



PEREGRINE FALCON *FALCO PEREGRINUS* IN BRAZIL: NATURAL HISTORY THROUGH THE LENS OF CITIZEN SCIENCE

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Abstract · Brazil is an important wintering area for *Falco peregrinus*, specifically for the subspecies *F. p. tundrius* and *F. p. anatum*. Using data from WikiAves, we analyzed and discussed aspects of the species natural history, including migratory behavior, geographical distribution, diet, and ecological interactions. Peregrine Falcons were recorded in the country from October until April. Our data suggest that adults can arrive up to a month earlier than juveniles. Individuals have been recorded in all 26 states and there was no significant difference in their geographical distribution in relation to subspecies or age, but there is an apparent lack of records in the Center of the country. Our results showed that in Brazil peregrines prey mainly on Columbiformes and Charadriiformes. Some individuals share the same perch and engage on agonistic interactions with other bird species, usually mobbing or kleptoparasitism.

Resumo · Falcão-peregrino *Falco peregrinus* no Brasil: história natural através das lentes da ciência cidadã

O Brasil é uma importante área de invernada para *Falco peregrinus*, especificamente para as subespécies *F. p. tundrius* e *F. p. anatum*. Utilizando dados provenientes do WikiAves, nós analisamos e discutimos aspectos da história natural da espécie, incluindo o comportamento migratório, distribuição geográfica, dieta e interações ecológicas. Os falcões-peregrinos podem ser avistados no país entre outubro e abril. Nossos dados sugerem que adultos chegam até um mês antes dos juvenis. Indivíduos foram registrados em todos os 26 estados e não existe nenhuma diferença significativa na distribuição geográfica devido à subespécie ou faixa etária, mas existe uma aparente escassez na região Centro Oeste. Nossos dados apontam ainda que no Brasil os falcões-peregrinos se alimentam majoritariamente de Columbiformes e Charadriiformes. Alguns indivíduos dividem o mesmo poleiro, registramos também a ocorrência de interações agonísticas com outras espécies, geralmente tumulto ou cleptoparasitismo.

Key words: *Community science · Ecology · Raptors · Urban fauna · WikiAves*

INTRODUCTION

The Peregrine Falcon, *Falco peregrinus* Tunstall 1771, is a medium sized bird of prey with 19 subspecies distributed worldwide, four of which are recorded across North, Central, and South America (White et al. 2020). These raptors share centuries of history with humans; they have been admired by falconers, persecuted by gamekeepers, despised by pigeon fanciers and now are a symbol of hope for the conservation of wildlife (Ratcliff 1980, White et al. 2020).

The first documented record of the species in Brazil was in 1835 by Johann Natterer, who collected two individuals at Pará state (see Silva e Silva 1996); ever since, individuals from the subspecies *F. p. tundrius* White 1968, and *F. p. anatum* Bonaparte 1838, have been recorded in 18 states, particularly in the south and southeast regions (Silva e Silva 1996, Mestre 2007). Peregrines do not reproduce in Brazil, using this area only during the boreal wintering season, while they are usually described as solitary, perched on high structures, or flying over open areas while hunting birds or other prey, such as bats and insects (Sick 1960, Albuquerque 1978, Sick 1997, Silva e Silva 1997, Pereira et al. 2006).

Peregrines almost went extinct during the middle portion of the twentieth century in Europe and North America due to the use of pesticides such as DDT and its effects on reproduction (Hickey 1969, Ratcliffe 1969, Fyfe et al. 1976, White et al. 2020, Brown et al. 2007, Holroyd & Bird 2012). The recovery process of the species was remarkably successful, and surveys show a trend of the species becoming increasingly urban (Luniak 1995, Holroyd & Bird 2012).

Given the presence of *F. peregrinus* in Brazil and the lack of information on the distribution of the species in space and time,



this study aims to deepen our knowledge about the species natural history using data from WikiAves, a Brazilian birding and citizen science platform. The proximity of peregrines to urban areas facilitates the development of studies using citizen science since it is geographically accessible for city dwellers who have an interest in ornithology (Greenwood 2007, Wei et al. 2016). Peregrines have the ability to catch society's attention (Sick 1960) and may play an important ecological role as top predators in the control of Columbiformes in urban ecosystems (Luniak 1995). We analyzed population characteristics, such as age and subspecies, as well as their geographical distribution, migration timing, prey types, and ecological interactions. By compiling basic natural history information on its wintering grounds, we aimed at propitiating future and more specific studies, as well as reinforcing the potential use of citizen science platforms for natural history research.

METHODS

Data was obtained from WikiAves (wikiaves.com.br), an online Brazilian platform where anyone can share pictures and vocalizations of birds (WikiAves, 2021). Other citizen science platforms such as eBird and iNaturalist were considered during the early stages of the study. However, WikiAves had until 16 January 2021 (the date of our compilation) significantly more image records of *F. peregrinus* in Brazil compared to these other platforms (WikiAves ~2200; eBird ~62; iNaturalist ~60).

Data supplied by the administrator of WikiAves is shared in a spreadsheet. All records (photos and sounds) are displayed in rows and identified by a specific number, "WAID". Columns contain all the information available for each record, ranging from more basic information, such as author, locality, and date of publication, to detailed information provided by the author, such as sex and age of the recorded individual or the main action depicted in the picture/the context of the sound (such as "feeding/hunting", "flying", "parasitizing another bird", "lek"). Users do not need to specify all the fields when sharing their records; rows without information come as blank or "NULL" cells. The original csv file is available as supplementary material (Supplementary Table S1).

The package tidyverse (Wickham et al. 2019) from RStudio (2022), was utilized for data cleaning and manipulation. The cleaning process involved the removal of sound records and their specific columns, photos that were not taken in Brazil, and duplicates. To avoid the influence of a single individual bias from our results of subspecies and distribution, we filtered pictures that were taken in the same municipality and on the same day, maintaining only one record for each.

For the analysis of diet, we selected all pictures within the "Action" column available at the WikiAves spreadsheet classified by the photographer as "Feeding/Hunting" and then manually checked each picture for the presence or absence of diet information and for multiple records of the same scene. We studied diet both through image analysis and authors' commentaries, discussing the results separately.

Based on the indication in the literature of the occurrence

of two subspecies in Brazil (Sick 1960, Albuquerque 1978, Sick 1997, Silva e Silva 1997, Pereira et al. 2006), one of our objectives was to analyze the WikiAves photos to determine whether the possible diagnostic characteristics of the subspecies would allow identifying biogeographic patterns in the country. Subspecies and age classification were based on the description of Ferguson-Lees & Christie (2001). For subspecies, both *tundrius* and *anatum* were considered as "Holarctic white-cheeked" forms, but the first one has a lighter tone of grey, with usually a pale forehead and large white/cream cheek patches, while the second has a darker tone of grey and a broad mustache that can completely cover the cheek patch. To also help in the differentiation between subspecies, pictures were kindly reviewed by Frederick Pallinger, a well-recognized specialist on Brazilian raptors. For age classification, we assumed that adults have grey plumage on the head, back, and tail, with white throat and chest and a more or less flecked abdomen, depending on whether it's male or female. Juveniles have brown plumage and a heavily marked chest and abdomen.

Information about migration was obtained from the "Date of Record" column. After classifying individuals by age group and subspecies, we summed up the records by month from all the years and then compared differences between groups. For the months of arrival and departure, we divided the records between the first and second half of the month. To test for differences in the time of arrival of adults and juveniles, we performed a linear regression using the first day of publication at WikiAves for each year as the dependent variable, and age as a categorical independent variable.

Geographical distribution was mapped using ArcGIS (2010) from municipality information (latitude and longitude) available within WikiAves spreadsheet. We utilized descriptive analysis to compare the distribution of subspecies throughout Brazilian five regions (North, Northeast, Central-West, Southeast, and South).

Regarding ecological interactions, any record exhibiting more than one *F. peregrinus* was selected as a case of intraspecific interaction, while records that included the presence of a different species (not depicting feeding) were selected as a case of interspecific interaction. We analyzed each of these records and described the apparent behavior of the individuals, such as flying, perch sharing, mobbing, or hunting. Some records were classified as neutral when there was no apparent interaction, or as negative, when the photograph shows a peregrine with another territorialist species, such as the American Kestrel (*Falco sparverius*), even if they are not interacting.

RESULTS

Data. Until 16 January 2021, WikiAves had a total of 2362 records of *F. peregrinus*. After data filtering, it was reduced to 1668 pictures. The individual analysis of each picture revealed two images that were not of interest (i.e., a misidentified record of *F. sparverius* and a record of food remains), which resulted in 1666 records of peregrines left for discussion in

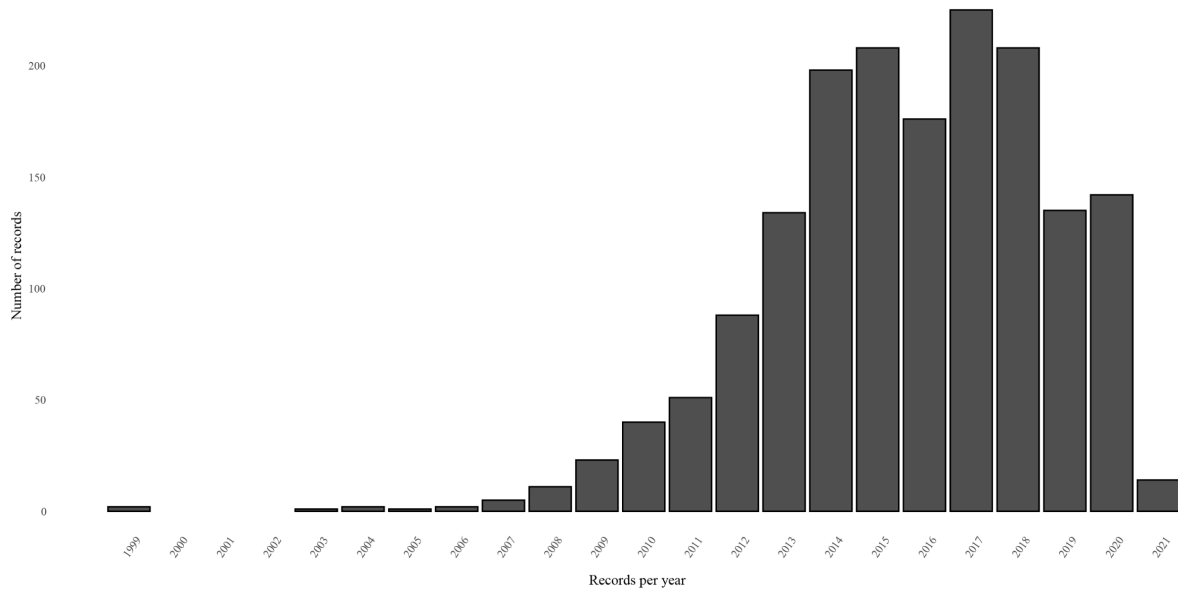


Figure 1. Records of *Falco peregrinus* on WikiAves per year after manipulation (N = 1666). WikiAves was created in December of 2008 and records have increased until 2013 when it consistently had over 130 records per year. Prior to 2008, there are 13 records submitted by authors. The year 2021 has only 14 records because our data was collected until 16 January 2021.

this article.

There was a high concentration of records after 2008, which is explained by the fact that WikiAves was created in December 2008, although users have the option to share their records from any year (Figure 1). In total, we found 14 records before 2008. From 2013 onwards, WikiAves receives consistently more than 130 records of peregrines per year (mean = 178 ± 36.8 , for the period of 2013 – 2020).

Subspecies. We were able to identify subspecies in 1334 pictures, which corresponds to 80% of the data. Most falcons (N = 1201) presented characteristics similar to *F. p. tundrius* appearance, while only 133 pictures showed falcons having a typical *F. p. anatum* phenotype. Juveniles (N = 145) were not included for the identification of subspecies; also 187 images did not allow analysis for numerous reasons, such as falcons flying at a great distance against light or falcons with the head

covered by a structure (i.e., tree branch, light pole).

Age. From 1585 records that allowed for age identification, 1440 (90.85%) represented adults and 145 (9.14%) represented juveniles.

Migration. Records showed that the majority of peregrines arrive in Brazil in October and stay in the country until the first half of April (Figure 2). There was a difference in migration related to age: adults arrive in October, especially during the second half of the month (84%), while juveniles start arriving in November. The earliest date of arrival for adults was October 6th, in the years 2015, 2017, and 2020. The latest date for adults was at October 27th, in the year of 2011. It is relevant to mention that in 2011, there were only three records in October, while in 2015, 2017, and 2020, there were over 10. From 2013 onwards, the latest date was October 20th, 2014

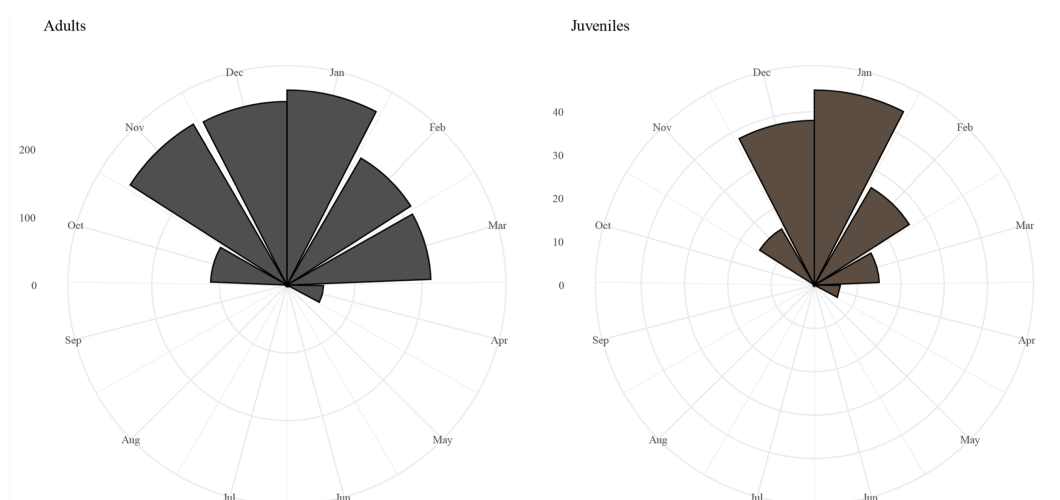


Figure 2. Time and differences on the arrival of adults and juveniles in Brazil. Juveniles represent approximately one in 10 records of *Falco peregrinus*. Adults can be seen in Brazil in October, while juveniles arrive only in November. Both groups stay until April. The pattern is consistent with other discussions in literature, and more focused research is necessary to understand its reason.

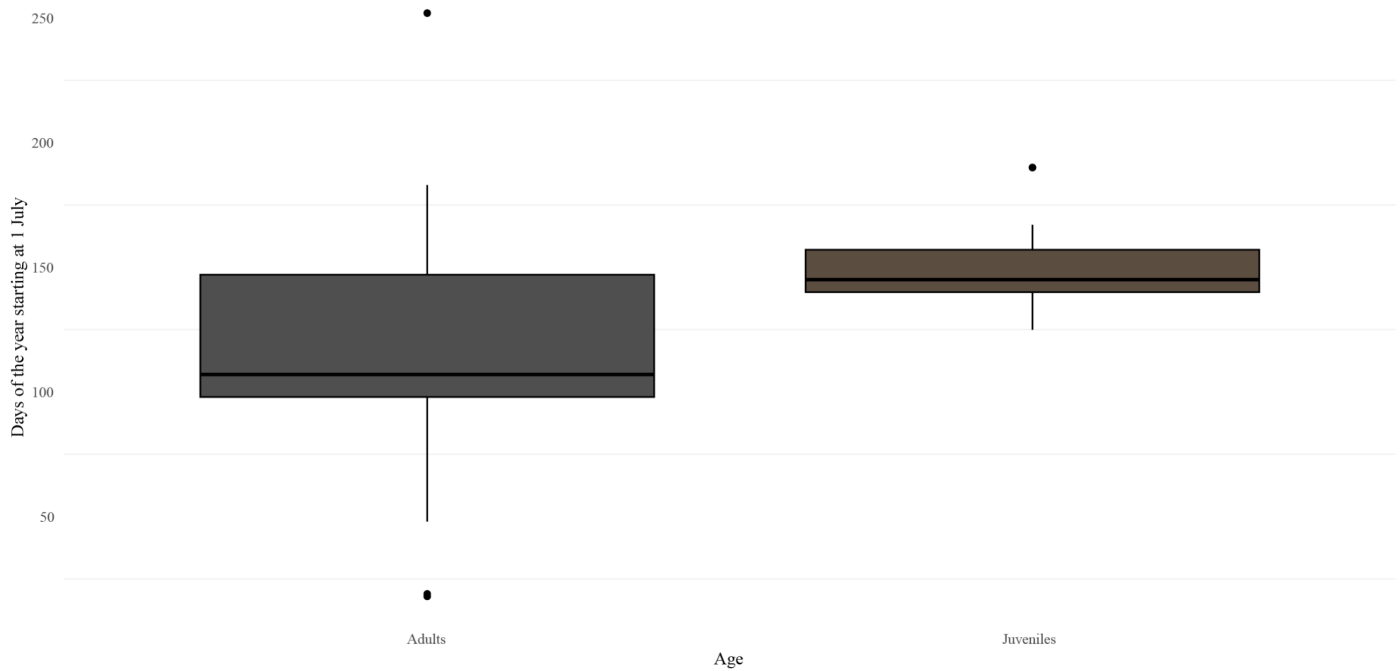


Figure 3. Comparison of the first day of occurrence at WikiAves between age groups for each year of *Falco peregrinus* in Brazil. Since Peregrines stay in Brazil from October to April, we changed the first day of the year to July 1st for better visualization. The estimate of the first day of sighting is October 24th for adults and November 30th for juveniles.

(mean 13 ± 6.2 , for the period of 2009 – 2020). For juveniles, the earliest arrival date was November 2nd, 2014. The latest date was November 30th 2011, and November 21st in 2015 and 2016 (mean 16 ± 8.54 , for the period 2011-2020). By examining the average date of the first record for adults and juveniles in each year (as shown in Figure 3), we found that there was a significant difference between the two age groups; with adults arriving in Brazil an average of 36.8 days earlier than juveniles (SE = 9.94 for adults and 15.85 for juveniles, $df = 31$, $p < 0.05$, $N = 20$ adults and 13 juveniles).

Distribution. There are records of *F. peregrinus* by photographers throughout the whole country of Brazil, including all 26 Brazilian states and the Federal District. South and Southeast regions concentrate most records ($N = 1,264$; 75.7%; Table 1), while the Central region has the lowest number ($N = 47$; 2.8%). Subspecies and age do not seem to affect the geographical distribution of peregrines in their wintering grounds (Table 1).

Prey. There were 200 records classified by the authors as

“Feeding/Hunting” on WikiAves. After manual revision, we ended up with 99 pictures of prey consumption. Since we considered the author's comments, we have 79 pictures of a peregrine falcon with the prey and 20 pictures of a solitary peregrine, and a commentary on diet by the author.

Amongst the records that depicted feeding/hunting, we were able to identify the order of 24 and the species of 18 images, birds were the prey in all cases (Table 2). Columbiformes appear on 66.6% (16 out of 24) of records. Charadriiformes and Psittaciformes had three records each.

Between author’s reports (Table 3), we found mentions of avian orders Columbiformes, Charadriiformes, Anseriformes, Suliformes, and Tinamiformes. Mentions to orders Columbiformes and Charadriiformes followed the pattern found in the records with pictures (13 and three records, respectively). Anseriformes, Suliformes, and Tinamiformes had one mention each. We found three mentions of predation on bats (Chiroptera). We also found two reports of peregrines preying on Hymenoptera and one mention of a peregrine hunting young sea turtles on the beach (the author did not reply to our contact).

Table 1. Comparison between the major five Brazilian regions of records on WikiAves vs registered observers; *F. p. tundrius* vs *F. p. anatum* subspecies; and adults vs juveniles.

Region	Records (%)	Users (%)	<i>F. p. tundrius</i> (%)	<i>F. p. anatum</i> (%)	Adults (%)	Juveniles (%)
North	83 (4.97)	1580 (4.16)	57 (4.74)	10 (7.51)	70 (4.86)	10 (7.51)
Northeast	274 (16.42)	4837 (12.74)	197 (16.40)	22 (16.54)	231 (16.04)	29 (20)
Central	47 (2.81)	3032 (7.98)	29 (2.41)	10 (7.51)	40 (2.77)	2 (1.50)
South	468 (28.05)	8528 (22.46)	335 (27.89)	36 (27.06)	404 (28.05)	39 (26.89)
Southeast	796 (47.72)	19978 (52.63)	583 (48.54)	55 (41.35)	695 (48.26)	65 (44.82)

Table 2. List of records, identified by WAID, that represents diet choices of *Falco peregrinus* in Brazil.

WAID	Order	Species	Date	Municipality	State
565320	Charadriiformes	<i>C. canutus</i>	2012-01-27	Apicum-Açu	MA
804986	Charadriiformes	<i>J. jacana</i>	2012-11-17	Pão de Açúcar	AL
1636802	Charadriiformes	<i>V. chilensis</i>	2015-03-12	São Gonçalo do Amarante	RN
3585350	Columbiformes	<i>C. livia</i>	2019-11-19	Fortaleza	CE
3586172	Columbiformes	<i>C. livia</i>	2019-11-19	Fortaleza	CE
887810	Columbiformes	<i>C. livia</i>	2013-02-16	Vila Velha	ES
557600	Columbiformes	<i>L. verreauxi</i>	2012-01-25	Artur Nogueira	SP
2846369	Columbiformes	<i>Z. auriculata</i>	2018-01-13	Campo Grande	MS
1648362	Columbiformes	<i>Z. auriculata</i>	2015-03-28	Paiçandu	PR
1651389	Columbiformes	<i>Z. auriculata</i>	2015-04-01	Paiçandu	PR
1892652	Columbiformes	<i>Z. auriculata</i>	2015-10-31	Taubaté	SP
2919246	Columbiformes	<i>Z. auriculata</i>	2018-03-12	Patos de Minas	MG
3352968	Columbiformes	<i>Z. auriculata</i>	2019-03-07	São Carlos	SP
4165147	Columbiformes	<i>Z. auriculata</i>	2021-01-14	Londrina	PR
2435996	Columbiformes		2017-01-15	Foz do Iguaçu	PR
3633811	Columbiformes		2020-01-03	Cruz Alta	RS
2377981	Columbiformes		2016-11-16	Americana	SP
3592079	Columbiformes		2019-11-18	Patos de Minas	MG
3268633	Columbiformes		2019-01-26	Rio de Janeiro	RJ
2944729	Passeriformes	<i>T. palmarum</i>	2018-04-17	Peruíbe	SP
1567109	Passeriformes		2015-01-03	Parnaíba	PI
789350	Psittaciformes	<i>B. tirica</i>	2012-10-31	São Paulo	SP
548084	Psittaciformes	<i>M. monachus</i>	2012-01-01	Uruguaiana	RS
913754	Psittaciformes	<i>N. hollandicus</i>	2013-03-20	Recife	PE

Intraspecific interactions. We found 23 records of intraspecific interaction, which are indicated in Table 4. Most records (16 out of 23, 69.5%) represented two adults sharing the same perch, while other records depict peregrines flying, with only two possible agonistic interactions.

Interspecific interactions. There were 17 records of peregrines with other bird species (Table 5). Four of these records seem to be non-agonistic or neutral interactions: in three of these there is a peregrine flying in the same frame of a Magnificent Frigatebird *Fregata magnificens*, *Chaetura* sp. and Cathartidae and in one there is a *F. peregrinus* sharing perch with a Black Vulture *Coragyps atratus*. The other twelve records represented agonistic interactions, such as mobbing, kleptoparasitism, and hunting. The species performing these behaviors with peregrines were the American Kestrel *F. sparverius*, the Crested Caracara *Caracara plancus*, the Tropical Kingbird *Tyrannus melancholicus*, the American Oystercatcher *Haematopus pal-*

liatus, the Cliff Flycatcher *Hirundinea ferruginea* and *Milvago* sp. Overall, we identified six families of birds interacting with Peregrine Falcons during the wintering season in Brazil.

DISCUSSION

Peregrine Falcons were photographed in all 26 Brazilian states and Federal District, which alludes to the species wide and varied distribution (White et al. 2020). Before this study, the most up to date compilation of peregrines in Brazil pointed its occurrence in 18 states (Silva e Silva 1996). It is a great example of one of the reasons why citizen science is such an important opportunity for research, which is the capability of collecting data that otherwise would not be possible due to limitations of time and resources (Sullivan et al. 2009, Dickinson et al. 2010). For future studies, it is important to combine all sources of information about species distribution, such as museum collections, citizen science platforms, literature reviews,

Table 3. List of records, identified by WAID, that depict an author's commentary about a possible diet choice of *Falco peregrinus*.

WAID	Order	Species	Date	Municipality	State
546620	Anseriformes	<i>C. moschata</i>	2010-02-07	Itumbiara	GO
912764	Charadriiformes	<i>C. alba</i>	2013-03-18	Bragança	PA
866695	Charadriiformes	<i>Calidris</i> sp.	2013-01-22	Tavares	RS
2813116	Charadriiformes	<i>H. palliatus</i>	2017-12-06	Vitória	ES
318433	Columbiformes	<i>C. livia</i>	2011-03-25	Juiz de Fora	MG
3214302	Columbiformes	<i>C. talpacoti</i>	2018-12-15	Grossos	RN
3164665	Columbiformes		2018-10-28	Patos de Minas	MG
2942694	Columbiformes		2018-04-15	Peruíbe	SP
2944731	Columbiformes		2018-04-17	Peruíbe	SP
2512131	Columbiformes		2017-03-19	Santo Ângelo	RS
1543023	Columbiformes		2014-12-10	Santos	SP
2804919	Columbiformes		2017-12-04	Fortaleza	CE
2918661	Columbiformes		2018-03-21	Fortaleza	CE
3164108	Columbiformes		2018-10-31	Fortaleza	CE
189875	Columbiformes		2009-03-10	Salvador	BA
771162	Columbiformes	<i>Z. auriculata</i>	2012-10-10	Patos de Minas	MG
1701678	Columbiformes	<i>Z. auriculata</i>	2015-01-28	Curitiba	PR
2893250	Suliformes	<i>N. brasilianus</i>	2018-02-21	São Bernardo do Campo	SP
810025	Tinamiformes	<i>Nothura</i> sp.	2012-11-16	Piratini	RS
198841	Chelonidae		2004-12-20	Campos dos Goytacazes	RJ
2907145	Hymenoptera		2018-03-02	Areia	PB
2854034	Hymenoptera		2018-01-11	Fortaleza	CE
329841	Quiroptera		2011-04-11	Ilhabela	SP
3569676	Quiroptera		2019-11-04	Fortaleza	CE
2760617	Quiroptera		2017-10-31	Fortaleza	CE

and grey literature.

The higher concentration of records in South and Southeast regions (Table 1) is consistent with other works in literature that have found 56% (Mestre 2007) or 66% (Silva e Silva 1996) of peregrines in these regions during sightings or captures of banded individuals. Still, it is possible that this result is somehow biased by the number of observers and researchers interested in birds in these areas (Silva e Silva 1996). Numbers seem to support this hypothesis: according to Wiki-Aves (2021), South and Southeast regions hold 75% of registered users; also, these regions have the highest populational density in the country (IBGE, 2021). Besides, the results of this work show a concentration of records in the North region around rivers, which are an important transport route and an opportunity to have a clear view of peregrines on the margins (Figure 4).

The Central region can be considered an exception, for it has around 8% of users but only 2.8% of records; for comparison, the North region has 4.2% of users and 4.9% of records (Table 1). The lack of peregrines in the Central region has

been already noticed in literature (Silva e Silva 1996, Mestre 2007). Further studies are needed to clarify whether there really are aspects of the Central region that are not favorable for habitat selection by peregrine falcons (e.g., hydrography heavily based on river headwaters or regions modified by agriculture) or whether it is a bias induced by the lower proportion of observers. The influence of the geographic distribution of birders is a common challenge in understanding the real distribution of species (see Lopes & Schunck 2022).

Adults of *F. peregrinus* are more common in the wintering grounds in Brazil than juveniles. It is known that age influences migratory behavior in peregrine falcons (Mueller et al. 2000). In addition to adults migrating first, they also travel longer distances than juveniles. Amongst juveniles, sex influences the distance as well, since males are more likely to migrate further than females (Gahbauer 2008). Thus, the proportion found between ages is within the expected of the literature.

Regarding the seasonality and migratory behavior of *F. peregrinus*, our study found that peregrines are present in Brazil from October to April. Previous works indicated this

Table 4. Intraspecific interactions.

WAID	Ages	Action	Date	Municipality	State
2924831	A/A/A	Flying	2018-03-05	Santo Cristo	RS
3192780	A/A	Flying	2018-11-22	Fortaleza	CE
3391452	A/A	Hunting	2019-03-21	Fortaleza	CE
2836824	A/A	Perch sharing	2018-01-05	Jaú	SP
1623710	A/A	Perch sharing	2015-02-15	Arroio do Meio	RS
1998983	A/A	Perch sharing	2016-01-22	Castro	PR
2911664	A/A	Flying	2018-03-11	Fortaleza	CE
3321496	A/A	Flying	2019-03-20	Fortaleza	CE
2222477	A/A	Perch sharing	2015-01-10	Guarulhos	SP
2222478	A/A	Perch sharing	2016-03-31	Guarulhos	SP
1480800	A/A	Perch sharing	2014-03-05	Itapira	SP
1151685	A/A	Perch sharing	2013-11-12	Jaú	SP
2874955	A/A	Perch sharing	2018-01-16	Linhares	ES
1972509	A/A	Perch sharing	2016-01-02	Londrina	PR
1644594	A/A	Perch sharing	2014-11-28	Monção	MA
585984	A/A	Perch sharing	2012-02-05	Monte Alegre	PA
1202520	A/A	Perch sharing	2014-01-03	Rio de Janeiro	RJ
1250268	A/A	Perch sharing	2014-02-09	São Paulo	SP
2112780	A/A	Perch sharing	2014-02-21	São Paulo	SP
1216566	A/A	Perch sharing	2014-01-08	Taubaté	SP
1947219	A/A	Perch sharing	2015-12-15	Taubaté	SP
594797	A/J	Flying	2012-01-20	Fortaleza	CE
2884105	A/J	Perch sharing	2018-02-14	Taubaté	SP

same period (Sick 1997, Silva e Silva 1997), while others included September (Silva e Silva 1996, Pereira et al. 2006). We also found a difference between the time of arrival of adults and juveniles (Figures 2 and 3), which was already expected from literature. A previous study (Mueller et al. 2000) found that *F. peregrinus* differs from other species of falcons, with adults leaving the breeding grounds sooner than juveniles. There are at least two hypotheses on why this happens: (1) adults leave the breeding territory earlier because they are able to reach the body condition to migrate sooner than recently fledged juveniles or to avoid parent-offspring conflict, (2) adults and juveniles migrate at the same time, but adults, being larger and familiar with the route, are faster (see Newton 1979, Mueller et al. 2000). We believe that mapping individuals with site fidelity would be a first step towards selecting individuals worth following throughout the year to investigate these differences in migratory behavior.

Analysis of subspecies based on phenotypic characters revealed a higher prevalence of *F. p. tundrius* (90.02%) than of *F. p. anatum* (9.97%). Also, we found no evidence of *F. p. cassini* between the records, which has been hypothesized to occur in Brazil (Silva e Silva 1996).

Even though we classified the overwintering individuals into subspecies, it is important to mention the debate around this subject: many authors argue about the validity of the distinction between *F. p. anatum* and *F. p. tundrius* based on morphological characters, due the process used for the reintroduction of the species in North America (Brown et al. 2007, Talbot et al. 2017). Analysis of the evolutionary relationship between the three North American subspecies suggests that there is no genetic differentiation from individuals identified as *F. p. tundrius* and *F. p. anatum* from higher latitudes; besides, there is gene flow between populations of these subspecies and a high percentage of shared haplotypes (Talbot et al. 2017). Nevertheless, the subspecies does not seem to affect migration timing and distribution in the wintering grounds (Table 1).

The diet of *F. peregrinus* in Brazil, as observed from records, is composed of three main groups of birds: Columbiformes, Charadriiformes, and Psittaciformes. Columbiformes as the most consumed prey corresponds with other descriptions of their feeding habits in urban areas (Drewitt & Dixon 2008). The presence of Charadriiformes was expected since some falcons share the same migratory route with members

Table 5. Intraspecific interactions.

Waid	<i>F. peregrinus</i>	Species or Family	Action	Date	Municipality	State
609356	<i>F. p. tundrius</i>	<i>C. atratus</i>	Neutral/Perch sharing	2012-04-03	Comodoro	MT
885568	<i>F. p. anatum</i>	<i>C. plancus</i>	Kleptoparasitism	2013-02-14	Salto	SP
3559990	<i>F. peregrinus</i>	<i>C. plancus</i>	Kleptoparasitism	2019-11-03	Americana	SP
1280572	<i>F. peregrinus</i>	<i>C. plancus</i>	Negative/Flying	2014-03-23	Salto	SP
1949398	<i>F. peregrinus</i>	Cathartidae	Neutral/Flying	2010-12-29	Lavras	MG
1638401	<i>F. p. tundrius</i>	<i>Chaetura sp.</i>	Neutral/Flying	2015-03-15	Santo Ângelo	RS
817087	<i>F. p. tundrius</i>	<i>F. magnificens</i>	Neutral/Flying	2012-11-07	Macaé	RJ
3201646	<i>F. peregrinus</i>	<i>F. sparverius</i>	Mobbing	2018-12-03	Maceió	AL
3578518	<i>F. peregrinus</i>	<i>F. sparverius</i>	Negative/Flying	2019-11-14	Rodelas	BA
1599467	<i>F. p. tundrius</i>	<i>F. sparverius</i>	Negative	2015-01-23	Campo Mourão	PR
4105551	<i>F. p. tundrius</i>	<i>F. sparverius</i>	Negative	2020-11-05	Campos dos Goytacazes	RJ
3586660	<i>F. p. tundrius</i>	<i>F. sparverius</i>	Negative	2019-11-26	São José dos Campos	SP
2787874	<i>F. peregrinus</i>	<i>H. ferruginea</i>	Mobbing	2017-11-20	Barra Bonita	SP
2813116	<i>F. peregrinus</i>	<i>H. palliatus</i>	Negative/Hunting	2017-12-06	Vitória	ES
3391452	<i>F. peregrinus</i>	<i>Milvago sp.</i>	Hunting	2019-03-21	Fortaleza	CE
267470	<i>F. p. anatum</i>	<i>T. melancholicus</i>	Mobbing	2008-05-10	Salvador	BA
2424136	<i>F. peregrinus</i>	<i>T. melancholicus</i>	Mobbing	2016-11-22	Foz do Iguaçu	PR

of this order (Albuquerque 1985, White et al. 2020). Amongst the records of Psittaciformes, we found the consumption of a Cockatiel (*Nymphicus hollandicus*), a domestic species probably captured after having escaped captivity. Overall, these results corroborate the predominance of small to medium size birds in their diet (Ratcliffe 1980, Ferguson-Lees & Christie 2001) and point to the importance of *F. peregrinus* in urban environments as a top predator in the control of Columbiformes (Luniak 1995), but also draw attention to possible conflicts with society, due their opportunistic behavior and consumption of domestic birds (see Boal & Driska 2018). Finally, the high predation of Psittaciformes stands out the adaptability of the species to add to its diet a mostly tropical bird group practically unavailable on its breeding grounds (Winkler et al. 2020), but also adapted to urban environments, reinforcing peregrines capacity of local or individual specialization on groups (Ratcliffe 1980, Ferguson-Lees & Christie 2001).

Considering the records from WikiAves composed of photographs where the prey could not be visually identified, but for which the birdwatchers that obtained the records included a paragraph describing what they had seen right before taking the picture, there are 13 records where the prey items belong to the order Columbiformes; three for Charadriiformes where the authors identified the taxa as *Calidris sp.*, Sanderling *Calidris alba* and the American Oystercatcher *Haematopus palliatus*; and one record for each order Anseriformes, Suliformes, and Tinamiformes. It is reasonable to assume that these mentions are correct, since the first two orders include birds of aquatic and open areas, and the last order represents

a common prey for resident raptors (Sick 1997).

The records of peregrines preying on Chiroptera points to their crepuscular hunting habits (DeCandido & Allen 2006), and also to their adaptation to urban environments, where the lights may allow for an extended period of hunting. According to the literature (Albuquerque 1978, Silva e Silva 1997, Pereira et al. 2006), we expected more records of peregrines eating bats since they are considered their second most sought after food source in wintering areas, but the small number of records may be due to the smaller number of observers since at dawn there are fewer birdwatchers taking pictures. Mentions of peregrines preying on Hymenoptera are in accordance with other works which have pointed to the presence of insects in peregrines diet in Brazil, with the orders Blattodea (Sick 1997) and Hemiptera (Pereira et al. 2006). Finally, regarding the mention of a peregrine hunting young sea turtles on the beach (which has not been confirmed by the author), other works have pointed the presence of Squamata as their prey in Brazil (Pereira et al. 2006), but it is the first mention to Cheloniidae. Published data on the predation of reptiles by birds, also using records from citizen science, did not find any records of peregrines eating snakes (de Souza et al. 2022).

Records of intraspecific interactions are apparently neutral or non-agonistic, with individuals sharing the same perch or even hunting together. Even though the species is monogamous during the reproductive season and couples get reunited every year, they are considered mostly solitary during the wintering season, apart from being territorialists (White et al.

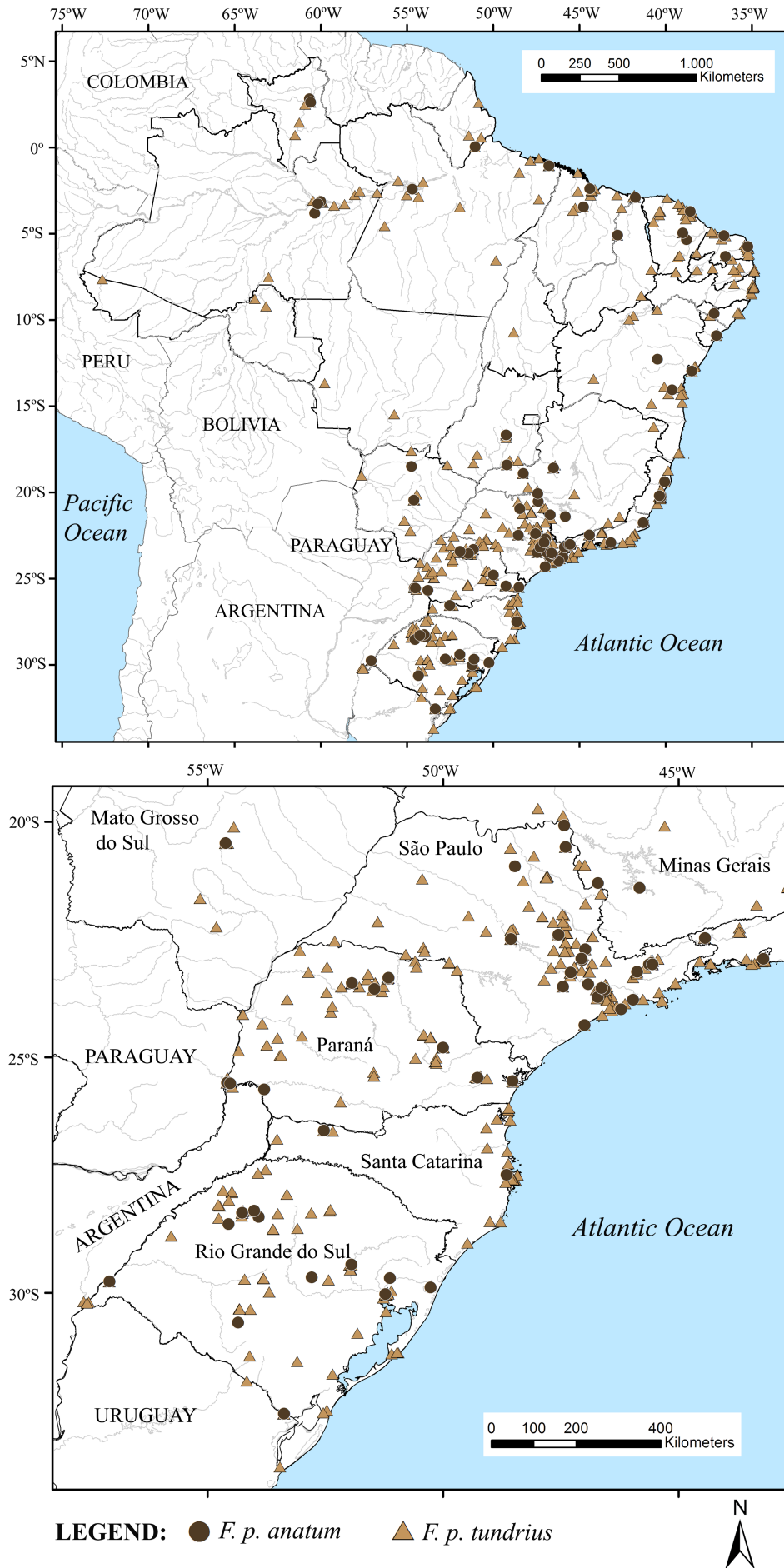


Figure 4. Localities where the records were carried out. Each point represents the center of the municipality identified on WikiAves. We made an overlay of the distribution maps according to subspecies and we show in more detail the locations with records in the southeast region. There is no difference in the distribution of the subspecies and records are closely related to rivers/water bodies.

2020). However, it has already been described in literature the presence of couples during the wintering season in South America (Silva e Silva 1997, Kéry 2007), even performing courtship behavior (White et al. 2020), which points out the necessity of deepening our knowledge about their reproductive behavior outside the reproductive period.

Analysis of interspecific interactions has a different pattern than intraspecific ones. Most records of *F. peregrinus* with other species are agonistic and understanding these relations is key to comprehend perch selection (see Sergio et al. 2004). Finally, our work adds to the previous literature (Silva e Silva 1997, Pereira et al. 2006) on the presence of interactions with two new families, Fregatidae, and Apodidae.

Community science platforms, such as WikiAves, provide researchers with a substantial amount of data to understand species natural history. Despite the growing number of publications using the term “citizen science” in the last two decades, we still lack a universal definition of the practice. It is commonly associated with the participation of the non-scientific population in the generation of data for scientific purposes (Haklay et al. 2021). WikiAves is the most popular birding platform in Brazil, with more than 40 thousand users. In addition to being a virtual community, WikiAves is also a citizen science platform, since data is accessible upon request for any stakeholder and records can be easily tracked by researchers through an ID code. In this study, through WikiAves database, we were able to identify characteristics such as differences in migration of adults and juveniles, distribution of the species, the proportion of the subspecies, prey items, and ecological interactions. *F. peregrinus* has all the characteristics, being a migrating raptor with site fidelity easily found in urban environments, that catch public attention. We hope this article can be a source for anyone interested in knowing more about this species, in addition to being evidence of the relevance of data from citizen science in natural history studies. Not only can we use this data directly to analyze aspects of species, but we can also use it as a basis for conducting broader studies.

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