality of rainfall or resource availability [37].

The Pantanal is still in a relatively pristine condition with low human population density and activity. However, in recent decades, rapid environmental changes due to deforestation, the intensification of agricultural activities, fires, changes in the flood regime, and climate change have increased the threats to this unique ecosystem [38–46].

This study was conducted in a private protected area, where human activity is low. This could contribute to a better understanding of activity patterns and social organization within populations where environmental conditions are still intact while also providing some important baseline information for future research or management applications, not only for the Pantanal.

The objective of our study was to determine whether a grid-based camera trap approach could help to record and analyze life history patterns, such as diurnal and seasonal activities (breeding, pair bond, and other social behaviors) and habitat preferences, along several annual cycles. Since we had good results in a previous study on medium-sized terrestrial mammals, we hypothesized that the similar-sized and ground-dwelling Bare-faced Curassow was a suitable avian target species for our life history studies.

2. Materials and Methods

2.1. Study Area

The life history study of the Bare-faced Curassow (hereafter BFC) was conducted in the SESC Pantanal, Baía das Pedras. The private reserve, with an area of approximately 4200 ha, is located in the municipality of Poconé in the Northern Pantanal in the Brazilian state of Mato Grosso (16°29′55″ S, 56°24′46″ W) and is one of the units of the SESC Pantanal Ecological Resort. The vegetation of the study area consists of a mosaic of forests and savanna areas. The Pantanal of Mato Grosso has four seasonal periods determined by the annual water regime: high water (January to March), receding (April to June), dry (July to September), and rising (October to December) [36]. The climate in the region is humid and tropical (an average annual temperature of 24 °C and an annual rainfall of 1000–1500 mm). It is located in the floodplains of the Cuiabá River, which is seasonally inundated by the Paraguay River (October to April), followed by a terrestrial phase (May to September) [47,48]. Elevations in the study area range from 115 to 137 m, with an average of 122 m [49].

2.2. Data Collection

Camera traps (hereafter CTs) were set up in a regular grid of 37 fixed sampling locations with 1 km between each station (Figure 1). During CT deployment, data were collected undisturbed for at least 5 days. CTs were fastened on trees or larger bushes 60 cm above the ground between July 2015 and December 2017. Following the predefined grid configuration, CTs were placed in diverse habitat types, including semideciduous forest, riverine forest, swamp, shrubland, and different types of savanna formations. CTs were also placed when the sampling location was already flooded until the water level was above the selected placement height while also accessible. The CTs were active 24 h a day during deployment and were operated with a passive, infrared-triggered system. Five different camera trap models were used (Bushnell Trophy Cam Aggressor, Bushnell Trophy Cam HD 2012, Reconyx PC800, Reconyx HC600, and Uway VH400), of which three models had a camouflage design.

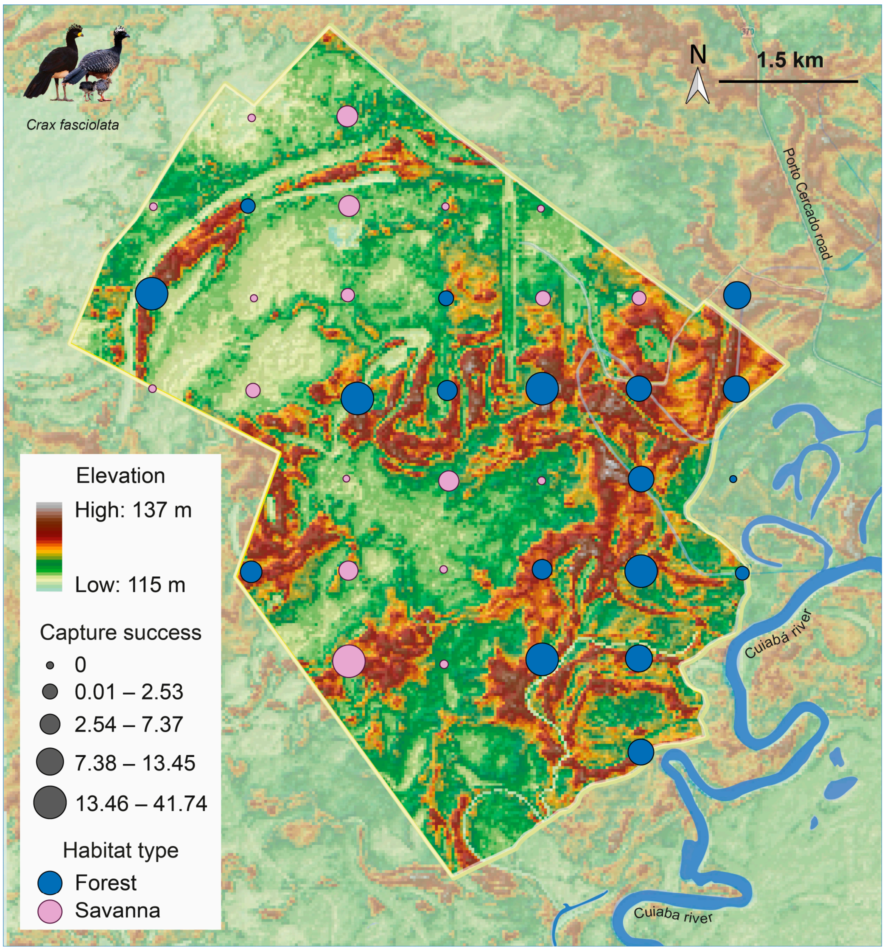

Figure 1. Topography of SESC Baía das Pedras Park (Northern Pantanal, Mato Grosso State, Brazil) at 30 m resolution (Copernicus WorldDEM-30 [50]) and associated sampling locations in a 1 km square grid (circles). Elevations in the area range from 115 m to 137 m, with an average of 122 m [49], and are shown with background colors depending on elevation. The smallest circles represent sampling locations where Bare-faced Curassow (*Crax fasciolata*) was not captured, and the remaining circle sizes represent values for capture success (number of independent captures per 100 sampling days) divided into equal quantiles, from lowest to highest. The pink circles represent sampling locations dominated by savanna, and the blue circles represent sampling locations dominated by forest.

2.3. Data Preparation

For this study, we used the same data as those of Senič et al. [18], with both studies complementing each other. Consecutive images or videos of BFCs taken 30 min apart were defined as one independent capture of the presence of a species. If different individuals were detected in the same capture or were clearly identifiable in subsequent videos or images, they were counted as one independent capture of individuals and considered part of the same family group as the previous capture(s) [21,51]. Each independent capture provided the number of individuals, time of day, and date of capture. Together, they provided information on BFC presence and detection rates over a given time period. As the sampling effort (number of days—24 h cycles when CTs were active) varied among months, sampling occasions, and sampling locations, the capture success (hereafter CS) was defined as the number of independent records divided by sampling effort and multiplied by 100 to obtain the number of independent captures per 100 sampling days [21,51].

To assess the potential effect of habitat and seasonal period on the detection rates and activity of the species, habitat types were roughly divided into forest and savanna habitats [52], and captures were categorized according to seasonal period (high water, receding, dry period, and rising). To investigate social organization, BFC captures were divided as follows: (a) single adult female, (b) single adult male, (c) male–female pair, (d) group with offspring, and (e) any other form of grouping. To determine the activity pattern (the distribution of the activity throughout the day), the captures were categorized into 24 one-hour intervals (e.g., 12:00–12:59, 13:00–13:59, etc.).

As existing CT studies on *Crax* species used different time intervals [13–15,21,34], and a recent study suggested that different time-to-independence intervals can affect the activity pattern estimates of mammal species, especially for highly social species [53], we prepared datasets using different independence measures to run comparative analysis. In addition to the 30 min interval, we (1) applied 1-, 10-, 20-, 60-, and 90 min intervals and considered only the first capture of consecutive captures, and (2) applied all 6 intervals but considered all consecutive captures of recognized BFC individuals to discard as few data as possible. Similar to Peral et al. [53], the shortest interval had to be 1 min due to potential differences in the number and duration of detection bursts between camera traps.

2.4. Statistical Analysis

First, the Shapiro–Wilk test was performed to test whether the occurrence of BFCs was normally distributed throughout the day, while the one-sample Kolmogorov–Smirnov test was used to test the daily (24 h basis) activity of BFCs for uniformity.

Following the methodology of Srbek-Araujo et al. [21], the nonparametric chi-square test was used to analyze differences in (1) seasonal activity patterns between (a) all seasonal periods, (b) habitats, (c) the defined social organization categories, (2) adults (male, female, and male–female pair) with offspring presence and absence, and (3) daily activity patterns between: (a) seasonal periods, (b) single adult males and females, (c) the defined social organization categories, and (d) habitats. When necessary, Yate's correction was applied to adjust for bias [54]. When the data size was too small to meet the sample size assumption of the chi-square test, the maximum likelihood ratio chi-square statistical test (LR) was applied [55]. In addition, the standardized residuals (SR) were used to define the significant contributions to the total chi value. The significance level used was $p < 0.05$.

A one-way ANOVA was conducted to test whether there was a difference in the number of BFC individuals captured per independent capture event between seasonal periods. To determine between which pairs of seasonal periods the difference occurred, post hoc Tukey's honest significant difference (HSD) was used for multiple comparisons.

In addition, male and female abundances were compared separately for adults and offspring based on data from all individual captures. Comparisons were made to determine the sex ratio of adults and offspring (number of males per female) and whether it was biased. Comparisons of available sex ratio data for different *Crax* species were also made [13,14,19–25].

To determine if independence measures affected the general activity pattern estimates of the species, we compared the 1 min interval activity pattern to the remaining activity pattern estimates considering (1) first captures only and (2) all consecutive captures of recognized individuals. We then compared the same interval activity pattern of only the first capture against all captures. We used the chi-square test and the approach by Peral et al. [53] to evaluate whether potential differences might be better detected with these methods. We fitted circular kernel density functions and estimated the coefficient of overlap using the overlap package (vers. 0.3.4). The coefficient of overlap ranges from 0 (no overlap) to 1 (complete overlap). The estimator Δ_4 for sample sizes greater than

75 was used. The 95% confidence intervals for Δ_4 were calculated from 1000 bootstrap samples [56,57]. Watson's two-sample test was then conducted to determine if the activity patterns were significantly different using the CircStats package (vers. 0.2–6) [58].

To investigate whether independence measures affected the overall CS and to assess the comparability of CS between different studies, we compared the CS obtained using the first capture and 30 min interval against the CS obtained from using the first capture and intervals applied in previous studies on BFC (10-, 20-, 60-, and 90-min) [13–15].

All statistical analyses were conducted in R (vers. 4.2.1, The R Foundation for Statistical Computing 2022 [59].

3. Results

3.1. Camera Trap Records

The CTs were active for 4768 sampling days. Due to the accessibility of sampling locations during inundation and/or CT malfunctions, the sampling effort per sampling location and sampling occasion varied, averaging 128.9 ± 56.5 days per sampling site (mean ± SD, range: 46–238). At 26 (70.27%) of the 37 sampling sites, a total of 554 BFC individuals were captured during 357 independent captures (Table 1). Of these, 65 offspring were captured during 44 independent captures at 8 sampling locations (21.62%). They were never observed without parent(s).

Table 1. Number of independent captures (presence of species based on 30 min independence interval) followed by number of individuals detected in those captures (based on 30 min independence interval), sampling effort (sampling days—24 h cycles), and capture success (number of independent captures per 100 sampling days) of Bare-faced Curassow (*Crax fasciolata*, BFC) obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, grouped by habitat dominance (forest/savanna) and seasonal periods defined by water regime (high water, receding, dry period, and rising).

Variables		Independent Captures	Detected Individuals	Sampling Effort	Capture Success
Total		357	554	4768	7.49
Season	High water (Jan–Mar)	28	33	473	5.92
	Receding (Apr–Jun)	101	184	1076	9.39
	Dry period (Jul–Sep)	145	211	1989	7.29
	Rising (Oct–Dec)	83	126	1230	6.75
Habitat	Forest	302	463	2261	13.36
	Savanna	55	91	2507	2.19

3.2. Capture Success, Seasonal Activity Patterns, and Social Organization

The overall CS based on the 30 min independence interval was 7.49 (Table 1). With respect to the different seasonal periods, it was highest during the receding period (9.39), followed by the dry period (7.29) and rising water period (6.75), while the lowest CS was recorded during the high-water period (5.92).

There was little evidence that BFC-independent captures varied between all four seasonal periods ($Chi^2 = 7.14$, df = 3, $p = 0.07$). However, the p value was just above the significance level, and the results from SR suggest that although the result of the chi-square test was not significant, the number of captures in the receding period was greater than expected (SR = 2.1, $p < 0.05$). The average number of BFC individuals captured per independent capture also indicated greater activity during this period. Overall, there was an average of 1.55 ± 0.81 SD (range: 1–4) animals per independent capture. Considering seasonal periods, the highest average was recorded during the receding period (1.82 ± 1.03 SD, range 1–4), followed by the rising period (1.52 ± 0.69 SD, range 1–3) and the dry period (1.46 ± 0.72 SD, range 1–4). The high-water period (1.18 ± 0.39 SD, range 1–2) yielded the lowest average number of individuals. One-way ANOVA revealed that there was a statistically significant difference in the number of BFC individuals captured between at least two groups ($F(3, 353) = 6.69$, $p < 0.001$). Tukey's HSD test for multiple comparisons indicated that there was a significant difference in the mean number of BFC individuals captured between the high and receding water ($p < 0.001$). There was no statistically significant difference between any other two groups.

The frequency of BFC captures differed significantly between savanna and forest-dominated habitats ($Chi^2 = 182.10$, df = 1, $p < 0.001$). Of the 19 sampling locations dominated by savanna vegetation, the BFC was detected at 9 locations (47.37%; with a total CS = 2.17; Figure 1), while of the 18 locations dominated by forest, BFCs were captured at 17 locations (94.44%; with a total CS = 13.36). There was no significant difference in the frequency of BFC captures among all four seasonal periods at the forest-dominated sampling locations ($Chi^2 = 5.34$, df = 3, $p = 0.15$). However, there is evidence of a significant difference in the capture frequency of BFCs between the same four periods at the savanna-dominated sampling locations ($Chi^2 = 15.38$, df = 3, $p < 0.01$). The largest contributor to the overall significant chi-square test was the higher number of BFC capture rates in the receding period (SR = 2.36, $p < 0.05$) and the significantly lower capture rates in the rising period (SR = −3.03, $p < 0.05$).

Single males were captured most frequently (33.05%; n = 118; Figure 2), followed by single females (27.73%; n = 99). All individually captured animals were classified as adults, while no offspring were detected outside of group formations. Pairs (male–female) were the most common group formation (21.29%; n = 76), followed by adults with offspring (12.32%; n = 44) and other group formations (5.60%; n = 20). The latter consisted of various combinations of adults: (a) pairs of males (n = 5), (b) pairs of females (n = 4), (c) a single male with two females (n = 5), (d) a single female with two males (n = 4), and (e) groups of four (two males and two females, n = 2). The occurrence of the different individual and group categories differed between seasons ($Chi^2 = 50.01$, df = 12, $p < 0.001$). The largest contributor to the overall significant chi-square test was the difference between captures of the group with offspring. The number of captures was significantly higher during the receding-water period (SR = 4.69, $p < 0.05$) and lower during the dry period (SR = −3.52, $p < 0.05$).

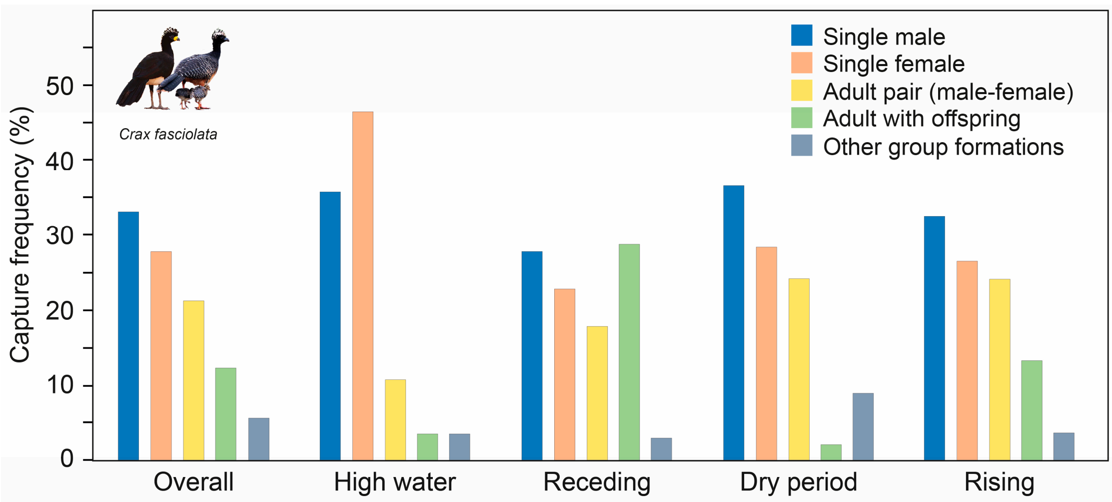

Figure 2. Proportion (%) of independent captures of Bare-faced Curassow (*Crax fasciolata*) (based on a 30 min independence interval) grouped by single female, single male, adult pair (male–female), adult with offspring, and other group formations for the overall study and for seasonal period defined by water regime (high water, receding, dry period, and rising) obtained between July 2015 and December 2017 in the Northern Pantanal (Mato Grosso, Brazil).

Offspring were mainly observed accompanied by both parents (54.55%; n = 24; Figure 3), followed by observations with single adult females (29.55%; n = 13) and single adult males (15.91%; n = 7). The comparison of single males, females, and male–female pairs captured with and without offspring showed that there was a difference between those appearances ($Chi^2 = 16.88$, df = 2, $p < 0.001$). The largest contributor to the overall significant chi-square test was the greater number of adult pairs (male–female) captured with offspring (SR = 3.03, $p < 0.05$) and the smaller number of individual males captured with offspring (SR = −2.31, $p < 0.05$). In contrast, the captures of females with offspring were not significantly different from the expected values (SR = −0.42, $p > 0.05$).

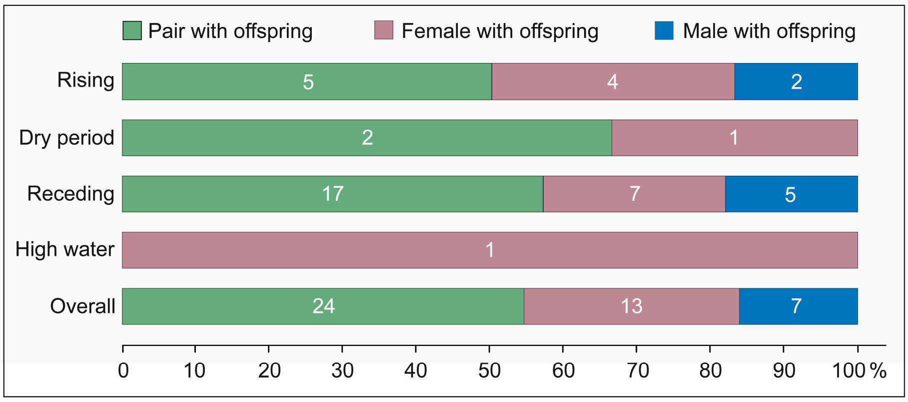

Figure 3. Number of independent captures (based on a 30 min independence interval) of Bare-faced Curassow (*Crax fasciolata*) adult(s) with offspring grouped by female, male, and pair (male–female) for the overall study and for seasonal period defined by water regime (high water, receding, dry period, and rising) obtained between July 2015 and December 2017 in the Northern Pantanal (Mato Grosso, Brazil).

3.3. Daily Activity Patterns

The daily activity pattern of the BFC deviated significantly from the normal distribution (Shapiro–Wilk test: W = 0.94; df = 357, $p < 0.001$). BFC captures also showed a nonuniform distribution (one-sample Kolmogorov–Smirnov test: Z = 2.69; df = 357, $p < 0.001$), indicating significant differences in BFC occurrence throughout the day (24 h period). All BFC captures were recorded within a 13 h interval, with the earliest recording at 05:04 and the latest at 17:54, showing a clear bimodal distribution (Figure 4). A peak occurred between 06:00 and 07:00, and the second (lower) occurred between 16:00 and 17:00. The lowest values of daily activity were recorded between 13:00 and 14:00 (Figure 4).

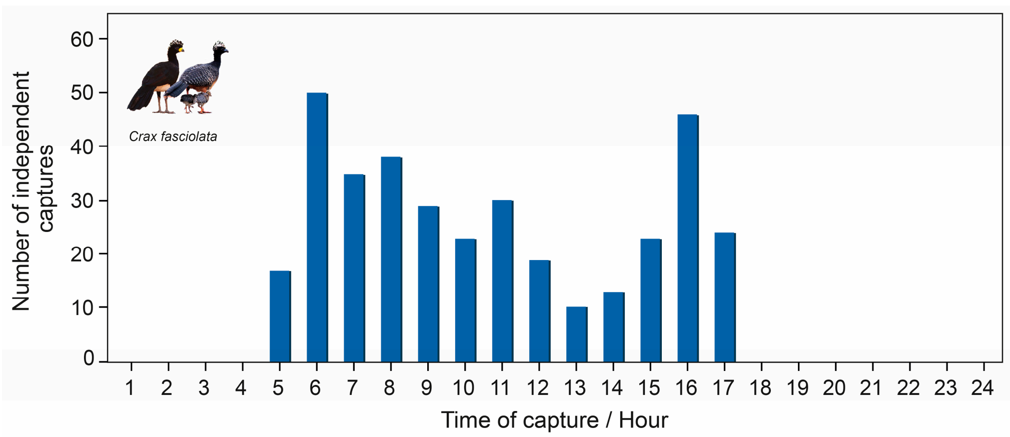

Figure 4. Number of independent captures of Bare-faced Curassow (*Crax fasciolata*) (based on a 30 min independence interval) obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, grouped into 1 h periods.

The daily activity pattern differed significantly between the different seasonal periods (LR = 53.25; df = 36, $p = 0.03$). There was no significant difference between males and females when only captures with single adults were considered (LR = 10.65; df = 12, $p = 0.56$). A comparison between all CT captures without offspring and those where offspring were present revealed no significant difference in the timing of captures (Figure 5; LR = 12.39; df = 12, $p = 0.41$).

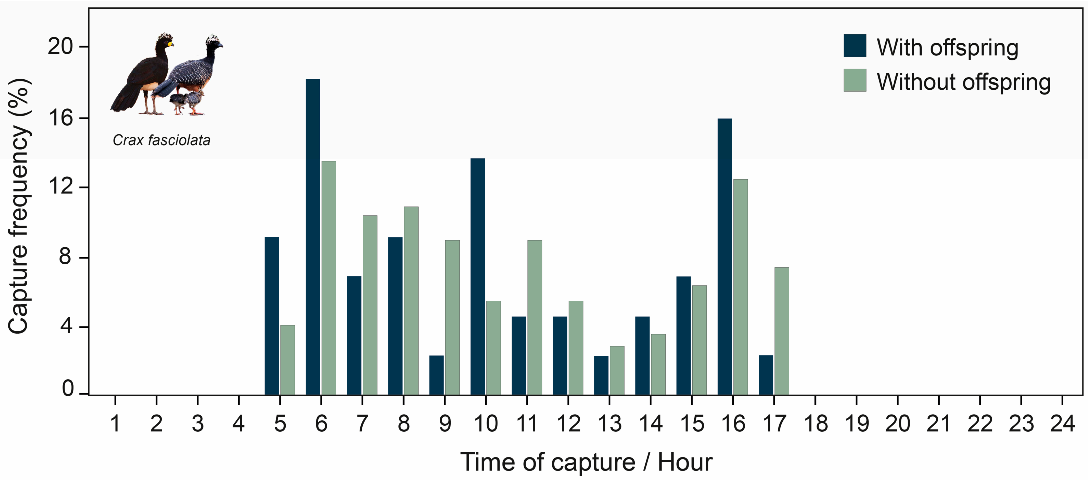

Figure 5. Frequency (%) of independent captures of Bare-faced Curassow (*Crax fasciolata*) (based on a 30 min independence interval) with and without offspring obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, grouped into 1 h periods.

A more detailed comparison between different BFC appearances (a—single female, b—single male, c—male–female pair, d—group with offspring, and e—any other form of grouping) also did not provide sufficient evidence to infer a difference in daily activity patterns with respect to capture composition (LR = 56.0; df = 48, $p = 0.2$). There was a significant difference in daily activity between savanna and forest habitats (Figure 6; LR = 34.31; df = 12, $p < 0.001$). The highest contribution to the overall significant chi-square test came from the higher capture values of BFC in savanna habitats between 6.00 and 7.00 (SR = 2.27, $p < 0.05$) and between 17.00 and 18.00 (SR = 2.76, $p < 0.05$).

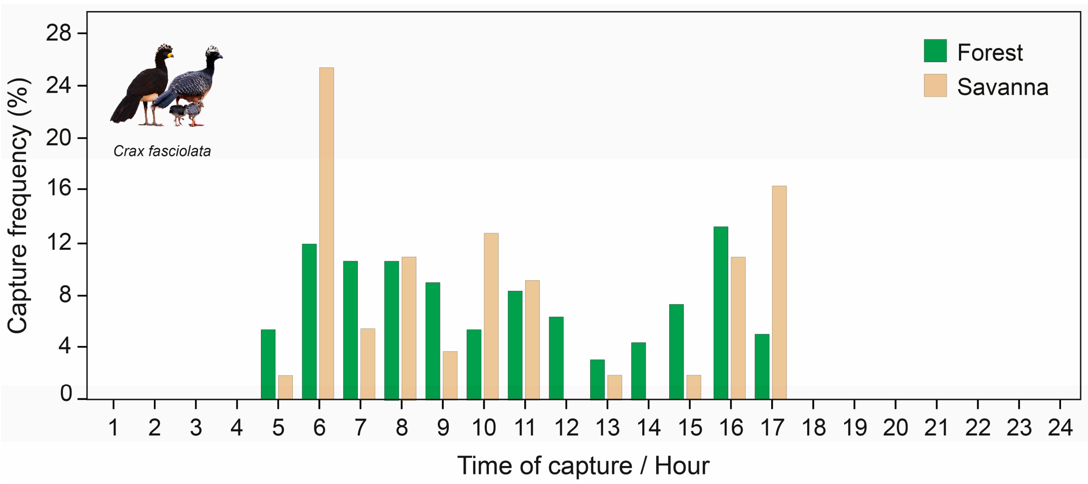

Figure 6. Frequency (%) of independent captures of Bare-faced Curassow (*Crax fasciolata*) (based on a 30 min independence interval) in forest and savanna-dominated habitats obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, grouped into 1 h periods.

3.4. Sex Ratio: Sexual Structure of the Population

There were 272 (49.10%) independent captures of males, 279 (50.36%) of females, and 3 (0.54%) captures where the sex could not be identified (Figure 7), giving an overall sex ratio of 0.97:1.00. When adults and offspring were considered separately, the offspring sex was identified in 62 (95.38%) of 65 independent captures, with 21 (32.31%) males and 41 (63.08%) females, yielding a sex ratio of 0.51:1.00. Adult males were identified in 251 (51.33%) and females in 238 (48.67%) captures, yielding a sex ratio of 1.05:1.00.

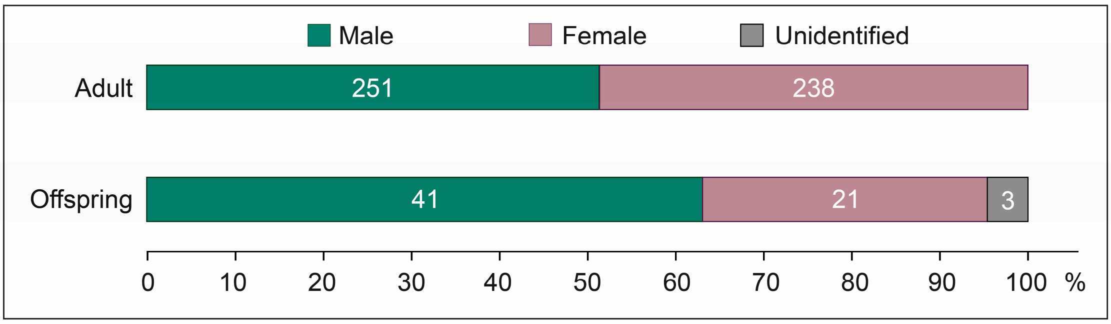

Figure 7. Number of independent captures of Bare-faced Curassow (*Crax fasciolata*) (based on a 30 min independence interval) obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, grouped by adult and offspring sex structure.

3.5. The Effect of Using Different Data Filters

The activity pattern estimated using different independence measures indicated a very high overlap with coefficients ranging between 0.94 and 0.97. Both chi-square and Watson's two-sample test suggest no significant difference between the compared activity patterns. The use of independent filters caused a loss of sample size (captures), ranging between 17.06 and 36.29% (Table 2).

Table 2. Sample size (n), n loss (cumulative loss of captures, %), Chi^2 statistics overlap coefficients, and Watson's U^2 statistics for pairwise comparisons of activity pattern estimates of different time-to-independence intervals compared to the 1 min time-to-independence interval baseline for (1) all independent captures based only on the first capture of the species, (2) for all independent captures of different individuals, and (3) for each time-to-independence interval between (1) and (2) for the Bare-faced Curassow (*Crax fasciolata*) obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017.

	Time Interval (min)	n	n Loss (%)	Chi^2	*p* Value	Overlap (Δ_4)	95% CI	Watson's U^2	*p* Value
Independent BFC captures (only first)	1	461	-	-	-	-	-	-	-
	10	369	19.96	3.29	0.99	0.96	0.91–0.99	0.06	>0.10
	20	358	22.34	3.94	0.98	0.95	0.91–0.99	0.06	>0.10
	30	357	22.56	4.08	0.98	0.95	0.90–0.99	0.07	>0.10
	60	343	25.60	4.73	0.97	0.95	0.90–0.98	0.08	>0.10
	90	337	26.90	5.60	0.93	0.94	0.89–0.98	0.10	>0.10
All detected BFC individuals	1	686	-	-	-	-	-	-	-
	10	569	17.06	3.65	0.99	0.96	0.92–0.99	0.06	>0.10
	20	556	18.95	4.05	0.98	0.96	0.93–0.99	0.06	>0.10
	30	554	19.24	4.86	0.96	0.95	0.91–0.99	0.08	>0.10
	60	536	21.87	5.26	0.95	0.95	0.91–0.98	0.09	>0.10
	90	529	22.89	5.95	0.92	0.95	0.91–0.98	0.10	>0.10

Table 2. *Cont.*

Time Interval (min)		n	n Loss (%)	Chi^2	*p* Value	Overlap (Δ_4)	95% CI	Watson's U^2	*p* Value
Comparison between									
1 (first)	1 (all)		32.80	2.62	1.00	0.97	0.93–1.00	0.03	>0.10
10 (first)	10 (all)		35.15	3.37	0.99	0.96	0.92–1.00	0.03	>0.10
20 (first)	20 (all)		35.61	3.86	0.99	0.96	0.92–1.00	0.03	>0.10
30 (first)	30 (all)		35.56	3.38	0.99	0.96	0.92–1.00	0.03	>0.10
60 (first)	60 (all)		36.01	3.85	0.99	0.96	0.92–1.00	0.03	>0.10
90 (first)	90 (all)		36.29	3.55	0.99	0.96	0.92–1.00	0.03	>0.10

There was little difference in the overall values of CS when different independence intervals were used (Table 3). The difference from baseline (CS for 30 min interval) was +3.34% (CS = 7.74; 10 min interval), +0.27% (7.51; 20 min interval), −4.01% (CS = 7.19; 60 min interval), and −5.61% (7.07; 90 min interval).

Table 3. Capture success (number of independent captures per 100 sampling days) of Bare-faced Curassow (*Crax fasciolata*) obtained in the Northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017, based on different independence intervals (10, 20, 30, 60, and 90 min), with expressed deviations from the baseline used in this study (30 min independence interval).

Independence Interval (min)	10	20	30	60	90
Capture success	7.74	7.51	7.49	7.19	7.07
Deviation from the baseline	+3.34%	+0.27%	-	−4.01%	−5.61%

4. Discussion

The results of the study confirm the strong seasonality of inundation pulses in the Pantanal of Mato Grosso, which influences the seasonality of vegetation, resources, and water and, consequently, also influences the differences in the seasonal activity patterns of the Bare-faced Curassow. Its daily activity has been shown to be bimodal, differing between forest- and savanna-dominated areas, but not between different sexes, seasonal periods, and the presence or absence of offspring accompanied by parents. Biparental care was the norm, while the adult sex ratio was equal and the offspring sex ratio was female-skewed.

In the last decade, CT studies have proven useful for obtaining novel information on different aspects of BFC natural history, such as habitat preference, behavior, social organization, diurnal activity patterns, and breeding phenology [13–15,18]. With this study, we try to complement already-existing information while focusing on the activity patterns, social organization, and sex ratios of BFCs.

Comparing the CS between different BFC studies [13–15,32] should be carried out with caution. The same is true when comparing capture frequency with other species within the *Crax* genus [21,23,34]. All differed in various aspects of methodology, such as the camera placement relative to different habitat types, the distance between sampling locations, the number of cameras per sampling location, the height of the camera placement, and the time interval for independent captures. Comparing different intervals for independent captures for our dataset (10, 20, 30, 60, and 90 min) had little effect on the results of CS, suggesting that the different intervals for independent capture chosen in the studies discussed are not problematic for the comparison between existing studies and this research.

Our results of the comparison of different activity patterns indicate that the use of different independence measures and discarding data did not alter the estimated activity pattern of BFCs in our study area. According to Peral et al. [53], the risk of biases and sample size loss were particularly strong for gregarious and herbivorous species, while sample size loss was lowest for solitary carnivores during their study. As BFCs occurred solitarily, pairwise, or in small groups during our study, captures rarely accumulated during specific times, resulting in a comparably low sample size loss. Numbers of records during a specific time accumulated only when individuals intensively foraged, rested, or maintained their feathers directly at the camera trap site, which we observed only on a few occasions. However, as this is the first time a comparative activity analysis on camera trap data was performed for ground-dwelling birds, further studies using different sample sizes are needed to investigate this matter in depth.

Palencia et al. [60] described the influence of CT placement height on detection probability as inconclusive, while they suggested that camera placement at shoulder height should positively influence the detection probability. They also concluded that placing the CT too high or too low can result in missed detections. In our study, CTs were placed higher (60 cm) than in other studies (20–45 cm) where this information was available for the *Crax* genera [14,15,21,23,24,34] because the BFC was not our primary target. However, it seems that the deployment height of the CT did not significantly affect the results, or at least it was not obvious, because the trapping frequency was higher than in most other reports. It is also not possible to evaluate this variable because the influence of different deployment heights of CTs has not yet been tested for *Crax* genera, leaving the possibility of missed detection open. It is also important to mention that the use of different camera trap models during our study (e.g., not all camera traps were camouflaged) could potentially impact the CS.

In accordance with previous BFC studies using CTs, we found different results. It is clear that the significantly lower capture frequency reported by Gomes et al. [32] is because BFCs are extremely rare in the Brazilian state of São Paulo. Fernández-Duque et al. [13] also reported significantly lower CS while conducting a CT study of BFCs in gallery forests in the Humid Chaco (Formosa, Argentina), where the BFC is also rare and geographically restricted [61]. Since BFCs show a preference for forest and riparian habitats [9,13,14], it can be concluded that the CS is significantly lower due to lower population densities rather than methodological differences. In the case of Laino et al. [14], the higher capture success is most likely the result of the sampling method. The CTs were placed in different forest habitats (subhumid flooded, semideciduous quebracho mesoxenophytic, and riparian forest), while in our study, the CTs were placed in a fixed grid with a spacing of 1 km, regardless of habitat type. There are reports of various cracids occurring in larger aggregations at lakes or rivers when they consume water, and they have been observed to migrate along lake sandbanks and visit salt licks [7,9,12,13,62]. In the report by Santos et al. [15], the greater number of bays and salt ponds could be the main reason for the significantly higher CS than in other reported cases.

4.1. Seasonal Activity Patterns

During the high-water period, CTs were not set up at sampling locations that were already flooded to the level of fixed camera placement height (60 cm). They were placed only if flood levels were low. This could affect the capture rates, leading the CS toward overestimation during this season. There were no detections of BFCs at any flooded locations where CTs were active, indicating the low use to non-use of those areas already fully flooded or with interrupted accessibility. The sampling of heavily flooded sites would, thus, likely result in lower capture rates during high-water periods, if the BFC continues the trend of not using flooded areas. The calculated p value for differences in BFC capture between all four seasonal periods was very close to significance. Under the prior assumption of overestimation, we classify the difference as significant. This is additionally supported by significant SR values for CS during the receding period, for which the average numbers of animals captured per independent capture were also significantly higher, with offspring captures having the greatest influence on the average.

BFCs have already been found to breed year-round in this area (Pantanal of Mato Grosso; [18]). However, notes on reproductive activity are still very rare and do not provide information on the extent to which reproduction is opportunistic at the peaks of reproductive activity. Although most offspring were captured during the period of receding, it cannot be assumed that this is the main breeding period for BFCs. Considering the estimated age of the offspring captured during the receding, none of them hatched during this period but rather during periods of high water or rising.

Kattan et al. [37] indicated that the movement patterns of several cracids (Yellow-knobbed Curassow, *Crax daubentoni*; Salvin's Curassow, *Mitu salvini*; and Cauca Guan, *Penelope perspicax*) are related to the seasonality of rainfall or resource availability, congregating around water sources during the dry season or around seasonally abundant food sources. Seasonal periods in the Pantanal are determined by the annual water regime [36]. They are the main drivers of environmental changes that affect resource and niche availability and cause bird species to adapt or migrate [63]. This could explain the changes in seasonal activity patterns of BFC in this study. It could also explain the increased activity during the receding period due to greater mobility following a drop in water level and the associated opening of the previously flooded area with new potential resources. Since BFCs are mainly frugivores that usually pick up fruits from the ground after they fall from trees [12] and are, at least to some extent, opportunistic in foraging [64], a declining water level increases their foraging opportunities. Savanna-dominated landscape formations are predominant for periodically inundated floodplains, while forest vegetation such as semideciduous forests or woodlands prefer higher, nonflooded grounds above the inundation level [65]. This was also characteristic of our study area, with savanna-dominated sampling sites more susceptible to the effects of water seasonality. This could explain the nonsignificant difference between the different seasonal activity patterns in forest habitats, while the difference in savanna-dominated habitats is strong. This is especially true during periods of rising and falling water levels. The higher BFC detection frequency in savanna-dominated habitats during the receding could be explained by the fact that the area opens up to ground-dwelling animals, while during the rising period, the area becomes more fragmented as animals move away from the rising and adapt their habitat use to environmental conditions [41,66].

4.2. Daily Activity Patterns

The observed daily occurrence of BFCs supports the previously observed bimodal distribution of daily activity patterns for BFCs [9,13–15,21], while they most closely resemble those reported for *Crax blumenbachii* [21], with most activity occurring before noon, a peak appearing in the early morning and late afternoon, and the least activity being around midday or early afternoon. A bimodal distribution is also reported for *Crax rubra* [34,67], while there is also a report of a more even distribution of its activity throughout the day [33]. The similarity in the activity patterns of BFC, *C. rubra*, and *C. blumenbachii* may be due to similar feeding strategies and habitat preferences. All three prefer lowland forest habitats, are mainly terrestrial foragers, and are primarily frugivorous [11,12,68].

For the other cracids outside the *Crax* genera, Chaco Chachalaca (*Ortalis canicollis*) showed a more consistent activity pattern throughout the day with a small activity peak in the morning, while the White-throated Piping-Guan (*Pipile grayi*) peaked in the morning and around midday and early afternoon [15]. The Trinidad Piping-Guan (*Pipile pipile*; [69]), Plain Chachalaca (*Ortalis vetula*) [67], Spix's Guan (*Penelope jacquacu*; [70]), and Cauca Guan (*Penelope perspicax*; [71]) showed the highest activity around noon. The Razor-billed Curassow (*Mitu tuberosum*; [70]) was reported to be most active in the morning, while the activity pattern of Sira Curassow (*Pauxi koepckeae*; [72]) peaked in the afternoon.

The detected lower midday activity of BFC in the Pantanal of Mato Grosso may be related to higher temperatures [13]; the evening peak suggests movements to nocturnal roosts [21], while the morning peak suggests dispersal to foraging habitats. More homogeneous diurnal activity patterns at forest-dominated sampling locations than at more open savanna-dominated locations could be the result of diurnal differences in microclimatic conditions, with greater temperature variation and extremes at the savanna-dominated locations, as it has already been suggested that temperature may have an influence on BFC diurnal activity patterns [13].

A comparison of the diurnal occurrence of individually captured males and females suggests that sex-specific behavior does not influence activity patterns. Similar results were reported for *C. blumenbachii* [21] and *C. rubra* [34]. Furthermore, a comparison of daily activity patterns between captures with offspring presence or absence suggests that the presence of offspring does not cause adults to change their temporal behavior. However, for the dataset considered in this study, it was previously reported [18] that detection rates were lowest in the first 30 days after hatching. Therefore, additional observations should be made to unambiguously determine the daily activity patterns of BFC aggregations with offspring.

4.3. Social Organization

Studies on the social organization of BFCs are rare. Desbiez and Bernardo [10] recorded larger groups of more than 2 individuals (3–12) on 20 different occasions (10% of total records) as part of a line transect study in the Central Pantanal, Brazil (18°59′ S, 56°39′ W), and observed for the first time possible classic lekking behavior in this species. There is no other report of observation of lekking behavior in BFCs. Krieg and Schumacher ([73]; cited in Delacour and Amadon [12]) reported observations of similarly large, unisexual groups (8–11) of males in forests of eastern Paraguay. Fernández-Duque et al. [13] conducted a study in Estancia Guaycolec, Argentina (25°54′ S, 58°13′ W) in the Mirikiná Reserve (11 km^2), using line transects and CTs. Groups with more than two BFC individuals (3–5) were observed on six different occasions (32% of total records) during line transects, averaging 2.05 ± 1.28 SD per survey occasion. For CTs, more than two individuals (3–5) were captured on five different occasions (4% of total records), averaging 1.23 ± 0.59 SD per survey occasion. Zalazar et al. [17] reported 1–6 individuals with an average occurrence of 2.5 ± 1.5 SD during transect surveys in the eastern area of Formosa Province, Northern Argentina. Laino et al. [14] conducted a study in the Southern Paraguayan Chaco (24°58′ S, 57°22′ W) and reported observing BFC groups of more than 2 individuals (3–5 birds) on 10 different occasions (8.8% of total records), with an average of 1.45 ± 0.83 SD individuals per survey.

The highest observed number of BFCs per single survey occasion in this study was lower than in the study by Fernández-Duque et al. [13] and Laino et al. [14]. In addition, the average values for all captured individuals were very similar. All of these values were higher in studies that used transect observations [10,13,17] than in CT studies ([13,14]; this study). It is important to emphasize that in this study, all captured BFCs were considered in the calculation of averages, both adults and offspring. There are no reports of offspring in other studies referenced in this paragraph.

There are also some disadvantages of line transects compared to CT surveys. Male curassows are likely to be more visually and aurally detectable than behaviorally tame females because of their sexual behavior and display. The latter are also more cryptically colored, making them even more difficult to depict [10,12,23,74]. As a result, line transect studies appear to be more prone to male-biased results.

Cracids are considered monogamous, but males show a tendency toward polygamy with two or three mates [12]. Although groups with one male and two females and vice versa were also captured, polygamy in BFCs remains unclear because there is too little evidence. Moreover, no behaviors indicative of possible lekking were observed in this study. However, this aspect of BFC biology may also be underestimated, as CTs have the tendency of lower detection of different BFC individuals compared to line transects [13]. The recognition of different individuals of the same sex and age was clearly challenging when they were not captured in the same continuous photo or video sequence and in rare cases having some unique feature that helped to distinguish them from the others (authors' observation).

4.4. Sex Ratio: Sexual Structure of the Population

CTs are a valuable tool for assessing sex ratios. Alves et al. [22] suggested that CT data are more accurate than data obtained from transects in assessing the sex composition of a population (*C. blumenbachii* study). Donald [75] noted that skewed sex ratios are common in birds and that they are usually male-skewed. He also noted that higher female mortality, rather than a skewed offspring sex ratio, is the main reason for this and that there is no quantitative evidence that an equal sex ratio between males and females is the norm in bird species.

The observed sex ratio of offspring captures in this study was significantly skewed in favor of females. This is comparable to the observed sex ratio of hatchlings in the *C. rubra* study (Table 4; [19]). It is important to emphasize that the offspring sex ratio was considered from offspring of different age classes [18] and not only from hatchlings (since they were captured only once). It could be hypothesized that a female-skewed sex ratio among offspring in *Crax* species populations is the norm if similar results are obtained in future studies.

Table 4. Sex ratio data available for various *Crax* species relative to pooled and adjusted data available from various surveys. In each case, the sex ratio is expressed as the number of males per female. Approaches considered: a—visual survey; transect-based survey; b—camera-trap-based survey; c—observed in captivity.

Studied Species	Adult Sex Ratio		Offspring Sex Ratio	Source
Great Curassow (*Crax rubra*)	-	-	0.59:1.00 c	[19]
Wattled Curassow (*Crax globulosa*)	1.20:1.00 a	-	-	[20]
Great Curassow (*Crax rubra griscomi*)	0.56:1.00 a	-	-	[25]
Red-billed Curassow (*Crax blumenbachii*)	-	1.56:1.00 b	-	[21]
Bare-faced Curassow (*Crax fasciolata*)	1.60:1.00 a	1.67:1.00 b	-	[13]
Red-billed Curassow (*Crax blumenbachii*)	-	1.60:1.00 b	-	[22]
Great Curassow (*Crax rubra*)	-	0.71:1.00 b	-	[23]
Great Curassow (*Crax rubra*)	-	1.50:1.00 b	-	[24]
Bare-faced Curassow (*Crax fasciolata*)	-	1.26:1.00 b	-	[14]
Bare-faced Curassow (*Crax fasciolata*)	-	1.05:1.00 b	0.51:1.00 b	This study

In our study, the adult sex ratio of BFC was much more balanced than in other existing CT studies of BFC where the sex ratio could be inferred [13,14]. These were significantly male-biased, although the reason for this is not explained, as the adult sex ratio was not their primary focus. However, the study by Laino et al. [14] also had the least variation in the sex ratio when comparing different studies with our study. Most other CT studies on *Crax* species, such as *C. blumenbachii* [21,22] and *C. rubra* [24], showed a significantly male-skewed result, similar to the results for BFC in Fernández-Duque et al. [13].

Studies on *Crax rubra griscomi* [25] concluded that increasing populations of feral dogs on Cozumel Island, possibly in combination with hunting pressure, may be the main reason why the sex ratio shifted from a similar sex ratio, as in this study, to a highly female-skewed ratio within a single decade (from 1995 to 2005). They also suggested that a skewed adult sex ratio could be the result of a skewed sex ratio in offspring. Our results suggest that the latter, at least for BFC, is most likely not the case. Whitworth et al. [24] concluded that the recently observed skewed sex ratio in *C. rubra* indicates the success of hunting elimination programs. In addition, these authors suggested that the absence of hunting provides an opportunity for the release of mesopredators that may prey on nesting females. Nest predators could be one of the reasons for the higher proportion of males in the adult sex ratio, as females are more vulnerable to predators when protecting their nests [22]. It is worth noting that the fact that females leave the nest only a few times a day, while males remain near the nest during the breeding season [76], could also have a small influence on the sex ratio.

It is possible that the male-skewed adult sex ratio is more the norm in BFC and in other *Crax* species, but more detailed field studies are needed to confirm this. Our results are not consistent with a significantly skewed adult sex ratio but rather suggest that a more even adult sex ratio may be characteristic of at least BFC. We cannot conclusively determine the reason for this, but it may be because our study was conducted in a protected area where there is no large anthropogenic activity. Human movement is restricted or logistically limited. Hunting and logging were not allowed and were not observed during the study. Feral dogs were also not detected. Desbiez and Bernardo [10] also concluded that hunting is not a major threat to BFCs in the Pantanal. If future CT studies conducted in protected areas with stable populations show similar results, a more even sex ratio found in such studies should be considered the norm, while a skewed adult sex ratio should be considered an indicator of a possible negative impact on population dynamics.

4.5. Parental Care

We have previously reported in detail on various aspects of the breeding phenology of BFC [18] based on the same dataset used in this study. However, it is important to emphasize that we performed a statistical analysis that provides additional support for biparental care as the norm in BFCs, and it is also consistent with some previous observations of individual families [12,77,78]. In general, bird parents cooperate more when sexual selection is not strong and the adult sex ratio is not highly skewed. In addition, males rarely care for offspring in bird species with high extrapair paternity [79]. The prevalence of polygamy is related to the sex ratio in both sexes [80]. Thus, the prevalence of biparental care in the population studied suggests that BFC is highly monogamous while reflecting a stable adult sex ratio. Single-parent care and polygamy in BFCs might, therefore, indicate the mortality rate in one of the sexes present.

4.6. Recommendations for Future Studies

This grid-based study provides new information on many different aspects of the life history of the BFC and demonstrates the use of camera trapping as an important tool to better understand its biology. In addition, the results of this study are particularly important because they were conducted in a remote and protected area with little human disturbance. Since there were some limitations in setting up a single CT, especially when addressing lekking behavior and polygamy, it would be highly recommended to set up multiple cameras per sampling location to obtain a 360° view, as detection rates are proven to be much higher when employing additional camera(s) [81]. Sampling should also focus more on forest and riparian habitats, as these are considered important "social gathering areas" for BFCs (M. S., personal observations; [10,13]), which could help to study intraspecific social behavior in more detail. For future studies, it is also strongly recommended to collaborate with other studies that can provide additional datasets but are not primarily focused on ground-dwelling birds [35] or even to plan future collection jointly with different specialists. This could be a great benefit, not only improving the availability of datasets but also optimizing the use of resources. This study already shows the importance of such collaboration to improve existing data collection and knowledge of the target species.

The results of the present study suggest that BFCs in the Pantanal depend on strong seasonality and forest-dominated habitats. Since we only made a very rough classification of habitats into forest and savanna habitats, and the Pantanal region is characterized by a highly diverse landscape, we recommend a more detailed vegetation analysis for future studies. Additionally, future studies should address how social organization, group size, and number of offspring might be related to resource availability. Combining camera trap data with detailed vegetation analysis could provide important additional insights into species-specific habitat requirements.

Human disturbances, such as deforestation, cattle ranching, tourism, hunting, and agriculture, could affect habitat use and activity patterns, especially for a primary diurnal and forest-preferring species such as BFCs. Investigating the potential effect of anthropogenic aspects and investigating species behavior in more disturbed areas would strongly improve our knowledge about species' adaptive responses.

5. Conclusions

In regard to capture success, the method is best suited for replication within the same area over longer time periods because changes in trapping frequency could also indicate changes in actual abundance, but it is less suited to comparison among different areas. A grid-based sampling design is extremely useful for assessing and statistically evaluating seasonality, social organization, and sex ratios. We strongly recommend the use of CTs in future studies monitoring these and other cracid species in the wild.

The use of different data independence filters did not affect the activity pattern results of BFCs in this study. This suggests that the results of different BFC studies using different data filters are quite comparable. However, this should be additionally tested for different sample sizes and *Crax* species to see to what extent this is true.

Significant differences in seasonal activity were found between different seasonal periods and habitats, suggesting that environmental changes caused by the annual water regime are responsible for these differences. There is some evidence that peaks in breeding activity may also influence seasonal activity, but further investigation is needed. The daily activity patterns of BFCs showed a clear bimodal distribution, while the sex-specific behavior, different groupings, and the presence of offspring did not influence patterns. The habitat did have an influence, however, with forest-dominated habitats showing more homogeneous patterns. The daily activity also differed between seasonal periods. Both were due to changes in environmental conditions. In future studies, we should also investigate the influence of possible predators and their activity patterns on BFC activity patterns.

Some adjustments are needed when studying group sizes and lekking behavior, as the methodology used tends to underestimate group size. CTs are considered a good approach to assess sex ratios. We concluded that the sex ratio of female-skewed offspring may be the norm in BFC, as the almost-equal adult sex ratio was inconsistent with previous reports. Further studies are needed to confirm these ratios.

We should also note that changes in activity patterns and social organization, and especially changes in adult sex ratios, should be taken seriously as one of the first indicators of significant change within the population under study. Since cracids, especially Curassows, are very sensitive to habitat loss and hunting pressure and are also important seed dispersers, they can be considered important bioindicators of habitat quality.

Deforestation, fires, and climate change in the area are expected to increase in the coming decades. While the Pantanal is already becoming drier, there are strong indications that this could significantly affect seasonal flooding and ecosystem functioning in the area. Therefore, it is critical to better understand the dynamics within the population under normal conditions. This information is important for future species conservation and management efforts to maintain BFC populations in the Pantanal in their current state. In particular, the area is currently one of the BFC strongholds with the highest known population densities. Despite the high densities, there is little information on BFCs in the area. Therefore, this study contributes significantly to better understanding the species and filling existing knowledge gaps with some basic life history information. The

Pantanal is still in relatively good condition compared to most other BFC distribution areas. Because hunting and deforestation, two of the main threats to the BFC, did not occur in the study area, the results may provide valuable information for stakeholders to better plan future population recovery efforts in other, more degraded areas with disturbed population dynamics. The results can also be used to evaluate existing conservation measures and management strategies and may also indicate potential threats when compared to the CT data obtained from these areas.

In summary, CTs have proven to be a powerful tool to obtain valuable information about the natural history of BFCs. Since this study was conducted within a protected area where anthropogenic influences are almost absent, the results could provide important insights into some behavioral and ecological characteristics of BFCs under good conditions, thus providing an important basis for future assessments, management strategies, and conservation measures.

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