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SHORT NOTE

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MALE AND FEMALE CONTRIBUTIONS TO PARENTAL CARE IN THE RUFOUS-TAILED JACAMAR (*GALBULA RUFICAUDA*, GALBULIDAE) IN SOUTHERN GOIÁS, BRAZIL

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Abstract · We quantified patterns of male and female parental care of the Rufous-tailed Jacamar *Galbula ruficauda* during incubation and nestling feeding, over four breeding seasons in southern Goiás, Brazil. Reproduction in this species was seasonal, occurring during the transition between dry and wet seasons from September to November. Only females incubated overnight, but male and female shared incubation duties during the day, having similar length of incubation bouts (male = 45 ± 16 min vs. female = 47 ± 14 min; $t = -0.56$, $P = 0.57$). The nestling diet was composed exclusively of insects - mainly flies, butterflies, and dragonflies- and males fed nestlings more often than females (male 59% vs. female 41%, $\chi^2 = 1783$, df = 1, $P < 0.0001$). The results confirm biparental care, with high levels of paternal care, especially during incubation, as predicted for tropical birds with a monogamous social mating system.

Resumo · Contribuições do macho e da fêmea no cuidado parental da Ariramba-de-cauda-ruiva (*Galbula ruficauda*, Galbulidae) na região sul de Goiás, Brasil
Nós quantificamos os padrões de cuidado parental do macho e da fêmea da Ariramba-de-cauda-ruiva *Galbula ruficauda* durante a incubação dos ovos e a alimentação dos ninhegos ao longo de quatro períodos reprodutivos no sul de Goiás, Brasil. A reprodução nessa espécie foi sazonal, ocorrendo durante a transição entre as estações seca e úmida de setembro a novembro. Apenas as fêmeas incubaram os ovos durante a noite, mas macho e fêmea compartilharam as tarefas de incubação durante o dia, dedicando-se de forma semelhante à incubação (macho = 45 ± 16 min vs. fêmea = 47 ± 14 min; $t = -0.56$, $P = 0.57$). A dieta dos ninhegos foi exclusivamente composta de insetos – principalmente moscas, borboletas e libélulas – e os machos alimentaram os ninhegos mais frequentemente do que as fêmeas (macho 59% vs. fêmea 41%, $\chi^2 = 1783$, df = 1, $P < 0.0001$). Os resultados confirmam o cuidado biparental, com altos níveis de cuidado paternal, principalmente durante a incubação, como previsto para aves tropicais com sistema de acasalamento monogâmico social.

Key words: Brazil · Breeding season · Feeding · Incubation · Nestlings · Social monogamy

INTRODUCTION

The breeding season is a critical period for birds, as it demands high levels of energy expenditure to maintain specific activities, such as mating rituals, nest building, egg laying, incubation, feeding, and protection of the offspring (Drent & Daan 1980). In addition, the breeding season increases mortality risks due to male competition for females and parental care (Liker & Székely 2005). Considering that the parents' efforts are offset by reproductive success (Stearns 1976), the variation of male participation in parental care is of key importance in the evolution of avian mating systems. For example, polygyny is strongly linked to the low participation of males in incubation, and its occurrence is expected to be higher in temperate zone birds due to the high breeding synchrony (Stutchbury & Morton 2001). Despite harboring the richest avifauna at global scale (Piacentini et al. 2015), the Neotropical region is still little studied in terms of avian breeding systems (Macedo et al. 2008, Medeiros & Alves 2010).

The Rufous-tailed Jacamar (*Galbula ruficauda*) occurs in forests from Mexico to Argentina and is widely distributed from northern to southeastern Brazil (Sick 1997). Sexual dimorphism is low and the sexes differ mainly

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Table 1. Number of prey, split by broad taxonomic categories, offered to nestlings of the Rufous-tailed Jacamar (*Galbula ruficauda*) during the initial and final nestling periods in 2011–2014, in the Parque Natural de Morrinhos, Morrinhos, Brazil. [1] Yates Correction.

Prey	Nestling periods		χ^2	*P*
	Initial (first week)	Final (last week)		
Fly	41	56	2.32	0.13
Butterfly	24	22	0.09	0.77
Cicada[1]	0	11	9.09	0.003
Miscellaneous	73	64	0.59	0.44

by throat color: white plumage in males and rust colored in females. To nest both males and females dig burrows in earth banks along streams, in clumps of soil adhering to the roots of fallen trees or in termite mounds (Skutch 1963, 1968). Although common in its distribution range, the breeding biology of this species has been little studied, especially male and female contributions to parental care (Skutch 1937, 1963, 1968). Therefore, the aim of this study was to describe and quantify patterns of parental care in *G. ruficauda* during incubation and feeding of the nestlings.

METHODS

This study was conducted in Morrinhos Natural Park (PNM), a 104 ha reserve in the municipality of Morrinhos, Goiás, Brazil (17°43'35"S, 49°07'52"W). The vegetation in PNM can be classified as Semideciduous Seasonal Forest (Campanili & Prochnow 2006), and the park protects the source and part of the course of the Maria Lucinda river. The earth banks of the stream are between 1 and 5 m high and are bare or partially covered by herbaceous and shrubby vegetation. The climate of the region is seasonal, with heavy monthly averages of rains from November to February (241.07 ± 32.50 mm), reduced from May to August (9.57 ± 1.44 mm), and intermediate in March–April and September–October (77.34 ± 13.46 mm) (Pesquero et al. 2012).

We visited the PNM monthly for four years (2011 to 2014) searching for active nests along a section of ca. 700 m of stream banks along the Maria Lucinda river, and in clumps of soil adhering to the roots of fallen trees and in termite mounds. Each year, two active nests were randomly selected for data collection on incubation and feeding of nestlings. Two observers positioned six meters away from the nests collected the data weekly from sunrise to sunset, totaling 65 h of observation per nest obtained during five days. Levels of parental care in incubation and nestling feeding were quantified separately for males and females based on the incubation turns and on-bout duration, and nestling feeding rate, respectively. The daily feeding rate rhythm was standardized both by number of nestlings within each nest and by time of sunrise (Costa 2005). The number of nestlings was quantified with the aid of a endoscopic camera (3 m), which was connected to a computer and inserted in the nests once a week while adult birds were absent (Pesquero et al. 2014). Food items brought to the nest to feed nestlings were identified by direct observation using binoculars (8 x 40).

Parental care of males and females during incubation was compared based on the average incubation time using the *t*-test for independent observations. Nestling feeding rate of males and females were compared using the chi-square test (χ^2) for equality of proportions. The relationship between feeding rate and age of the nestlings was analyzed using the non-parametric Spearman Rank Correlation (r_S) due to small sample size. Descriptive statistics were reported as mean ± standard deviation. Statistical analyses were conducted using the BioEstat 5 software program (Ayres et al. 2007).

RESULTS & DISCUSSION

We found 14 nests of *G. ruficauda* throughout the study period: three in 2011, 2013, and 2014, and five in 2012. Although some termite mounds and clumps of soil attached to up-rooted trees occur in the PNM, *G. ruficauda* used only the stream banks for nesting during 2011–2014. Nests were located on average 150 ± 69 m (76–199 m, N = 10) away from its nearest neighbor, and 237 ± 130 cm (110–450 cm, N = 14) above the water surface. Nest tunnels were on average 38.21 ± 8.24 cm long (20–55 cm, N = 14), with a 4.33 ± 0.65 cm wide entrance (3.4–5.1, N = 14). Average clutch size was 3.43 ± 0.51 (2–4) white eggs (N = 14 nests), and average brood size by the onset of the fledgling stage was 1.75 ± 1.22 nestlings (N = 12 nests). Average incubation and nestling periods were estimated at 17 ± 1.2 days and 21 ± 0.8 days, respectively, and the entire breeding period lasted on average 40 ± 1.9 days (N = 12 nests).

Except for a nest in which the female laid three eggs in the first week of October, and the parents fed the nestlings until November, all 13 females started egg laying in September and nestlings fledged in October, confirming only one breeding cycle per year (Skutch 1963). The seasonal breeding of *G. ruficauda* coincided with the transition between dry and wet seasons from September to November in the region (Pesquero et al. 2012), which matches the breeding pattern of many bird species of tropical and subtropical climates (Piratelli et al. 2000, Marini et al. 2012, Marques-Santos et al. 2015).

Incubation. The female always performed the last incubation turn 7 ± 9 min before dusk (N = 16 days, 8 nests), replacing the male that, after leaving the nest, was not seen until the next day. The female was always the one seen leaving the nest 8 ± 4 min after dawn (N = 16 days, 8 nests) to be replaced by the male. These results confirm nocturnal incubation by

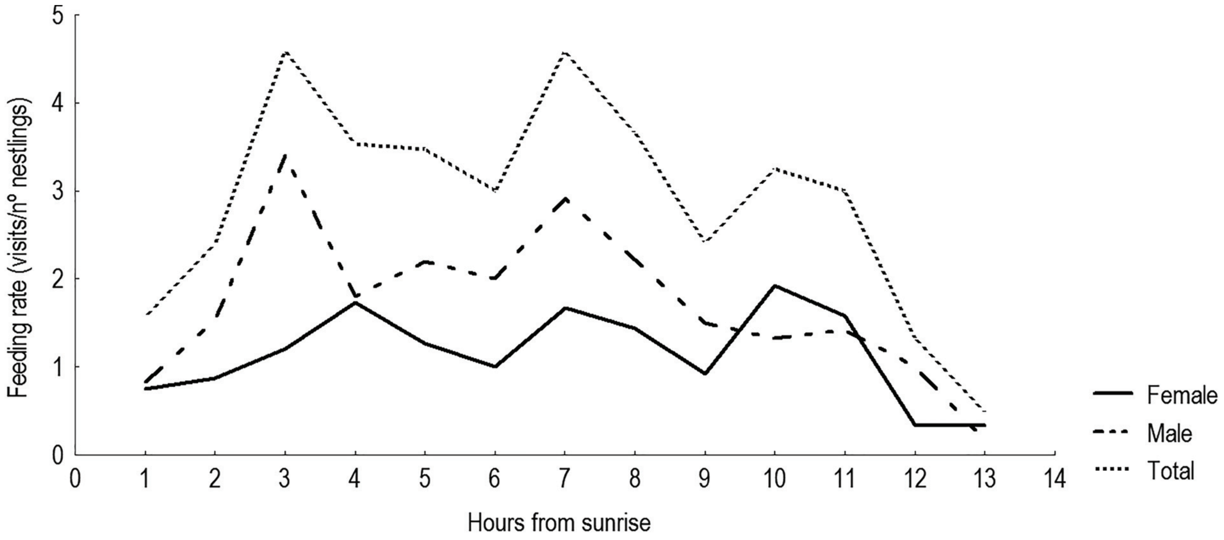

Figure 1. Daily variation in male and female Rufous-tailed Jacamar (*Galbula ruficauda*) nestling feeding rate in the Parque Natural de Morrinhos, Morrinhos, Brazil during 2011–2014.

females in this species as observed in Honduras (Skutch 1937). The parents shared incubation during the day, and incubation bout switches (13.8 ± 1.3 per day, N = 14 days, 8 nests) were announced by a brief call issued by the mate perched near the entrance of the nest. Considering that each incubation bout switches lasted less than a minute, the incubation activity remained therefore practically uninterrupted throughout the day.

Males and females incubated to a similar extent during the day. They did not differ in the length of the incubation bouts (male = 45 ± 16 min vs. female = 47 ± 14 min; $t = -0.56$, df = 206, $P = 0.57$, N = 14 days, 8 nests). Skutch (1963), in Costa Rica, observed longer incubation bouts (male and female, 102 ± 12 min, N = 1 day, 1 nest) compared to our data (46 ± 16 min, N = 14 days, 8 nests) and, consequently, a smaller number of daily incubation turns (8, N = 1 day, 1 nest) compared to this study (13.8 ± 1.3, N = 14 days, 8 nests).

Infestation of probably hematophagous insects occurred in one nest, which interfered with the incubation behavior, reducing the length of the incubation bouts (nests without insects = 46 ± 16 min, N = 14 days, 7 nests vs. nest with insects = 14.12 ± 9.5 min, N = 2 days, 1 nest). In this nest, only one of three eggs hatched. We observed adults carrying green leaves and branches (nine occasions) into two nests during the beginning of the nestlings feeding period. This behavior occurs in other birds and has a protective function against parasites (Lafuma et al. 2001).

Nestling feeding. The parents often perched on branches near their nests to catch flying insects, which they either ate themselves or fed to the nestlings. The nestling diet was composed exclusively of insects. Diptera (51%), Lepidoptera (31%), and Odonata (10%) were the most frequent insect orders, but small cicadas (Hemiptera, 4%), wasps (Hymenoptera, 2%), and beetles (Coleoptera, 1%) were also part of the diet. Only cicadas were preferentially offered to the nestlings during the final nesting period (Table 1). Although cicadas were common during the study, the large body volume and heavily sclerotized integument of this insect may have limited its use as food to the young nestlings. Skutch (1937) mentioned no cicadas as part of nestlings' diet, but he noted that parents already fed larger prey (dragonflies and butterflies) for four-day-old nestlings.

Skutch (1963), in Costa Rica, named the insects fed to nestlings in the following order: butterflies, dragonflies, beetles, large diptera, and bees. Despite the taxonomic similarity of prey identified by Skutch (1963), the divergence in the frequencies of captured insect orders indicates that the diet of *G. ruficauda* probably depends on the local abundance of flying insect-prey types. Food availability is an important factor determining the start of the breeding season (Perrins 1970). Because seasonal variation can affect insect abundance (Wolda 1988), we hypothesize that *G. ruficauda*'s breeding seasonality may be mediated by food availability. In general, many species belonging to the three largest orders of insects fed to the nestlings by the population of *G. ruficauda* studied here are seasonal, being more abundant in the rainy season (Costacurta et al. 2003, Pozo et al. 2008, Vilela et al. 2016).

The nestlings were fed throughout the day, but three peaks of activity seemed apparent: mid-late morning, mid-afternoon and late afternoon (Figure 1). Males fed nestlings more often than females (male 59% vs. female 41%, $\chi^2 = 20.38$, df = 1, $P < 0.0001$, N = 481, 8 nests). The feeding rate increased with age of the nestlings ($r_S = 0.99$, $t = 9.12$, $P < 0.02$, N = 4 days and 1 nest, Figure 2), as observed for other bird species (Johnson & Best 1982, Ruggera & Martin 2010).

Our data confirms biparental care in *G. ruficauda*. Paternal care was intense, occupying a large part of

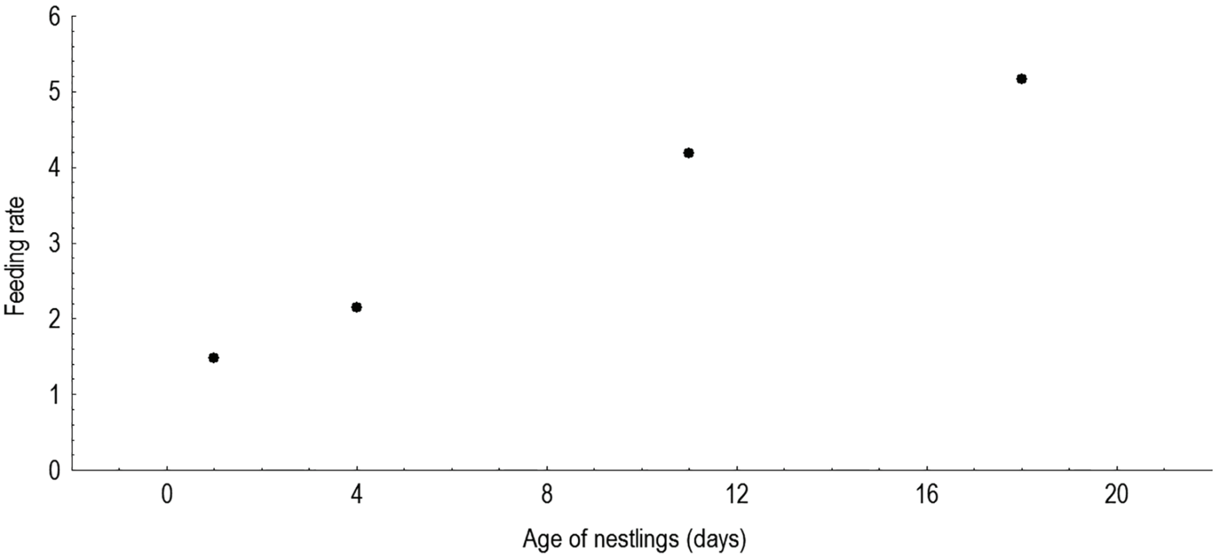

Figure 2. Feeding rate (average number of visits/hour/nestling) increase with nestling age in the Rufous-tailed Jacamar (*Galbula ruficauda*) in the Parque Natural de Morrinhos, Morrinhos, Brazil during 2011–2014.

the males' time in daytime incubation (48.5%) and nestling feeding (59%) as expected for tropical birds with a monogamous social mating system (Stutchbury & Morton 2001).

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