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ARTICLE

Reproduction phenology of a high conservation priority cracid – the Bare-faced Curassow (*Crax fasciolata;* Aves, Galliformes, Cracidae)

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Abstract. Knowledge of the reproductive biology of Bare-faced Curassows (BFC) from their natural habitats is very limited. Our study covers a two-and-a-half year breeding phenology on BFC in the northern Pantanal (Mato Grosso State, Brazil) with the main objective of collecting information on reproduction biology to contribute to future conservation management strategies of this cracid, which received a recent status of "High Conservation Priority". The study was conducted at the SESC Pantanal, Baía das Pedras, Mato Grosso, Brazil (16°29′55″S, 56°24′46″W), a private protected area of approximately 4,200 ha. Between July 2015 and December 2017, 37 sampling locations were monitored with camera traps placed in a regular grid with a spacing of 1 km. Offspring were detected at least once at 8 locations, namely, in March, April, and May 2016 and in June, July, October, and November 2017, always together with parent(s). Territorial overlap between different family groups was detected. The camera trap dataset was supplemented by data from Citizen Science Projects (*i.e.,* eBird) and the Global Biodiversity Information Facility (GBIF). Based on feather developmental stages and body size, offspring were classified into different age classes. Age determination indicates that breeding occurs year-round in the northern Pantanal region, supported by eBird and GBIF data. The use of a grid-based design for future camera-trapping studies of BFCs is strongly recommended. Our study is of biological relevance for conservation management projects since data were collected in an area with low anthropogenic disturbance and intact ecosystem services.

Keywords. Camera trapping; Cracidae; Northern Pantanal; Territorial overlap; Year-round breeding.

INTRODUCTION

Developing adequate management strategies for endangered species requires scientific knowledge of their ecological demands and patterns of reproductive biology. In the Neotropical Region, with the worldwide highest avian diversity and the largest number of threatened bird species, such knowledge gaps exist for most taxa, especially for forest-dwelling birds (Stotz *et al.,* 1996). In addition to the physical and logistical challenges of documenting the breeding biology of tropical birds, the increasing decline of populations due to habitat fragmentation and deforestation, contributing to local extinctions (Ribon *et al.,* 2003; Martensen *et al.,* 2012), represents a further constraint in filling current knowledge gaps in regard to bird reproduction.

Cracids (Cracidae, Galliformes) include 56 medium to large-sized species (Winkler *et al.,* 2020), almost all restricted to the Neotropical Region, of which 29 (51.8%) are globally threatened or near threatened and one (1.8%) already extinct in the wild. Moreover, population trend is decreasing for 47 (83.9%) of them (IUCN, 2021). The main reasons for the decline in their populations are deforestation and illegal hunting (Sick, 2001). These predominantly frugivorous birds play an important

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role in the dispersal of large seeds (Galetti *et al.,* 2013); therefore, their local extinction may have drastic impacts on the maintenance of forest structure, health, and ecosystem services such as carbon storage over time (Bello *et al.,* 2015). As several cracids have become locally extinct, conservation and reintroduction efforts have been undertaken to rescue their populations (Galetti *et al.,* 1997; Francisco *et al.,* 2021). However, basic knowledge about their reproduction that could help develop efficient management strategies is still very limited.

The Bare-faced Curassow (*Crax fasciolata,* hereafter BFC), the target species of this study, is a polytypic, dimorphic, large-bodied species (males: 2,700-2,800 g, females: 2,200-2,700 g) that occurs in Neotropical lowland forests and at woodland edges near water sources (Stotz *et al.,* 1996; Del Hoyo & Motis, 2004; Fernández-Duque *et al.,* 2013). It is generally terrestrial in habits, especially when foraging (Stotz *et al.,* 1996; Delacour & Amadon, 2004), and most active around dawn and dusk, with a bimodal daily activity pattern (Del Hoyo & Motis, 2004; Fernández-Duque *et al.,* 2013; Laino *et al.,* 2018). The species has been extirpated from many parts of its original range (Del Hoyo *et al.,* 2019) but is still common in an extensive area of central South America. The nominate subspecies *Crax f. fasciolata* occurs in central and southwestern Brazil, Paraguay, and northern Argentina (Clay & Oren, 2006). In Brazil, BFC is widely distributed and has been reported in Pará, Minas Gerais, Goiás, Mato Grosso, and northern Mato Grosso do Sul (BirdLife International, 2021). It is considered rare in São Paulo state (Gomes *et al.,* 2018) and in Paraná, while it is still common in the northern Pantanal (Mato Grosso), Emas (Brasilia), and Araguaia National Parks (Del Hoyo *et al.,* 2019), presumably because habitat destruction and hunting pressure are lower in these areas. Despite its relatively large range of occurrence (4,720,000 km^2), its global conservation status is classified as "vulnerable" and was recently classified as a "high conservation priority" species (Brooks & Strahl, 2000; Birdlife International, 2021).

There is a lack of published information on the reproductive characteristics of BFC, especially from their natural habitats. Records from captivity indicate that both sexes are involved in nest building, although usually only the female is responsible for incubation, which lasts approximately 30 days; both sexes contribute to rearing the offspring, which remain with the parents for several months (Coupe, 1966; Campbell & Lack, 1985; Delacour & Amadon, 2004). Information on the reproductive phenology of this species in the wild is limited to a few anecdotal reports of offspring accompanied by adults. In Paraguay, offspring have been observed in December (Krieg & Schumacher, 1936). In Argentina (Pirané, Formosa), a nest with eggs was discovered in late November (De la Peña, 1992), and as part of the reintroduction project in Iberá Park, a chick hatched there in February 2021 (Fundación Rewilding Argentina, 2021). However, in Brazil, there are records of two cases of a pair with a single offspring in July/August 2005 and late 2005 in Serra da Canastra National Park in Minas Gerais, southeastern Brazil (Bruno *et al.,* 2006). Another pair with a single small female offspring was observed in the Pantanal of Mato Grosso in early November 2006 (Kirwan, 2009). In late December, an adult pair accompanied by male and female offspring was observed in Goiás State (Kirwan, 2009: Emas National Park).

This limited information does not provide evidence of the duration and seasonality of breeding. Our study therefore addresses the long mid-term breeding phenology of BFC in the northern Pantanal (Mato Grosso State, Brazil) and provides additional insights into the temporal and spatial distribution of family groups. Using age-class assessment of captured offspring, we estimated periods of egg hatching and egg laying to determine the nesting seasonality of the species. Data from recognized Citizen Science projects (eBird) and the Global Biodiversity Information Facility (GBIF) were used to supplement and support our camera trap field dataset as part of this study, which contributed to the interpretation of our results. This study summarizes the literature and digital information combined with new and detailed information on the breeding phenology and parental care of BFC based on field observations and camera trap data from the northern Pantanal, as 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).

MATERIAL AND METHODS

Study area

The study was conducted at the SESC Pantanal, Baía das Pedras, one of the units of the SESC Pantanal Ecological Resort, in the municipality of Poconé, northern Pantanal, Mato Grosso State, Brazil (16°29′55″S, 56°24′46″W). The site is a privately protected area of approximately 4,200 ha within the floodplains of the Cuiabá River, which is seasonally inundated by the Paraguay River from October to April (Junk *et al.,* 2006, 2011), followed by a terrestrial phase from May to September. Vegetation consists of a mosaic of forests and savanna areas, and the regional climate is tropical and humid (average annual rainfall of 1,000-1,500 mm and average annual temperature of ~24°C).

Camera trapping

Camera traps (hereafter CTs) were placed at 37 sampling locations in a regular grid with 1 km spacing between each station (Fig. 1). The cameras (RECONYX PC800, RECONYX HC600, UWAY VH400, BUSHNELL TROPHY CAM AGGRESSOR, and BUSHNELL TROPHY CAM HD 2012) were mounted 60 cm above the ground between July 2015 and December 2017. All CTs were operated using a passive infrared-triggered system, and captures were recorded with date and time. CT studies on the life history of BFC (Fernández-Duque *et al.,* 2013; Gomes *et al.,* 2018; Laino *et al.,* 2018) and other *Crax* species (Srbek-

Araujo *et al.,* 2012; Lafleur *et al.,* 2014; Alves *et al.,* 2017; Pardo *et al.,* 2017; Pérez-Irineo & Santos-Moreno, 2017; Whitworth *et al.,* 2018) have documented the scientific importance of using this method and have provided a large amount of new data on various aspects of cracid behavior, occurrence, and habitat preferences.

Sampling effort (number of days – 24 h cycles when CTs were active) varied among different sampling occasions, sampling locations, and months. At each location, sampling was continuous without disturbing for at least 5 days when recorded data were collected.

Following the methodology of O'Brien *et al.* (2003), only consecutive images or videos of BFC taken 30 minutes apart were defined as an independent record (= capture). Except when different individuals were clearly identifiable in subsequent videos or im-

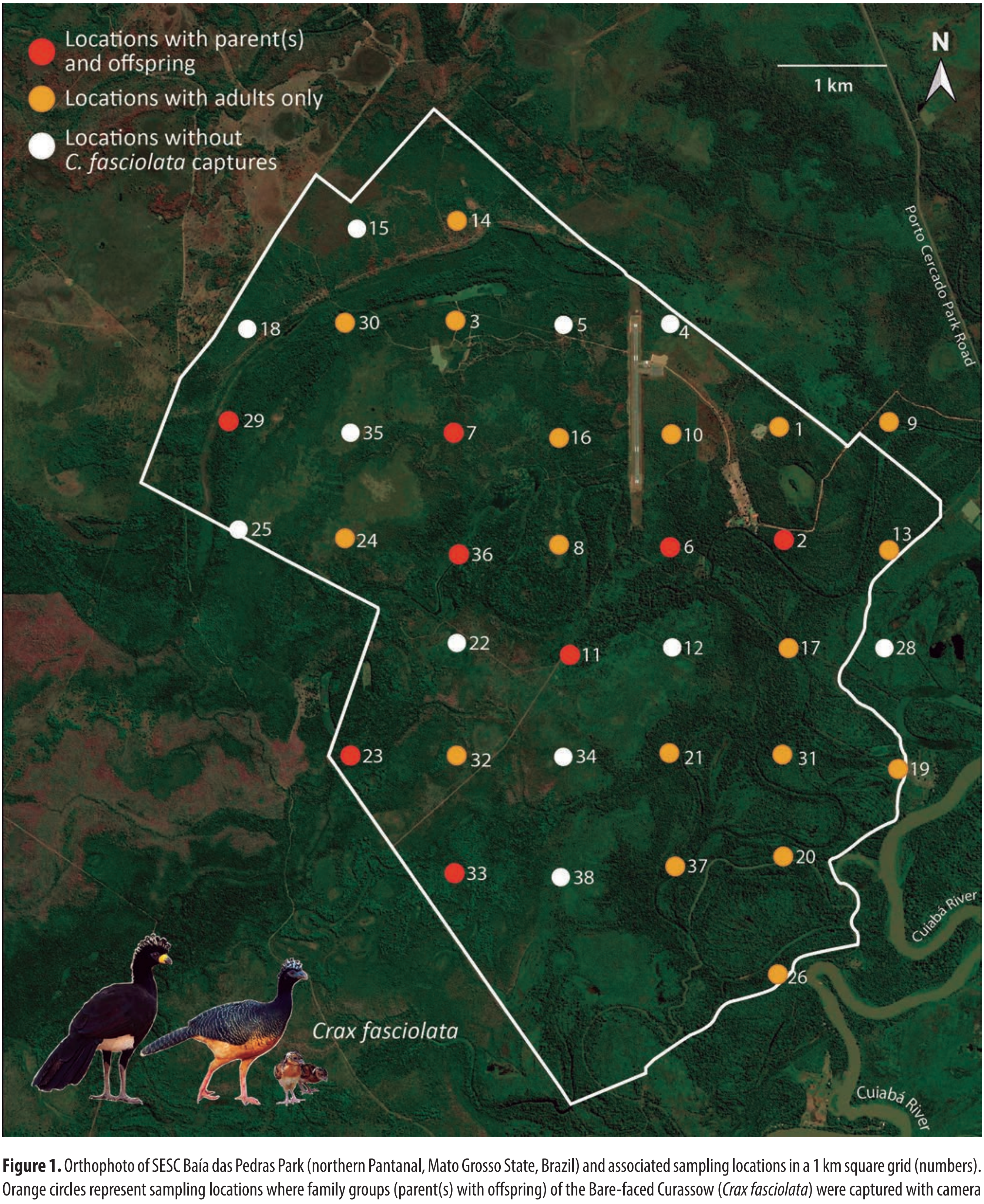

Figure 1. Orthophoto of SESC Baía das Pedras Park (northern Pantanal, Mato Grosso State, Brazil) and associated sampling locations in a 1 km square grid (numbers). Orange circles represent sampling locations where family groups (parent(s) with offspring) of the Bare-faced Curassow (*Crax fasciolata*) were captured with camera traps. Gold circles represent sampling locations where only adults were captured, while white circles represent those where no BFC was captured.

ages, then nonconsecutive images or videos were also counted as an independent capture. The latter was considered part of the same family group as the previous capture(s).

Breeding phenology

To estimate the period of the BFC breeding season based on CT recordings, each captured offspring was assigned to an age class based on feather developmental stages and body size. Age classes were determined based on comparisons of captures with existing (1) images and (2) descriptive data with assigned ages for BFC and other Cracinae species of similar sizes. The combination of multiple characteristics was considered to determine the age class of an individual capture. CT records varied in quality, and the different characteristics were not always visible on CT captures. Therefore, age class was easier to determine for captures of better quality. These were considered first and used as an additional reference data for (3) comparisons with the remaining lower-quality CT records. Records, when specific characteristics were not clearly identifiable, *e.g.,* size and plumage details, were excluded from the age-class estimation. Age classes were categorized into the following groups: (a) 1-14 days, (b) 15-30 days, (c) 30-60 days, (d) 60-90 days, and (e) 90 > days old. It is important to note that when estimating young birds older than one month, the error in age estimation may be greater than that for younger birds. In addition, estimating birds older than 90 days is too difficult to determine unambiguously. Therefore, the age-class categories were kept sufficiently large to limit this error.

Images (1) with assigned ages for various captive-raised *Crax* species were mostly available for offspring aged around 30 days or less (24-h, 15-day, and 30-day-old Great Curassow (*Crax rubra;* Taibel, 1940); few-day-old BFC, three-week-old *C. rubra* and one-month-old Wattled Curassow (*Crax globulosa;* Delacour & Amadon, 2004); and one- and 33-day-old Blue-billed Curassow (*Crax alberti;* AZA, 2012). Another image record used for age-class classifications was for 45-day-old *C. rubra* (Taibel, 1940) and 87-day-old Crestless Curassow (*Mitu tomentosum;* Endo *et al.,* 2021). Descriptive published notes (2) with assigned age were more common for younger birds. In the first month, changes in appearance were rapid and clearly expressed. Therefore, age-class estimation was easiest for juveniles that were one-month old or less. In addition to age class estimation, it is also possible to determine the sex of BFC offspring because they are identifiable shortly after hatching. Delacour & Amadon (2004) pointed out that the sex-specific pattern of males is darker than that of females. The colored pattern on the wings and tail is clearly visible and distinguishes males from females when they are only a few weeks old, which is also evident on CT records (authors observations).

The following descriptive notes were used to estimate the age classes:

(i) For Alagoas Curassow (*Mitu mitu*) in captivity (Nardelli, 1981, 1993 cited in Del Hoyo & Motis, 2004), it was noted: *"The down feathers begin to be lost after a week. Juvenile feathers begin to appear after two weeks on the upper back, belly, breast, flanks, and upper tail coverts; flight feathers and rectrices appear after four weeks…".* For Razor-billed Curassow (*Crax mitu*) in captivity (Heinroth, 1931, cited in Delacour & Amadon, 2004), it was noted that: *"At twenty days the wings are well developed."* and *"The tail quills grow more slowly, but are well developed at forty days. At this age, the wings, tail, and breast are well feathered, and the head is still in full down".* It can be assumed that the degree of molt is an important factor in estimating age class. This is especially true in young birds that are 30 days old or less.

(ii) The presence or absence of a curly crest can be considered one of the most important indicators. For captive-reared offspring of BFC, Coupe (1966) noted that *"At a little over eight weeks at captive breeding the curassow offspring were becoming darker in colour and beginning to develop the curly crest."* (*Note:* Small curly feathers on the top of their head already erecting at approximately one month of age while head is still in full downy plumage. However, these slowly erected feathers replacing the downy feathers are smaller and not yet in an adult-like shape (authors observations). Therefore, it is reasonable to assume that Coupe (1966) was talking about the formation of an adult-like crest at the point where he noted the curly crest.) Another report on captive *C. mitu* (Heinroth, 1931 cited in Delacour & Amadon, 2004) stated that the crest is less developed at 80 days. In summary, the offspring can be expected to be less than 2 months old if the curly crest is absent or just developing and (well) over 2 months old if the curly crest is well developed.

(iii) The body size of an offspring compared with its parents was also considered important. Roer, cited in Delacour & Amadon (2004) and supported by our studies, observed an approximately two-month-old offspring of *C. globulosa* in captivity. It was only one-third the size of an adult. It can be assumed that offspring are older than 2 months if their size is more than one-third that of an adult. Comparison of offspring body size with that of an adult individual on CT captures is only possible if the offspring are close to an adult in terms of image or video depth on the same video or image sequence. However, if the offspring is approximately half the size of an adult, it is about three to four months old (authors observations).

(iv) Appearance of offspring plumage compared with adult plumage of coaptive-reiased BFC individuals. For older offspring of BFC, Vaurie (1968) noted that *"Guimarães, Bergamin, and Carvalho (1935), Bronzini (1940, 1943), and Taibel (1940, 1953) … … noted the change in the plumage and stated that the downy-plumage had been replaced by a plumage similar to that of the adult in about two months, or in less than three."* For *C. globulosa,* it was noted (Roer, personal observation, cited in Delacour & Amadon, 2004) that the plumage of about two months old offspring already looked very much like that of an adult, with trace of some brownish molting on its wings. For *C. mitu,* it was noted (Heinroth, 1931, cited in Delacour & Amadon, 2004) that the plumage was entirely black (like the adults') after 65 days from hatching. For *C. rubra,* it was noted (Taibel, 1940; Delacour & Amadon, 2004) that immature offspring resemble adults after 3 months. In addition to the *Crax* species, it has been reported for *M. mitu* that the offspring are almost indistinguishable from their parents at 90 days of age (Nardelli, 1981, 1993 cited in Del Hoyo & Motis, 2004). Drawing a simplified conclusion, the appearance of immature birds resembles that of an adult after 2 or 3 months (Vaurie, 1968). However, for the BFC, the head fully changes in plumage in the latest stages of molting. The crest of BFC may already be well developed when the head can still miss feathers (authors observations). A similar pattern was noted (Endo *et al.,* 2021) for 87-day-old *M. tomentosum* with a small crest (which is generally less pronounced for this species than for BFC) but still missing feathers around the eyes. Therefore, if a juvenile resembles an adult in plumage and the head is also feathered like an adult, in addition to a well-developed curly crest and a size about half that of an adult or more, then it can be assumed that the juvenile is almost certainly more than three months old.

After this age classification of individual capture, the estimated age-class interval was subtracted from the date of capture to estimate the time frame for egg hatching. From this, an additional 30 days was subtracted, which represents the incubation period for BFC in captivity (Faust & Faust, 1963), to estimate the time frame for the onset of egg laying.

Citizen science projects and Global Biodiversity Information Facility (GBIF)

In addition to the CT survey, recognized Citizen Science projects, such as eBird, and Global Biodiversity Information Facility (GBIF) data collections were considered. (1) eBird checklists where photos of BFC were available were checked for offspring observations. Each checklist also contains important information about the date and location of observations. Therefore, comparison with the results of our CT survey was possible. For better comparison, only the images obtained in the northern Pantanal were evaluated. (2) The eBird Basic Dataset (2021) was obtained and checked for BFC offspring data from the northern Pantanal (Mato Grosso, Brazil). Again, date and location information were available and considered. For both eBird data collections, age-class estimation and breeding season assessment were conducted using the same methodology as that for the CT survey. (3) The GBIF data collection (GBIF, 2021) was used to check the overall occurrence of BFC during the year. Only data reported for the municipality of Poconé (northern Pantanal, Mato Grosso State, Brazil) were used. This decision was made because our CT survey was conducted in the same municipality and there were no data in the GBIF, specifically for the northern Pantanal. Therefore, this was considered the best option possible for comparison with our dataset. For the analysis of the data on the occurrence of BFC, the following search parameters were used: (a) basis of records: human observation, (b) country of area: Brazil, (c) dataset: EOD – eBird Observation Dataset, (d) administrative area (gadm.org): BRA.12.87_1 (Poconé, Brazil), and (e) scientific name: *Crax fasciolata* Spix, 1825. GBIF occurrence data for BFC were used and compared with records of offspring from eBird and our CT data collection to see if conclusions could be drawn about BFC breeding behavior based on occurrence data.

RESULTS

Camera trap records

Camera traps were active for 4,768 sampling days. Due to the accessibility of sampling locations during inundation and/or camera trap malfunctions, sampling effort per sampling location and sampling occasion differed, averaging 128.9 ± 56.5 days per sampling site (mean ± SD, range: 46-238). A total of 554 individual captures of BFC were taken within 357 independent capture occasions (30-min periods) at 26 (70.27%) out of the 37 sampling locations (Fig. 1). Of these, 65 offspring captures were taken within 44 independent capture occasions at eight sampling locations (21.62%). On most occasions, offspring were observed when accompanied by both parents (n = 24; 54.55%), followed by observations with single adult females (n = 13; 29.55%) and single adult males (n = 7; 15.91%). They were never observed without parent(s). The number of offspring captured was often one (n = 24; 54.55%) or two (n = 19; 43.18%) and once three individuals (2.27%).

Offspring were documented between March and May 2016 but also in June, July, October, and November 2017. Sampling effort also varied from month to month (Fig. 2). No offspring were detected in August, the month with the highest overall sampling effort (936 sample days). Offspring were successfully detected in March, the month with the lowest sampling effort (18 sample days).

Citizen science records

(1) All available image records of BFC from eBird checklists were reviewed. Only 10 users (Langeloh Roos, 2008; Loewen, 2013; Seifert, 2014; Abreu, 2017; Lepre, 2018; Alminhana Macil, 2018; Boyle, 2019; Carpenter, 2019; Kibbe, 2019; Schunck, 2020) uploaded an image of a BFC family group with offspring taken in Brazil. Five of these (Table 1; Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019) were included for further consideration because they were from the Pantanal of

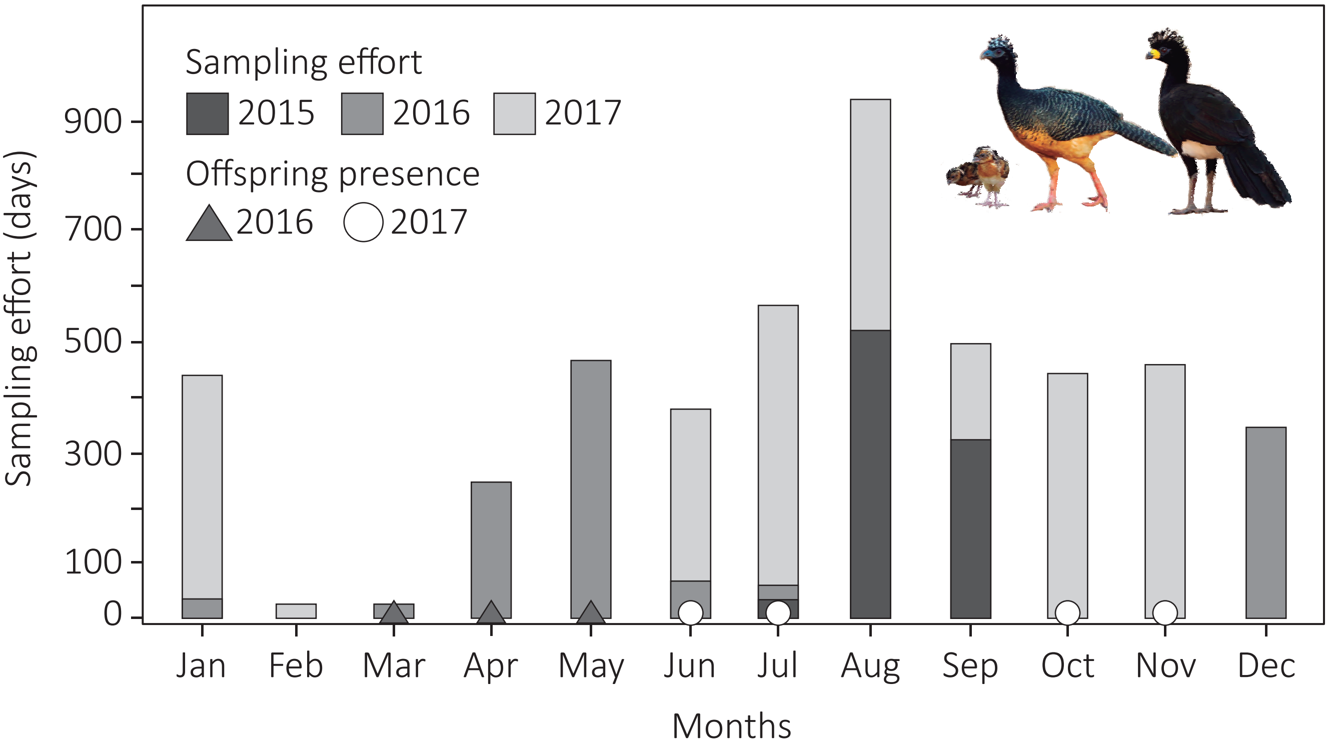

Figure 2. Sampling effort (y-axis) in SESC Baía das Pedras Park (northern Pantanal, Mato Grosso State, Brazil) expressed in days per month (x-axis) for different years (2015, 2016, and 2017) is represented by stacked bars. The presence of Bare-faced Curassow (*Crax fasciolata*) offspring is represented by the shapes on the x-axis. The triangle represents their presence during surveys in 2016, and the circle represents those in 2017.

Mato Grosso. (2) The eBird Basic Dataset was also reviewed (eBird Basic Dataset, 2021) and provided seven additional offspring datasets for the Pantanal of Mato Grosso. Combined, a total of 12 offspring records were evaluated, providing an important data supplement to our CT observations. Eleven of them were recorded in the municipality of Poconé and one in the neighboring municipality of Barão de Melgaço. All were very close to our study area (38.5 ± 17.1 km; mean ± SD, range: 4-61 km) and therefore compared very well with the CT dataset.

Other records

Kirwan (2009) published notes (with images) on single female offspring accompanied by parents. They were observed in the Pantanal of Mato Grosso on 3 November 2006, and a nesting female was recorded on 17 November 2020 in our study area by one of our field assistants.

Age-class estimation

Of the 44 independent capture events of BFC offspring in 18.2% (n = 8) the age class could not be assigned due to low quality of records (Table 1). Of the 36 remaining cases, offspring could be properly assigned to an age class (see Fig. 3 for examples of offspring assigned to different age-classes compared with the adult female size); most records were at 90 < (52.8%) and from 30-90 (36.1%) days, while individuals younger than 30 days were recorded in only four cases (11.1%).

Of the five additional eBird checklist records of offspring images (Table 1; Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019), one descriptive note with annotated age (S59554573) available from the eBird Basic Dataset (2021) and one published note (Kirwan, 2009) included in this study, three were classified as less than 30 days old (42.86%), three (42.86%) were classified as between 30-90 days old, and one (14.29%) was classified as 90 < days old.

Breeding season

Data from the CT captures showed that offspring were captured at 4 locations in 2016, with most of the offspring captured at location G6 (Table 1). They were captured between 31 March and 14 May. For those captures where age-class estimation was less than 90 days old, the breeding season (onset of egg laying) began between January and February. However, there were few captures where offspring were estimated to be older than 90 days. In these cases, the breeding season began in December 2015 or earlier. At G7, the only offspring were captured on May 20, 2016. The estimated onset of the breeding season was between February and March 2016. At G11, the estimated onset of the breeding season was in January or earlier for individuals captured between 16 and 24 May 2016. At location G36, offspring were captured on 20 May 2016, and the estimated onset of the breeding season was between February and March 2016. Offspring were captured at 5 locations in 2017. At location G2, offspring were captured between 12 and

Table 1. List of estimated age classes, egg laying and hatching months for all Bare-faced Curassow (*Crax fasciolata*) offspring captured in the northern Pantanal (Mato Grosso, Brazil) from July 2015 to December 2017. Camera trap data (our collection; Gn = sampling location)[1] with the addition of images from eBird database checklists[2] (Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019), non-image data from eBird Basic Dataset (2021)[3], published notes (Kirwan, 2009) and nesting female record from November 2020 (own records). Capital letters indicate the sex of individual offspring (F = female, M = male, and U = unidentified sex).

Data collection	Date	Time	Offspring	Estimated		
				Age-class (Days)	Egg laying (Month)	Hatching (Month)
G2[1]	12/06/2017	06:44	M	30-60	Mar/Apr	Apr/May
G2[1]	14/06/2017	16:01	M/M	—	—	—
G2[1]	15/06/2017	14:32	M	30-60	Mar/Apr	Apr/May
G2[1]	16/06/2017	16:49	M/M	30-90	Feb-Apr	Mar-May
G2[1]	19/06/2017	16:09	M	—	—	—
G2[1]	21/06/2017	15:44	M	—	—	—
G2[1]	24/06/2017	06:58	M	30-90	Feb-Apr	Mar-May
G6[1]	31/03/2016	16:13	M	30-60	Jan	Feb
G6[1]	03/04/2016	06:58	F/M	30-60	Jan/Feb	Feb/Mar
G6[1]	13/04/2016	07:34	F/M	90<	Dec or earlier	Jan or earlier
G6[1]	13/04/2016	10:48	F	90<	Dec or earlier	Jan or earlier
G6[1]	13/04/2016	13:24	F	90<	Dec or earlier	Jan or earlier
G6[1]	15/04/2016	06:49	F/M	30-60	Jan/Feb	Feb/Mar
G6[1]	15/04/2016	11:35	F	—	—	—
G6[1]	15/04/2016	15:03	F	30-60	Jan/Feb	Feb/Mar
G6[1]	18/04/2016	10:57	F/F	90<	Dec or earlier	Jan or earlier
G6[1]	19/04/2016	07:41	F/F/M	30-60	Jan/Feb	Feb/Mar
G6[1]	19/04/2016	12:23	F	90<	Dec or earlier	Jan or earlier
G6[1]	25/04/2016	07:51	F	90<	Dec or earlier	Jan or earlier
G6[1]	26/04/2016	11:53	F/F	90<	Dec or earlier	Jan or earlier
G6[1]	27/04/2016	10:04	F/F	90<	Dec or earlier	Jan or earlier
G6[1]	14/05/2016	09:53	F/F	90<	Jan or earlier	Feb or earlier
G7[1]	20/05/2016	16:19	F/F	30-60	Feb/Mar	Mar/Apr
G11[1]	16/05/2016	10:23	F	—	—	—
G11[1]	16/05/2016	17:07	F/M	90<	Jan or earlier	Feb or earlier
G11[1]	17/05/2016	06:08	F	90<	Jan or earlier	Feb or earlier
G11[1]	20/05/2016	08:52	F/M	90<	Jan or earlier	Feb or earlier
G11[1]	24/05/2016	08:08	F/M	90<	Jan or earlier	Feb or earlier
G23[1]	16/10/2017	12:02	F	90<	Jul or earlier	Aug or earlier
G23[1]	29/10/2017	16:30	U/U	0-14	Sep	Oct
G29[1]	29/10/2017	15:24	F	—	—	—
G29[1]	02/11/2017	05:09	F	60-90	Jul/Aug	Aug/Sep
G29[1]	04/11/2017	06:27	F	—	—	—
G29[1]	16/11/2017	06:02	F	90<	Jul or earlier	Aug or earlier
G29[1]	21/11/2017	16:37	F	90<	Jul or earlier	Aug or earlier
G29[1]	22/11/2017	05:46	F	—	—	—
G29[1]	22/11/2017	08:42	F	90<	Jul or earlier	Aug or earlier
G29[1]	24/11/2017	05:04	F/M	90<	Jul or earlier	Aug or earlier
G33[1]	27/06/2017	10:27	F	60-90	Feb/Mar	Mar/Apr
G36[1]	27/05/2016	06:56	F/F	30-60	Feb/Mar	Mar/Apr
G36[1]	23/07/2017	05:04	F/M	15-30	May/Jun	Jun/Jul
G36[1]	23/07/2017	14:55	F/M	15-30	May/Jun	Jun/Jul
G36[1]	25/07/2017	10:12	U	15-30	May/Jun	Jun/Jul
G36[1]	22/10/2017	08:01	F/M	90<	Jun or earlier	Jul or earlier
Loewen (2013)[2]	13/09/2013	—	F	30-60	Jun/Jul	Jul/Aug
Abreu (2017)[2]	05/07/2017	—	M/M	90<	Mar or earlier	Apr or earlier
Carpenter (2019)[2]	10/10/2019	—	F	60-90	Jun/Jul	Jul/Aug
Kibbe (2019)[2]	15/10/2019	—	F	15-30	Aug	Sep
Boyle (2019)[2]	19/10/2019	—	U	15-30	Aug/Sep	Sep/Oct
S59554573[3]	05/09/2019	—	U	0-14	Jul	Aug
S75514863[3]	15/08/2009	—	U	—	—	—
S83941794[3]	11/08/2011	—	U/U/U	—	—	—
S42575364[3]	03/09/2012	—	M/F	—	—	—
S24219353[3]	10/07/2015	—	U	—	—	—
S31252866[3]	25/08/2016	—	U	—	—	—
S60566998[3]	12/10/2019	—	F/F/F	—	—	—
Kirwan (2009)	03/11/2006	—	F	60-90	Jul/Aug	Aug/Sep
Own records	17/11/2020	—		Nesting female. Initiation of incubation Oct/Nov		

24 June 2017, and the estimated onset of the breeding season was between February and April. At G33, the offspring were captured on 27 June 2017, with the onset of the breeding season estimated between February and March. At G36, the offspring were captured in July and October 2017. In the first case, the estimated onset of the breeding season was between May and June, while in the second case, the onset was most likely in June or earlier. Since male and female offspring were captured in both cases, perhaps the same family group was captured a few months apart. For offspring captured in July 2017, the estimated age was a few weeks, while the offspring captured in October 2017 were already half the size and resembled adults, with an estimated age of 90 < days. At

Figure 3. Images of offspring captures of the Bare-faced Curassow (*Crax fasciolata*) in the northern Pantanal (Mato Grosso State, Brazil) compared with the adult female. The numbers (1-6) denote different capture occasions, and the uppercase letters (A-B) indicate that the images are from the same capture occasion and have been stitched together for better comparison. Young birds in the images are divided into different age classes. (1) An adult female with few-day-old fledglings (categorized as age class 0-14 days old). (2A) A few-week-old offspring (F/M) with an adult female and (2B) a single offspring (M) from the same series of photographs (categorized as age class 15-30 days old). (3A) Adult female with (3B) offspring (F) categorized in the estimated age class of 30-60 days old. (4) Adult female with offspring (F) whose estimated age class was 60-90 days old. (5, 6) Adult female with older offspring whose estimated age class is over 90 days old. In image (5), the young female resembles an adult except for the head, which is not yet fully feathered. In image (6), the young female and male are fully feathered, and both resemble adults but are still much smaller in size comparison.

location G23, offspring from 2 family groups were captured between 16 and 29 October 2017. For the first, the onset of the breeding season was estimated to be in September, and for the second, in June or earlier. The last location with offspring detection was G29, with captures taken between 29 October and 24 November 2017. The estimated onset of the breeding season was between July and August, with some captures in July 2017 or earlier.

Reports with image data (eBird checklists) were obtained at four locations. Loewen (2013) recorded an offspring in September 2013. The onset of the breeding season (egg laying) was estimated to be between June and July. In the case captured in July 2017 (Abreu, 2017), the young were older; therefore, the breeding season was not firmly resolved, but may have been March or an earlier onset. On 10 October, Carpenter (2019) reported a family with offspring for which the onset of the breeding season was estimated to be between June and July. At one of the locations, there were two reports of a family group with individual offspring (Boyle, 2019; Kibbe, 2019) only a few days apart (15 and 19 October 2019). The onset of the breeding season was estimated to occur between August and September 2019. In addition to the image data, there was one descriptive note about the age of the approximately one-week-old offspring on 5 September 2019 (eBird Basic Dataset, 2021). Its breeding season (egg laying) began in the second half of July. The estimated onset of the breeding season of offspring noted in Kirwan (2009) was between July and August. The estimated onset of the breeding season of nesting female recorded on 17 November 2020 (own data) had just started or started up to approximately one month before capture.

Summarizing all results for each independent capture event, the method of backdating the age of offspring suggests that the breeding season for BFC in northern Pantanal (Mato Grosso, Brazil) continues throughout the year (Fig. 4).

Territory overlaying

The number of family groups captured per sampling location ranged from one to three. There were also records of multiple family groups at the same sampling locations within short time intervals, indicating possible territorial overlap between breeding pairs. On 13 April 2016, two recognized family groups with well-grown chicks (both 90 < days old) were captured within a 3-hour interval at G6. On 15 April 2016, family groups with offspring from two different age classes (the first with 30-60-day-old offspring and the second with older but indeterminate age classes) were captured at the same location and within a 4-hour interval. Additionally, on 19 April 2016, two family groups (the first with 30-60-day-old offspring and

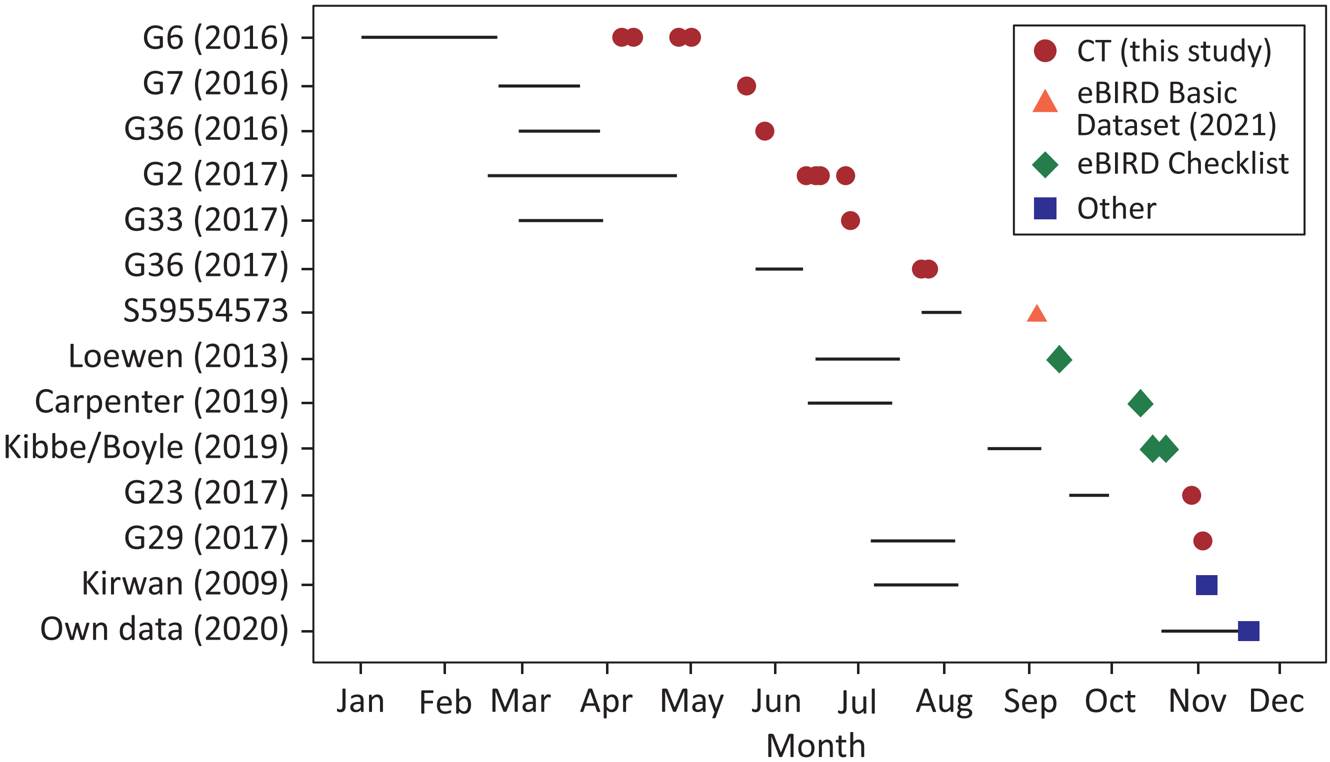

Figure 4. Shapes on the plot represent the timing of offspring records (= captures) on a monthly basis from different data collections. Line (–) represents the estimated time frame in which egg laying was initiated (considered the onset of the breeding season) at different sampling locations. The summary is based on the standardization of age classes of BFC offspring captured with camera traps – CT (our collection) between July 2015 and December 2017 in the northern Pantanal (Mato Grosso State, Brazil), eBird Checklist image records (Loewen, 2013; Boyle, 2019; Carpenter, 2019; Kibbe, 2019), single description note (S59554573 obtained from eBird Basic Dataset (2021)) and published note (Kirwan, 2009) of offspring recorded in the northern Pantanal. In addition, nesting female recorded at SESC in November 2020 (authors data) was included in the summary. Only records with age-class estimation between 0 and 90 days were summarized (data where estimation was not possible or it was more than 90 days were excluded from the plot).

the second with 90 < day-old offspring) were captured 5 hours apart. Overall, data for G6 indicated that at least three uniquely identifiable family groups were captured between 31 March and 14 May 2016. Two family groups identified by differences in offspring age classes in records 13 days apart (on 16 and 29 October 2017) also occurred at sampling location G23. Although a part of the dataset was excluded from the age-class evaluation due to the low quality of the camera trap data, it was still evident that the excluded family group consisted of older offspring than the one for which the age class was evaluated. Sampling location G36 was the only location where family groups were recorded two years in a row, one family group in May 2016 and at least one family group (at most two) between July and October 2017. The temporal clustering of such recordings suggests that breeding pairs, followed by their offspring, move from patch to patch, likely due to the abundance of local food resources such as fruit or as a dispersal strategy to avoid predation.

Annual detection pattern – species occurrence

To date (22 December 2021), 6,933 human observations of BFC have been entered into the EOD – eBird Observation Dataset (data from GBIF, 2021). Data were available for observations entered for 2020 or earlier. A total of 6,625 (95.56%) of these were noted for Brazil, of which 3,220 (48.60%) were observed in the municipality of Poconé (northern Pantanal, Mato Grosso State, Brazil), which covers an area of 17,261 km^2. This indicates that this species was observed most frequently there, with a total of 18.54 observations per 100 km^2, compared with the estimated total distribution area of BFC (approximately 4,720,000 km^2; IUCN, 2021), with only 0.14 observations per 100 km^2. Considering only the dataset for the municipality of Poconé (Fig. 5), based on historical data from GBIF (2021), most human observations were made between July and October, averaging 671.25 ± 112.34 (mean ± SD, range: 541-792) observations per month, as observations were significantly lower between November and June, averaging 66.88 ± 60.45 (mean ± SD, range: 11-187) observations per month.

Summarizing the individual CT occasions with captured offspring in our study, most were captured in the period from March to July (34; 77.27%), while 10 of them (22.73%) were captured between October and November. All 12 other offspring, from eBird checklists (eBird Basic Dataset, 2021) and image records (Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019) for the northern Pantanal (Mato Grosso, Brazil), were captured between July and October (Fig. 5). There was a strong positive correlation ($r(10) = .92$, $p < 001$) between offspring records from eBird data sources and the overall occurrence of the species (GBIF, 2021).

DISCUSSION

Birds generally breed when photoperiod and food resources are abundant, resulting in seasonal patterns in breeding phenology (Martin, 1987; Gwinner, 2003). Therefore, year-round breeding is exceptional in birds and, in the case of this study, may be enhanced by the location of the study area at a relatively low latitude where

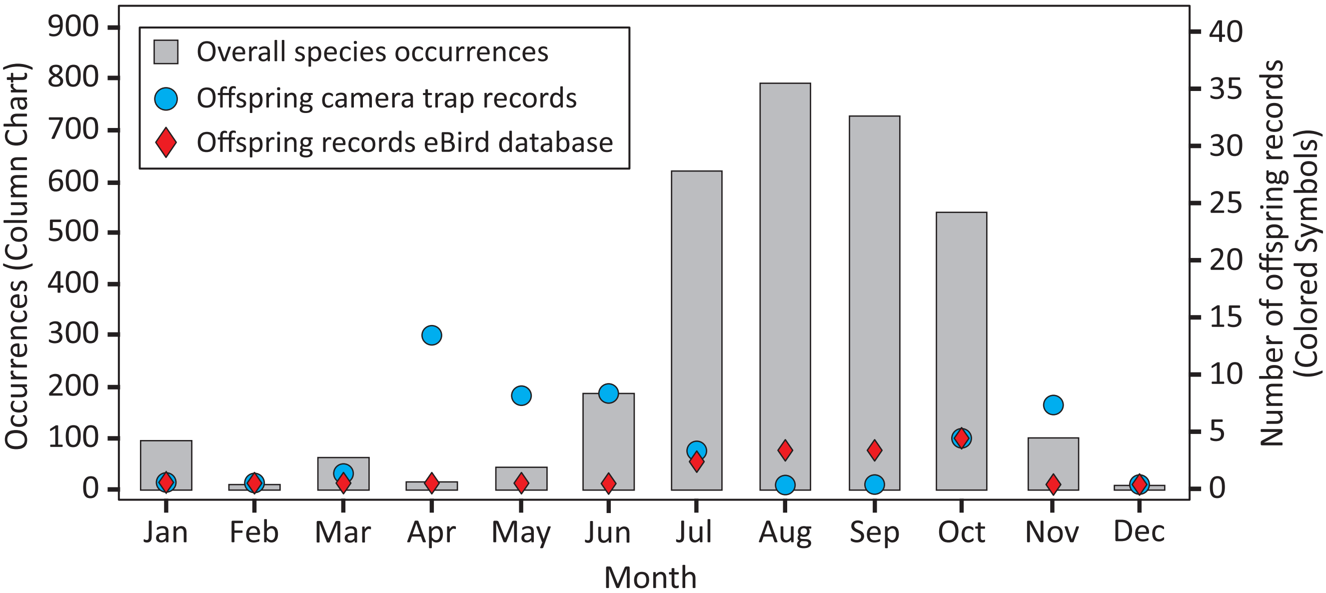

Figure 5. Occurrences of the Bare-faced Curassow (*Crax fasciolata*) per month (primary vertical axis: bar chart) reported for the municipality of Poconé (northern Pantanal, Mato Grosso State, Brazil). Data obtained from GBIF.org (06 September 2021) GBIF Occurrence download https://doi.org/10.15468/dl.vyrese. Parameters used: (1) "basis of records: Human observation", (2) "country of area: Brazil", (3) "dataset: EOD – eBird Observation Dataset", (4) "Administrative area (gadm.org): BRA.12.87_1", and (5) "scientific name: *Crax fasciolata* Spix, 1825". Number of independent offspring records (= captures) of Bare-faced Curassow (*Crax fasciolata*) in different months (secondary vertical axis: scatter plot), where (a) records from camera traps captured in the SESC Baía das Pedras Park (Poconé municipality, northern Pantanal, Mato Grosso State, Brazil), and (b) image records of offspring from eBird checklists (Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019) combined with offspring data from the eBird Basic Dataset (2021) for the northern Pantanal (Mato Grosso State, Brazil).

seasonal photoperiod variation is not as pronounced. Year-round breeding implies that BFC must be able to overcome the likely seasonality of their preferred diet. In addition, while rearing their offspring, parents must cope with the retreat of terrestrial foraging habitats due to flooding in the Pantanal. These two aspects, as well as their effects on the breeding success of this curassow species, deserve further investigation.

The wet season and peak of high waters may have contributed to the lack of offspring detected between December and February, as some of our sampling locations were in flooded areas. However, August and September are dry months, and the absence of offspring detections by CTs during this period remains a mystery, especially considering the large sampling effort in August (Fig. 2).

Our CT study provides new information on the breeding phenology of BFC, suggesting year-round breeding in the northern Pantanal. It also extends the information on the BFC life history provided by Desbiez & Bernardo (2011), Fernández-Duque *et al.* (2013), Gomes *et al.* (2018), Laino *et al.* (2018), and Zalazar *et al.* (2018). In addition, our results show that long-term studies, especially those using CTs, are crucial to better understand the biology and behavior of BFC and other cracids. The results are particularly valuable because the fieldwork was conducted in a remote and protected area of the northern Pantanal (Mato Grosso, Brazil) with little impact from human disturbance and intact ecosystem services. Data on the occurrence of BFC in Poconé compared with occurrence data for the entire range of BFC (both based on human observation data from GBIF (2021)) show that the municipality of Poconé is an "observation hotspot" for BFC (observation ratio of 132:1). Almost half (46.45%) of all observations were recorded in this area.

Reports of offspring CT captures of BFC or other curassow species captured during long-term studies are rare. No offspring have been reported for BFC, even when great efforts were made for CT data collection and adult (paired) individuals were frequently captured (Fernández-Duque *et al.,* 2013; Gomes *et al.,* 2018; Laino *et al.,* 2018; Zalazar *et al.,* 2018). This is also true for reports of other cracids. Females of *Crax rubra* were observed with their offspring on two separate occasions: (1) during the survey in the San Juan-La Selva Biological Corridor in northeastern Costa Rica between July 2009 and July 2011 (Lafleur *et al.,* 2014) and (2) from March 2011 to June 2013 in the Los Chimalapas region of southeastern Mexico (Pérez-Irineo & Santos-Moreno, 2017). On one occasion, two females of *Crax blumenbachii* were captured with two female juveniles in the Vale Natural Reserve, Linhares, Espírito Santo State, Brazil, between June 2005 and October 2008 (Srbek-Araujo *et al.,* 2012). Beirne *et al.* (2017) reported Sira Curassow (*Pauxi koepckeae*) offspring with an adult during a study in the Sira Communal Reserve, Peruvian Andes, between March and September 2015. In this study, however, such captures were not rare. Offspring of various ages were present in 44 of 357 (12.32%) independent captures (always together with adults) and at 8 of 37 sampling locations at least once. The study was conducted in a protected area in the northern Pantanal (Mato Grosso, Brazil), where human disturbance activities such as hunting are extremely low in regard to impacting the daily activities of the local cracid species, which might have contributed to greater capture success. The factors underlying the higher frequency of offspring captures in our study are still unclear, but we suspect that the grid-based design of our study also contributed to higher capture efficiency.

There is also important to emphasize that juveniles were recorded less frequently in the first 30 days (11.1%). Probably because their movements are more restricted at this stage, resulting in a lower ability to move within larger areas, and therefore they are not recorded at the specific grid points (= sampling locations) where our CTs were installed.

Sick (2001) suggested that each breeding pair defends a territory of 2-3 km, but we observed multiple family groups at the same sampling location within a few hours or days. Our results suggest that territories of family groups overlap in time and space, perhaps as a result of sharing foraging patches. Captures of offspring associated with adult males and females confirmed previous reports of biparental care (data from captive birds; Coupe, 1966). Camera traps are more likely to capture offspring with only one parent than with both parents. Therefore, a higher number of captures in which offspring appear with an adult pair is an even stronger indication that parental care by both parents is the rule rather than the exception. The possibility that family size is underestimated or that only one parent is captured is due to two different factors: (1) because one parent (or part of the family group) is often slightly farther away than the captured part of the family group when the camera trap is triggered and therefore not captured (authors observations). As observed in adult pairs (Desbiez & Bernardo, 2011), they usually stay close to each other (< 20 m). Therefore, in such cases, a correction according to our methodology is possible since they can retrigger the camera trap while following each other a few seconds or minutes later, and confirmed by similar observations in our study. (2) There is also a possibility that part of the family group crossed the camera trap on the opposite side of the camera trap viewing angle, since only a single camera trap was set per location. Therefore, detection on the back side of the camera trap is not possible. In future studies, this problem can be solved by placing multiple cameras per location so that a 360° viewing angle is achieved. However, the results obtained in this study show that the method with only one camera trap per sampling location was sufficient to collect a large amount of valuable data on occurrence, abundance, and behavior.

We recommend and emphasize the usefulness of CTs to gather new information on the breeding season and other life-history aspects of the BFC and similar forest-dwelling birds, such as activity patterns, sex ratios, and social organization. Despite the obvious advantages of CTs as a tool for detailed biological studies, some limitations should be noted. The major limitation was that the sampling effort varied significantly by sampling period and location because the study sites were inaccessible due to flooding or logistical obstacles. In future studies, sampling should focus on forest and riparian habitats, as these are considered important "social gathering areas" for BFC (authors observations; Desbiez & Bernardo, 2011; Fernández-Duque *et al.,* 2013), which could help clarify details on parental care and other intra- and interspecific social behaviors.

Several other cracid species were frequently observed during our field work. Therefore, in addition to BFC research, the study area is also suitable for long-term research on other cracid species, such as the Chestnut-bellied Guan (*Penelope ochrogaster*), the Blue-throated Piping-Guan (*Pipile cumanensis*), and, as previously reported by Pérez-Granados & Schuchmann (2021), the Chaco Chacalaca (*Ortalis canicollis*).

Citizen Science Data from eBird (Loewen, 2013; Abreu, 2017; Boyle, 2019; Carpenter, 2019; Kibbe, 2019; eBird Basic Dataset, 2021) and the GBIF (2021) database proved to be an important addition to our CT dataset. This finding supports our hypothesis of opportunistic year-round breeding in the northern Pantanal (Mato Grosso, Brazil), as indicated by human observers adding data and filling the CT record gaps, implying that the length of the breeding season was previously underestimated. The reason for the much higher number of human observations of BFC from July to October is not clear, but there are some explanations for this pattern: (1) people (mostly ecotourists) are more mobile because areas are more accessible during this driest time of year; and (2) birds are moving around more frequently searching for food and water sources.

However, it is important to emphasize that the review of the eBird dataset for BFC proved to be very important, contributing greatly to the interpretation of our CT study. Therefore, citizen science projects should be considered an important addition to the existing scientific literature for interpreting the life history of Cracidae.

CONCLUSION

We concluded that BFC breeds year-round in the northern Pantanal region and that family groups exhibit some degree of territorial overlap, since they are observed frequently in the same locations within a few hours or days. We also highlight the usefulness of CTs for monitoring these and other Cracidae species in the wild and recommend the use of a grid-based design for sampling point positioning for statistical approaches on seasonality and the impacts of phytophysiognomies.

Examination of the BFC datasets from the eBird and GBIF.org databases allowed a better interpretation of the CT data and understanding of monthly patterns of occurrence of parent birds and offspring. Comparison between our data from CTs and human observation data from these two databases suggests that the period of offspring occurrence based on human observations should not be unconditionally considered as the breeding season. This could lead to misinterpretations impacting conservation implications.

In summary, both CT studies and citizen science projects have proven to be an important approach to better understand the natural history of BFC.

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REFERENCES

Abreu, G. 2017. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S43985117. Access: 22/08/2021.

Alminhana Macil, P.A. 2018. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S44673129. Access: 22/08/2021.

Alves, F.; Lepoz-Iborra, G.M. & Silveira, L.F. 2017. Population size assessment of endangered red-billed curassow *Crax blumenbachii:* accounting for variation in detectability and sex-biased estimates. *Fauna and Flora International,* 51(1): 137-145. https://doi.org/10.1017/S0030605315000721.

Association of Zoos and Aquariums (AZA). 2012. Blue-billed Curassow (*Crax alberti*). *In:* AZA Galliformes Taxon Advisory Group. *Regional collection plan.* 2. ed. Silver Spring Md, Association of Zoos & Aquariums. https://ams.aza.org/iweb/upload/RCP_Galliformes2012-bc483ef3.pdf.

Beirne, C.; Pillco-Huarcaya, R.; Serrano-Rojas, S.J. & Whitworth, A. 2017. Terrestrial camera traps: essential tool for the detection and future monitoring of the Critically Endangered Sira curassow *Pauxi koepckeae. Endangered Species Research,* 32: 145-152. https://doi.org/10.3354/esr00802.

Bello, C.; Galetti, M.; Pizo, M.A.; Magnago, L.F.S.; Rocha, M.F.; Lima, R.A.F.; Peres, C.A.; Ovaskainen, O. & Jordano, P. 2015. Defaunation affects carbon storage in tropical forests. *Science Advances,* 1(11): e1501105. https://doi.org/10.1126/sciadv.1501105.

BirdLife International. 2021. *Species factsheet: Crax fasciolata. The IUCN Red List of Threatened Species.* Available: https://www.birdlife.org. Access: 10/08/2021.

Boyle, A. 2019. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S60881099. Access: 22/08/2021.

Bronzini, E. 1940. Descrizione di un ibrido *Crax fasciolata* X *C. alberti. Rivista Italiana di Ornitologia,* 10: 11-21. https://sisn.pagepress.org/rio.

Bronzini, E. 1943. La riproduzione di *Crax fasciolata* Spix. *Rivista Italiana di Ornitologia,* 13: 80-83.

Brooks, D.M. & Strahl, S.D. 2000. *Curassows, Guans and Chachalacas. Status Survey and Conservation Action Plan for Cracids 2000-2004.* IUCN/SSC Cracid Specialist Group. IUCN, Gland CH and Cambridge UK. 182p.

Bruno, S.F.; de Carvalho, R.B.A. & Kirwan, G.M. 2006. Bare-faced Curassow *Crax fasciolata* in Serra da Canastra National Park, Minas Gerais, Brazil. *Cotinga,* 26: 80-86.

Campbell, B. & Lack, E. 1985. *A Dictionary of Birds.* Vermillion SD, Buteo Books.

Carpenter, E. 2019. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S60514930. Access: 22/08/2021.

Clay, R.P. & Oren, D.C. 2006. Bare-faced Curassow (*Crax fasciolata*). *In:* Brooks, D.M.; Cancino, L. & Pereira, S.L. (Eds.). *Conserving cracids: the most threatened family of birds in the Americas. Miscellaneous Publications of the Houston Museum of Natural Science,* 6: 53-55.

Coupe, M.F. 1966. Breeding Sclater's crested Curassows (Bare-faced Curassow). News from Chester ZOO. *Aviculture Magazine,* 72: 168-169.

De la Peña, M.R. 1992. *Guía de Aves Argentinas. Falconiformes-Charadriiformes.* Buenos Aires, Literature of Latin America (L.O.L.A.).

Del Hoyo, J. & Motis, A. 2004. Update Chapter. *In:* Delacour, J. & Amadon, D. *Curassows and related Birds.* 2. ed. Barcelona, Lynx Edicions and National Museum of Natural History.

Del Hoyo, J.; Kirwan, G.M. & Sharpe, C.J. 2019. *Bare-faced Curassow (*Crax fasciolata*). In:* Del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D.A. & de Juana, E. (Eds.). *Handbook of the Birds of the World Alive.* Barcelona, Lynx Edicions. Available: http://www.hbw.com/node/53316. Access: 21/07/2019.

Delacour, J. & Amadon, D. 2004. *Curassows and Related Birds.* 2. ed. Barcelona, Lynx Edicions and National Museum of Natural History, and New York, Second edition.

Desbiez, J.A.L. & Bernardo, S.S.C. 2011. Density estimates of the Bare-faced curassow (*Crax fasciolata*) in the Brazilian Pantanal. *Revista Brasileira de Ornitologia,* 19(3): 385-390.

eBird Basic Dataset (EBD). 2021. Version: EBD_relJul-2021. New York, Cornell Lab of Ornithology, Ithaca.

Endo, W.; Baniwa, E.A. & Leite, G.A. 2021. Nest, nest site and early growth of crestless Curassow (*Mitu tomentosum*) in northern Amazonia. *Continga,* 43: 106-108.

Faust, R. & Faust, I. 1963. Breeding *Crax fasciolata. Der Zoologische Garten,* 28: 8-11.

Fernández-Duque, F.; Huck, M.; Dávalos, V. & Fernández-Duque, E. 2013. Estudio preliminar sobre la ecología el comportamiento y la demografía del Muitú (*Crax fasciolata*) en la selva en galería del Riacho Pilagá, Formosa, Argentina. *Hornero,* 28(2): 65-67. https://doi.org/10.5751/ACE-01241-130201.

Francisco, M.R.; Costa, M.C.; Azeredo, R.M.; Simpson, J.G.P.; da Costa Dias, T.; Fonseca, A.; Pinto, F.J.M. & Silveira, L.F. 2021. Recovered after an extreme bottleneck and saved by ex situ management: Lessons from the Alagoas curassow (*Pauxi mitu* [Linnaeus, 1766]; Aves, Galliformes, Cracidae). *Zoo Biology,* 40(1): 76-78. https://doi.org/10.1002/zoo.21577.

Fundación Rewilding Argentina. 2021. *Reintroduction project in Iberá Park. Bare-faced Curassow.* Available: https://rewildingargentina.org/ibera-project/#muitu. Access: 20/08/2021.

Galetti, M.; Guevara, R.; Côrtes, M.C.; Fadini, R.; Von Matter, S.; Leite, A.B.; Labecca, F.; Ribeiro, T.; Carvalho, C.S.; Collevatti, R.G.; Pires, M.M.; Guimarães-Jr., P.R.; Brancalion, P.H.; Ribeiro, M.C. & Jordano, P. 2013. Functional extinction of birds drives rapid evolutionary changes in seed size. *Science,* 340(6136): 1086-1090. https://doi.org/10.1126/science.1233774.

Galetti, M.; Martuscelli, P.; Olmos, F. & Aleixo, A. 1997. Ecology and conservation of the jacutinga *Pipile jacutinga* in the Atlantic forest of Brazil. *Biological Conservation,* 82(1): 31-39. https://doi.org/10.1016/S0006-3207(97)00004-9.

Global Biodiversity Information Facility (GBIF). 2021. GBIF Occurrence. Available: https://doi.org/10.15468/dl.vyrese. Access: 06/09/2021.

Gomes, A.P.N.; Fornitano, L.; Costa, R.T. & Kimberly, T.A. 2018. The importance of protected areas for conservation of bare-faced curassow (*Crax fasciolata* Spix, 1825) (Galliformes: Cracidae) in the São Paulo State, Brazil. *Biota Neotropica,* 18(3): e20180524.

Guimarães, J.R.A.; Bergamin, F. & Carvalho, J.P. 1935. Notas sobre a evolução e a biologia do Mutum (*Crax fasciolata* Spix). *Boletim Biológico,* 2(3): 76-81.

Gwinner, E. 2003. Circannual rhythms in birds. *Current Opinion in Neurobiology,* 13(6): 770-778. https://doi.org/10.1016/j.conb.2003.10.010.

Heinroth, O. 1931. Observations on curassow chicks. *Journal für Ornithologie,* 79: 278-283. https://doi.org/10.1590/1676-0611-BN-2018-0524.

International Union for Conservation of Nature and Natural Resources (IUCN). 2021. *IUCN Red List of Threatened Species.* Available: https://www.iucnredlist.org. Access: 29/12/2021.

Junk, W.J.; da Cunha, C.N.; Wantzen, K.M.; Petermann, P.; Strüssmann, C.; Marques, M.I. & Adis, J. 2006. Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. *Aquatic Sciences,* 68(3): 278-309. https://doi.org/10.1007/s00027-006-0851-4.

Junk, W.J.; Nunes da Cunha, C.; Da Silva, C.J. & Wantzen, K.M. 2011. The Pantanal: A large South American wetland and its position in limnological theory. *In:* Junk, W.J.; Da Silva, C.J.; Nunes da Cunha, C. & Wantzen, K.M. (Eds.). *The Pantanal: ecology, biodiversity and sustainable management of a large Neotropical seasonal wetland.* Sofia, Pensoft Publishers. p. 23-44.

Kibbe, D. 2019. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S60657430. Access: 22/08/2021.

Kirwan, G.M. 2009. Notes on the breeding ecology and seasonality of some Brazilian birds. *Revista Brasileira de Ornitologia,* 17(2): 121-136.

Krieg, H. & Schumacher, E. 1936. Beobachtungen von Wildhühnern. *Verhandlungen Ornithologischen Gesellschaft in Bayern,* 21(1): 1-18.

Lafleur, L.; Pardo, L.; Spínola, R.M.; Saénz, J. & Cove, M.V. 2014. Notes on plumage patterns and activity of the Great Curassow (*Crax rubra*) in northeastern Costa Rica. *Bulletin of the Cracid Group,* 36: 17-19.

Laino, R.; Musalem, K.; Caballero-Gini, A.; Bueno-Villafañe, D. & Chaparro, S. 2018. Uso de habitat y comportamiento de *Crax fasciolata* en el Chaco Húmedo Paraguayo. *Hornero,* 33(2): 121-127.

Langeloh Roos, A. 2008. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S79692948. Access: 22/08/2021.

Lepre, N. 2018. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S44147074. Access: 22/08/2021.

Loewen, S. 2013. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S15188648. Access: 22/08/2021.

Martensen, A.C.; Ribeiro, M.C.; Banks-Leite, C.; Prado, P. & Metzger, J.P. 2012. Associations of forest cover, fragment area, and connectivity with Neotropical understory bird species richness and abundance. *Conservation Biology,* 26(6): 1100-1111. https://doi.org/10.1111/j.1523-1739.2012.01940.x.

Martin, T.E. 1987. Food as a limit on breeding birds: a life-history perspective. *Annual Review of Ecology And Systematics,* 18(1): 453-487.

Nardelli, P.M. 1981. La preservación del Paujil del nordeste brasileño. *In:* Estudillo J. (Ed.). *Memorias Primer Simpósio International de La Familia Cracidae*. Mexico DF, UNAM. p. 273-283.

Nardelli, P.M. 1993. A Preservação do Mutum-de Alagoas *Mitu mitu.* Rio de Janeiro, Zôo-botânica Mário Nardelli.

O'Brien, T.G.; Kinnaird, M.F. & Wibisono, H.T. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation,* 6: 131-139. https://doi.org/10.1017/S1367943003003172.

Pardo, E.L.; Lafleur, L.; Spinola, R.M.; Saenz, J. & Cove, M. 2017. Camera traps provide valuable data to assess the occurrence of the Great curassow *Crax rubra* in northeastern Costa Rica. *Neotropical Biodiversity,* 3(1): 182-188. https://doi.org/10.1080/23766808.2017.1346548.

Pérez-Granados, C. & Schuchmann, K.L. 2021. Passive acoustic monitoring of Chaco Chachalaca (*Ortalis canicollis*) over a year: vocal activity pattern and monitoring recommendations. *Tropical Conservation Science,* 14: 1-11. https://doi.org/10.1177/19400829211058295.

Pérez-Irineo, G. & Santos-Moreno, A. 2017. Occupancy, relative abundance, and activity patterns of Great Curassow (*Crax rubra*) in Southeastern Mexico. *Ornitología Neotropical,* 28: 313-320.

Ribon, R.; Simon, J.E. & De Mattos, T.G. 2003. Bird extinctions in Atlantic forest fragments of the Viçosa region, southeastern Brazil. *Conservation Biology,* 17(6): 1827-1839. https://doi.org/10.1111/j.1523-1739.2003.00377.x.

Schunck, F. 2020. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S75403771. Access: 22/08/2021.

Seifert, R. 2014. *eBird Checklist: An online database of bird distribution and abundance.* Available: https://ebird.org/ebird/view/checklist/S92121604. Access: 22/08/2021.

Sick, H. 2001. *Ornitologia Brasileira.* 3. ed. Rio de Janeiro, Editora Nova Fronteira.

Srbek-Araujo, A.K.; Silveira, L.F. & Chiarello, A.G. 2012. The red Billed Curassow (*Crax blumenbachii*): Social Organization, and Daily Activity Patterns. *The Wilson Journal of Ornitology,* 124(2): 321-327. https://doi.org/10.1676/11-054.1.

Stotz, D.F.; Fitzpatrick, J.W.; Parker III, T.A. & Moskovits, D.K. 1996. *Neotropical birds: ecology and conservation.* Chicago, University of Chicago Press.

Taibel, A.M. 1940. Osservazioni sulla roproduzine in cattivià di *Crax globicera globicera* Linneus (synonymous to *Crax rubra*). Stazione sperimentale di aviculture di Rovigo. *Rivista Italiana di Ornitologia,* 10: 93-126.

Taibel, A.M. 1953. Osservazioni sulla riproduzione e allavamento in cattivia di *Penelope superciliaris* Temminck e *Ortalis garrula garrula* Humboldt. *Rivista Italiana di Ornitologia,* 23: 85-122.

Vaurie, C. 1968. Taxonomy of the Cracidae (Aves). *Bulletin of the American Museum of Natural History,* 138: 133-259. https://digitallibrary.amnh.org/handle/2246/1108.

Whitworth, A.; Beirne, C.; Flatt, E.; Huarcaya, R.P.; Cruz, J.C.D.; Forsyth, A.; Molnár, P.K. & Vargas-Soto, J.S. 2018. Secundary forest is utilized by Great Curassows (*Crax rubra*) and Great Tinamous (*Tinamus major*) in the absence of hunting. *The Condor,* 120(4): 852-862. https://doi.org/10.1650/CONDOR-18-57.1.

Winkler, D.W.; Billerman, S.M. & Lovette, I.J. 2020. Guans, Chachalacas, and Curassows (Cracidae), version 1.0. *In:* Billerman, S.M.; Keeney, B.K.; Rodewald, P.G. & Schulenberg, T.S. (Eds.). *Birds of the World.* Ithaca, Cornell Lab of Ornithology. https://doi.org/10.2173/bow.cracid2.01.

Zalazar, S.; Benitez, A.L. & Di Giacomo, A.S. 2018. Determining the factors that influence the occurrence of Bare-faced Curassows (*Crax fasciolata*) in Humid Chaco, northern Argentina. *Avian Conservation and Ecology,* 13(2): 1. https://doi.org/10.5751/ACE-01241-130201.

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