

Seasonal patterns in Gubernetes yetapa behavior

SEASONAL SHIFTS IN BEHAVIOR AND SOCIAL INTERACTIONS OF STREAMER-TAILED TYRANT (*GUBERNETES YETAPA*) IN SOUTHERN BRAZIL

Thuani Luísa Saldanha Wagener^{1*} , Luis Eduardo Silva dos Santos¹ , Ramiro Silva Almeida² , Nêmera Pauletti Prestes³ , Marilise Mendonça Krügel⁴  & Jaime Martinez⁵ 

¹ Universidade Federal de Santa Maria, Programa de Pós-graduação em Biodiversidade Animal, Avenida Roraima, 1000, Camobi, CEP 97105-900, Santa Maria, RS, Brazil. huaniwagener@gmail.com

² Universidade Federal de Santa Maria, campus Palmeira das Missões. Avenida Independência, 3751 - Vista Alegre, CEP 98300-000, Palmeira das Missões, RS, Brazil.

³ Associação Amigos do Meio Ambiente, Departamento de Vida Silvestre, CEP 99500-000, Carazinho, RS, Brazil.

⁴ Universidade Federal de Santa Maria, Departamento de Engenharia Sanitária e Ambiental, Avenida Roraima, 1000, Camobi, CEP 97105-900, Santa Maria, RS, Brazil.

⁵ Universidade de Passo Fundo, Programa de Pós-graduação em Ciências Ambientais, BR 285 Km 292.7, São José, CEP 99052-900, Passo Fundo, RS, Brazil.

E-mails: thuaniwagener@gmail.com (*corresponding author); luis-santos.1@acad.ufsm; ramiroalmeida1@hotmail.com; prestes@upf.br; marilise mk@gmail.com; martinez@upf.br

Abstract. This study investigates the seasonal shifts in behavior and social interactions of *Gubernetes yetapa* in southern Brazil, addressing significant gaps in understanding of wetland-dependent birds. We sampled two wetlands in northwestern Rio Grande do Sul state. Our research employed extensive observational methods to document the behavioral repertoire of *G. yetapa* across breeding and non-breeding season. A total of 25 behaviors were identified, revealing that the species plays a crucial role in mixed-species flocks during the non-breeding season while exhibiting increased territoriality and intraspecific interactions during the breeding season. Notably, *G. yetapa* demonstrated sentinel behavior within mixed flocks. We observed significantly

differences in activity patterns between the two seasons, particularly in social interactions. Our findings highlight the need for further research on the natural history and conservation of wetland-dependent birds, as understanding their behavioral dynamics is essential for effective habitat protection and management. This study contributes to the knowledge of *G. yetapa* and emphasizes the broader implications of mixed-species interactions in Neotropical ecosystems.

Keywords: breeding biology; Fluvicolinae; mixed flocks; Tyrannidae; wetlands.

Ethograms and behavioral repertoires are essential tools for understanding animal biology in both captive and wild conditions (Alcock 1997). However, there is still a significant gap in knowledge about Neotropical birds, especially their breeding biology (Heming et al. 2013, Crozariol 2016). This bias, combined with limited data even for common species, hinders effective conservation strategies (Studer & Crozariol 2020).

Gubernetes yetapa (Vieillot 1818), a monotypic member of the Tyrannidae family, is associated with Neotropical wetlands and damp grasslands (Farnsworth & Langham 2020). Its distribution includes Paraguay, Argentina, Uruguay, an isolated population in Bolivia (BirdLife International 2024), and in Brazil, from Bahia to Rio Grande do Sul (Sick 1997). Little is known about its behavior and ecology. However, current studies indicate that the species depends on wetlands for breeding and remains in pairs during the breeding season (Wagener et al. 2024). During the non-breeding season, it has been briefly reported in mixed flocks with *Xanthopsar flavus* and *Pseudoleistes guirahuro*, mainly while foraging (Ferrari & Motta-Junior 2018, Meller 2017, Wagener et al. 2024). The species is classified as Least Concern (LC) according to the BirdLife International (2024). However, it faces more critical situations in some regions. For example, in Argentina it is listed as Vulnerable (VU) (Aves Argentinas 2017) and in the Rio Grande do Sul state (Brazil) it is listed as Near Threatened (NT) (Rio Grande do Sul 2014). In this context, the objectives of this study are to (1) assess behavioral differences between the Breeding (BS) and Non-breeding seasons (NB), and (2) describe the activity patterns of *Gubernetes yetapa* when occurring in mixed-species flocks (interspecific) or in conspecific groups (intraspecific).

We carried out this study in two wetlands (hereafter WL1 and WL2) in Palmeira das Missões, Rio Grande do Sul, Brazil, an ecotone between the Atlantic Forest and Pampa biomes, predominantly grasslands. Extensive agricultural conversion has threatened the native vegetation (da Silva et al. 2013) and prone wetlands to drainage and irrigation due to uneven plateau streams (Soares 2004). The region's humid temperate climate (CFA) is characterized by annual temperatures ranging from 16 to 18°C and precipitation of up to 2500 mm (Alvares et al. 2013).

To locate and confirm the presence of *G. yetapa* in the wetlands, playback was used exclusively during the initial pilot sampling before data collection. WL1, covering 7.37 hectares (27°55'31.73"S; 53°19'10.48"W), is flanked by regenerating grasslands, riparian forest corridors, and agricultural fields. WL2 (28°03'54.0"S; 53°19'28.3"W) spans 24.9 hectares and shares similar surroundings. The two study areas are 44.31 km apart. From December 2017 to February 2019, we conducted 63 expeditions (WL1= 36; WL2= 27) resulting in a total of 264 hours of field effort, which were carried out only under favorable weather conditions. Each behavioral event performed by an individual, together with its corresponding time of occurrence, was considered a separate sample, resulting in 694 samples for WL1 and 411 for WL2. The average duration of focal observations was 264 ± 144 min (range = 60–540 min) for WL1 and 486 ± 145 min (range = 210–600 min) for WL2. The distribution of the sampling effort according to the hours of the day is available in Figure S1 of the supplementary material. The samples were always carried out by the same group of researchers (from 2 to 3) positioned ~20 meters from wetlands for optimal visibility, using binoculars and digital cameras. The individuals were not banded, so our study is only observational.

The breeding season (BS) of *G. yetapa* occurs between October and February, (Heming et al. 2016, Studer & Crozariol 2020, Wagener et al. 2024). Accordingly, field sampling was conducted biweekly throughout both the BS and the non-breeding season (NB; March to September). Observations employed the Focal Animal method for behavior frequency and duration and *Ad libitum* sampling for behavior descriptions (Altmann 1974). Data collection included breeding season (BS or NB) and behavioral categories (hereafter behaviors): Alert, Foraging, Movements

(flight), Maintenance, Reproduction, Social (Agonistic and Non-Agonistic), and Vocalization (adapted from Prestes 2000). Foraging categories was classified following Fitzpatrick (1980) and Ferrari (2015). All categories and their respective subcategories are described in the Table 1. To assess the daily activity pattern, we organized behavioral observations into hourly classes and calculated the proportion of records for each hour relative to the total number of observations. To compare the frequency of behaviors between biological cycles (BS and NB), we used the chi-squared test of independence. We finally calculated the frequency (percentage) and the duration (mean and standard deviation) of each behavioral category and their respective subcategory, for example, within the vocalization category, the percentage of long, alarm calls, and agonistic vocalizations. All the tests and graphs were performed using R software version 4.1.3 (R Core Team 2022).

Gubernetes yetapa was recorded in both study areas during all sampling months. The population size ranged from two individuals (breeding pair) in the pre-reproductive season (august; WL1 and WL2) to four individuals in WL2 (breeding pair and two offsprings) and five individuals in WL1 (pair, two offsprings, and one nest helper) during the post-reproductive season (march). No other pairs or populations were observed in the study areas. Thus, our study corresponds to a single population per wetland.

During all NB months, individuals of *Gubernetes yetapa* were observed joining mixed-species flocks, but their behavior became almost exclusively intraspecific as the breeding season approached (September). We therefore describe intra and interspecific behaviors separately below, focusing on the differences between the BS and NB, since it was statistically significant ($\chi^2 = 76.58$, $df = 8$, $p < 0.001$).

Table 1. Summary of behavioral categories (in bold) and subcategories recorded for *Gubernetes yetapa*, showing their frequencies (%), duration ranges (min–max; mean $\pm$ SD) in minutes, and corresponding descriptions. Percentages were calculated within each category and subcategories separately.

Category	Subcategory	Frequency (%)	Duration in minutes	Description
			– Min-Max (Mean $\pm$ SD)	
Alert (n= 73)		6,61	0,02 - 18 (4,08 $\pm$ 3,35)	

	Alert (n=58)	79,45	0,02 - 18 (3,89 ± 3,06)	The bird shows vigilance behavior, scanning the surroundings, often standing still and upright, with attention directed to potential threats.
	Sentinel (n=15)	20,55	1 - 18 (4,79 ± 4,37)	One or more individuals of <i>G. yetapa</i> perch in an exposed position, maintaining vigilance while mixed-flock forage or rest.
Foraging (n= 355)				
		32	0,02 - 180,05 (1,50 ± 9,94)	
	Aerial hawk (n= 163)	45,92	0,02 - 1,17 (0,09 ± 0,11)	The bird captures flying prey in the air.
	Perch-gleaning (n= 5)	1,41	0,05 - 4 (1,64 ± 1,49)	The bird picks food items from vegetation or substrates while perched.
	Perch-to-ground (n= 65)	18,31	0,03 - 180,05 (2,89 ± 22,32)	The bird flies from a perch to the ground to capture prey.
	Hover-ground (n= 7)	1,97	0,03 - 0,53 (0,24 ± 0,19)	The bird hovers briefly above the ground to capture prey (Ferrari 2015)
	Ground (n= 114)	32,20	0,05 - 40 (2,8 ± 4,59)	The bird searches for or captures food directly on the ground.
Movements (n= 141)				
		12,8	0,03 - 2 (0,27 ± 0,27)	
	Long (n= 35)	24,82	0,02 - 1,17 (0,56 ± 0,21)	Directed movement between distant points within or outside the study area, leaving the observers' visual range (approximately 300 m from the study area).
	Short (n= 106)	75,18	0,02 - 2 (0,18 ± 0,22)	Short movements between nearby perches.
Reproduction (n= 169)				
		15,3	0,05 - 120 (1,69 ± 9,39)	
	Territory vigilance (n= 89)	52,66	0,05 - 11 (0,53 ± 1,23)	One or two individuals flying in circles throughout the reproductive territory.
	Nest (n= 28)	16,57	0,08 - 120,08 (5,81 ± 22,59)	When individuals were observed descending through the vegetation toward the nest.
	Leaving nest (n= 4)	2,37	0,05 - 8,92 (2,3 ± 4,41)	When individuals were observed leaving the nest site.
	Feeding Fledglings (n= 48)	28,40	0,05 - 10 (1,38 ± 2,44)	Adult individuals feeding the fledglings.
Maintenance (n= 150)				
		13,6	0,03 - 18 (2,95 ± 3,44)	
	Scratch (n= 2)	1,33	0,03 - 0,05 (0,04 ± 0,01)	The bird scratches its body with a foot, usually around the head or neck.
	Preening (n= 53)	35,33	0,03 - 2 (0,41 ± 0,41)	The bird arranges or cleans its feathers using the beak.
	Bill-wiping (n= 5)	3,33	0,05 - 0,25 (0,12 ± 0,09)	The bird wipes its bill on a surface (e.g., branch) after foraging.
	Rest (n= 90)	60	0,1 - 18 (4,65 ± 3,51)	The bird remains perched or on the ground without visible activity.
Social Agnostic (n=16)				
		1,45	0,03 - 1 (0,32 ± 0,29)	
	Chase/Threat (n= 5)	31,25	0,03 - 0,43 (0,14 ± 0,17)	The bird chases or threatens another individual, usually to defend a resource or territory.
	Kleptoparasitism (n=1)	6,25	0,23	The bird steals food captured by another individual.

Fight (n=7)	43,75	0,12 - 0,75 (0,30 ± 0,22)	Physical or close aggressive interaction between individuals.
Mobbing (n=3)	18,75	0,25- 1 (0,67 ± 0,38)	Coordinated aggression toward a predator, often involving vocalizations and flights. Can involve all the mixed-flock.
Vocalization (n=191)	17,2	0,02 -180,07 (1,06 ± 12,03)	
Long (n= 34)	17,80	0,05 - 1,17 (0,23 ± 0,22)	The sound "crIIpêr crIIpêr" (Wagener 2019) characteristic of the species (Belton 1994, Meller 2017) accompanied by wing displays.
Alarm Call (n= 153)	80,10	0,02 - 180,07 (1,27 ± 14,59)	A single sound "uip" (Wagener 2018) used to call other individuals or during the flights.
Agonistic (n= 4)	2,09	0,07 - 1 (0,31 ± 0,46)	Harsh or loud calls emitted during aggressive interactions.
Hidden (n= 12)	1,09	2 - 213 (76,17 ± 70,99)	When the focal individual was not visible or when no individual was detected in the study area.
TOTAL =	1105		

Movements were more frequently observed during the BS while foraging and vocalization behaviors were more frequent during NB (Figure 1a). Considering vocalization category and sub-categories, alarm calls were predominantly during the BS (Figure 1b). During the NB, alarm calls were used to alert other members of the mixed-species flock to potential predators while foraging or to initiate group movements. The observed response of *P. guirahuro* and *X. flavus* to these alarm vocalizations was to approach *G. yetapa* individuals during foraging or to follow them when the flock started moving. In contrast, in response to long vocalizations, both species began vocalizing simultaneously (see records in Wagener 2019).

Considering intraspecific behaviors during the BS, individuals of *G. yetapa* consistently perched on higher branches for alertness, maintaining visual contact with each other and using alarm calls (see records in Wagener 2018). In the occurrence of predators (e.g., birds of prey) or intruders (e.g., other bird species and/or dogs) or even when the researchers arrived in the territory for sampling, this vocalization was used 100% of the time (Figure 1b).

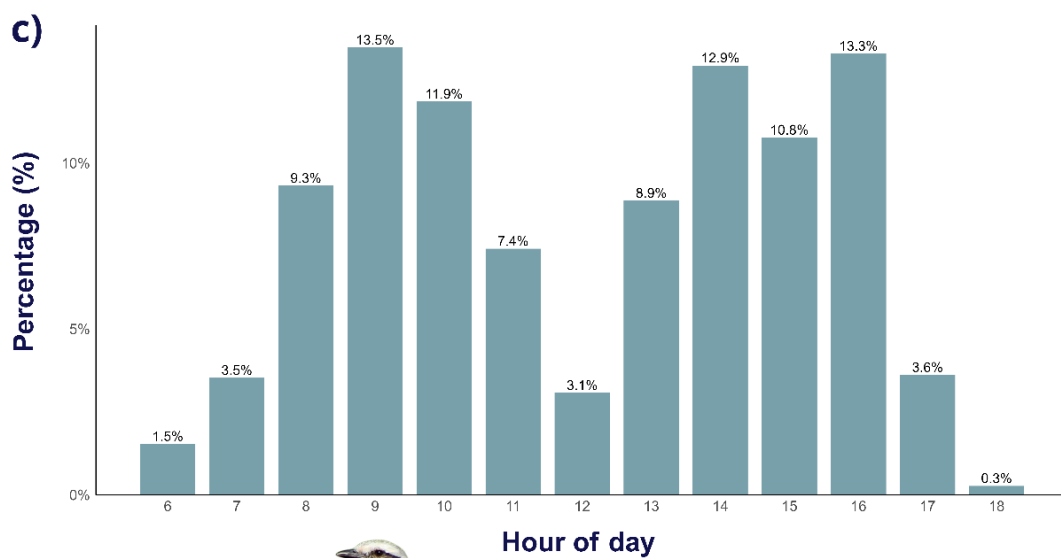
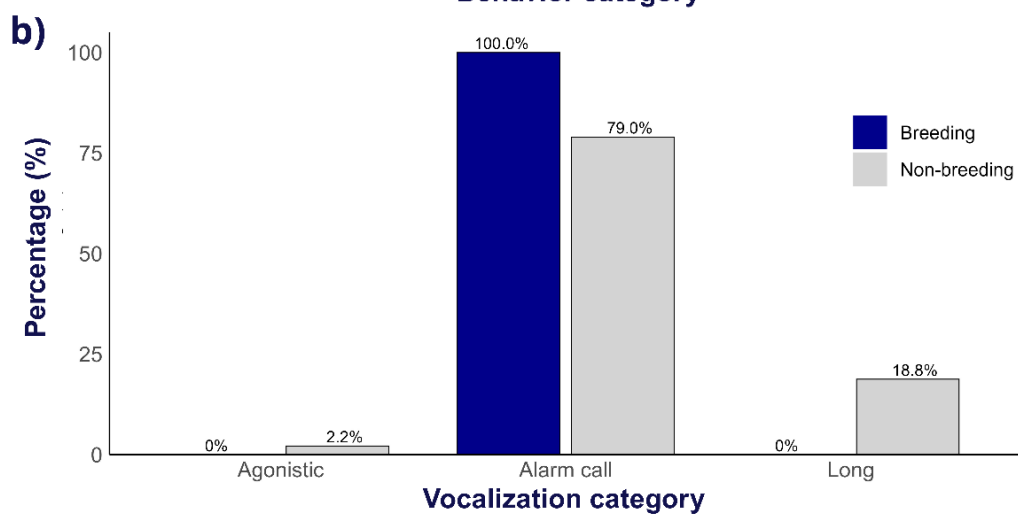
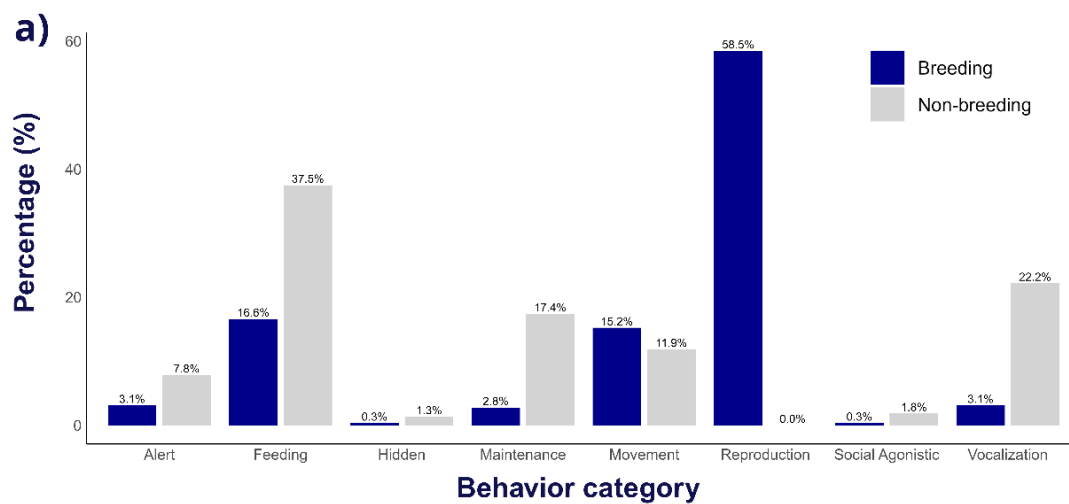


Figure 1. Behavioral patterns of *Gubernetes yetapa* across breeding (dark blue; October to February) and non-breeding seasons (gray; March to September) in two wetlands of Rio Grande do Sul state. (a) Proportional distribution of observed behavior categories. (b) Distribution of vocalization types. (c) Daily activity pattern showing the proportion (%) of behavioral records per hour (06:00–18:00), calculated relative to the total number of observations across the day.

Among foraging behaviors, aerial hawk was the most utilized strategy during the BS, followed by ground foraging, perch-to-ground, and hover-ground. Movements in the wetlands were mostly solitary and short, primarily related to foraging and feeding fledglings, with birds alternating perches across natural habitats and agricultural fields (Supplementary material figure S2). The difference in the number of movements compared to the NB is highlighted in Figure 1a. Maintenance behaviors like preening, resting, and scratching were performed independently, but often in proximity to a conspecific individual. Two agonistic interactions occurred during the breeding season where aerial confrontations were observed either during prey capture or after foraging, when individuals returned to their perch, often involving vocalizations. On one occasion in the end of September, an *G. yetapa* intruding individual was driven away by our focal group (the breeding pair and a nest helper from WL1), who displayed wings and emitted alarm calls before pursuing the intruder beyond the territory. Attacks were used to repel intruders (e.g. *P. guirahuro*) from the territory during the BS, with individuals flying toward the target species.

During the NB, interspecific interactions were mainly related to the formation of mixed-species flocks. In this season, the species exhibited sentinel behavior, with one or two individuals remaining perched as lookouts while others foraged on the ground. In total, 159 interspecific behaviors were recorded during the NB, representing 14.4% of all observed behaviors ($n = 1105$), and all were associated with mixed-species flock formation. In contrast, only three interspecific behaviors were recorded during the BS, all related to territory defense.

Considering foraging strategies in NB, *G. yetapa* primarily fed by walking on the ground often alongside species such as *X. flavus* and *P. guirahuro*, occasionally *Columbina talpacoti* and *Molothrus bonariensis* joined the mixed-flock. Long-distance movements with mixed flocks were observed, with *G. yetapa* consistently leading the flock. Individuals of *G. yetapa* begin to move

and emit alarm calls, and the mixed flock, in turn, follows in the same direction. Movements away from wetlands or long movements (Table 1) occurred mostly during the hottest hours of the day (from 11 AM to 5 PM), with individuals returning to the wetlands at dusk possibly to spend the night.

Agonistic interactions with other species were observed (Table 1). But different from BS, now the mobbing behavior was recorded in response to predators or during territorial disputes. This behavior included long vocalizations, wing displays, and coordinated movements also involving the other species of the mixed flock (e.g. *X. flavus* and *P. guirahuro*; see records in Wagener 2019). Perch disputes occurred when birds actively displaced other species to occupy a perch, often emitting vocalizations. Kleptoparasitism was recorded once when individuals competed for food, targeting prey dropped by *Mimus saturninus*.

Daily activity pattern revealed increased behaviors between 9AM (Figure 1c) and 10AM for both BS and NB, followed by reduced behaviors during the hottest hours due to long-distance movements. Activity peaked again in 16PM, decreasing toward the evening.

Our study provides new information about the behavior of *G. yetapa*, highlighting its varied strategies across BS and NB. Birds inhabiting open habitats, such as *G. yetapa*, are known to benefit from mixed-flock behavior due to increased vigilance against predators, which in turn facilitates aerial hawking, the species' primary foraging strategy (Ferrari & Motta-Junior 2018, Fitzpatrick 1980). Other behaviors related to mixed-flocks are the long-distance movements observed in the NB. Since *G. yetapa* and the other species joined mixed-flocks mainly to forage these movements can be related to food availability, which corroborates with previous findings that *G. yetapa* travels extensively in search of insects (Ridgely & Tudor 1994). This absence from the study area due to long-distance movements may be related to earlier reports questioning its residency (Belton 1994, Meller 2017). However, we highlight here that the species was consistently present throughout the year in our study.

Territorial behaviors observed in our study included auditory and visual signals, threats, and physical confrontations, consistent with Skutch (1976) descriptions. Moreover, the territory

vigilance observed only during BS (reproduction category; Figure 1a) indicates the species' reliance on territory defense to secure resources for reproduction and survival (Davies 1978). The aggressive behaviors, such as mobbing, during the BS further underscored the importance of nest and offspring defense, as reported for other Tyrannidae members (Marini et al. 2009, Sick 1997).

In the NB, individuals of *G. yetapa* joined mixed-species flocks, often acting as leaders by guiding flock movements and/or emitting alarm calls. Such strategies may enhance foraging efficiency and protection against predators, as flocking behavior generally increases survival rates compared to solitary foraging (Jullien & Clobert 2000), a key advantage in open habitats. Moreover, larger flock sizes are frequently associated with increased foraging times, likely due to the benefits of collective vigilance (Krebs & Davies 2009, Sridhar et al. 2009). Associations with species like *P. guirahuro* and *X. flavus* were observed. Notably, this is the first documentation of *G. yetapa* associating with *X. flavus*, which typically forms mixed flocks with *Heteroxolmis dominicanus* (Fontana & Voss 1996). These findings emphasize the role of mixed flocks in optimizing foraging strategies. Although mixed-species flocks occur in a variety of habitats, wetlands are particularly important for the species included in our study, which are strongly associated with wetland environments.

Although our study is observational, which may represent a limitation for behavioral inference as the individuals were not banded, it provides the first description of these behaviors for the species, offering important insights into its ecology and contributing to its conservation. Here, we observed behaviors that suggest complex social dynamics and possible adaptive strategies tied to seasonal changes. Such findings emphasize the importance of understanding how species interact with their habitats, especially in dynamic wetland ecosystems that are under increasing threat. Understanding these ecological dependencies is crucial for developing effective conservation strategies, since the species is considered near threatened in Rio Grande do Sul state, protecting both the species and their habitats. We also recommend further studies on the role of *G. yetapa* in mixed-species flocks, particularly its associations with *X. flavus* and *P. guirahuro*, as these interactions remain poorly documented.

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