

The Tocantins-Araguaia Basin as a migratory route and a wintering area of *Falco peregrinus* (Aves, Falconidae)

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Received on 20 September 2019. Accepted on 29 November 2019.

ABSTRACT: The Peregrine *Falco peregrinus*, is an Nearctic migrant to Brazil where its status in central Brazil is still poorly known. Herein we present a compilation of records of the species from the state of Tocantins and comment on its use of a wintering site in the state of Goiás. These records show that the Tocantins-Araguaia River Basin is a migration route for the species, and therefore a mid-continental migration route through the interior of South America.

KEY-WORDS: Araguaia River, bird of prey, Brazil central, Cerrado Biome, migratory bird, North-South Railroad, Tocantins River.

INTRODUCTION

The Peregrine Falcon *Falco peregrinus* Tunstall, 1771, is one of the most well studied birds in the world (Ferguson-Lees & Christie 2001, White *et al.* 2013) occurring on every continent except Antarctica. Some subspecies perform long migrations and can travel more than 14,000 km between wintering and breeding areas (Sick 1997, Fuller *et al.* 1998, Mestre 2007, Goodrich & Smith 2008).

In South America at least three migratory routes of *F. peregrinus* are known: two coastal and one continental (Fuller *et al.* 1998). In coastal routes, individuals of *F. peregrinus* follow the Pacific or Atlantic coasts, making use of urban centers and coastal environments as stopover sites to the southeastern and southern portion of Brazil, northern Argentina and Uruguay, which comprise their wintering areas. The continental route passes through the interior of the Amazon region, following river basins until reaching the Pantanal through central-west, southeast and southern Brazil, northern Argentina and Uruguay (Fuller *et al.* 1998, Erize *et al.* 2006, Mestre 2007).

In Brazil, the species has been recorded between September and April, mostly in the south, southeast and northeastern coasts (Silva-e-Silva 1996, Sick 1997, Mestre 2007). Migrant populations show great fidelity to their routes, stopover sites and wintering sites and may use the same wintering sites for several consecutive years (Silva-e-Silva 1996, Sick 1997, Drummond 2010, White *et al.* 2013).

Although there is much published information about migratory movements of the Peregrine Falcon, there is little information about the individuals that remain in Brazil during the wintering period, especially in the central portion of the country, where the species is under-recorded. Therefore, the aim of this study is present a synthesis of *F. peregrinus* records for the states of Tocantins and Goiás, central Brazil, demonstrating that the Tocantins-Araguaia River Basin is a migratory route of the species.

METHODS

The *F. peregrinus* records for the states of Tocantins and Goiás occurred in two ways: sightings and compilation of records. Sightings were conducted in the urban area of Goiânia, capital of the state of Goiás, between 2016 and 2018, and from January to April 2019, and in the region with natural vegetation and pastures under the influence of the North-South Railway (NSR), in the rural area of the municipality of Oliveira de Fátima, central portion of the state of Tocantins, during fieldwork between 20 to 25 March 2019.

The compilation of records of *F. peregrinus* was obtained from the citizen science platforms WikiAves (wikiaves.com.br) and eBird (ebird.org), which are publicly and freely accessible (Lees *et al.* 2014). The compiled records are presented by the accession number on these respective platforms. However, some records were

kindly provided through requests to other ornithologists or birdwatchers (Table 1). The compiled records were mapped, assuming the geographic distribution of *F. peregrinus* as presented by White *et al.* (2019).

RESULTS

On 22 March 2019, at 17:30 h, T.D. sighted a *F. peregrinus* perched on a dry branch on a medium-sized tree top (between 10 and 15 m high) on the borders of the North-South Railroad (NSR), municipality of Oliveira de Fátima, central region of the state of Tocantins (10°41'S; 48°48'W). Given the small size of the individual, it was assumed to be a male (Fig. 1). The region is located within the Cerrado Biome, 90 km from the right bank of the Tocantins River. The vegetation was composed of a mosaic of fragments of semideciduous seasonal forests, “Cerradão” gallery forest and Cerrado *sensu strictu*, interspersed with pastures intended for livestock. This record shows to be the first documented of the species in Tocantins.

Reports of the occurrence of *F. peregrinus* in the state of Tocantins are remarkably scarce compared with the numerous records of the species in other regions of Brazil (Mestre 2007). While in cities, such as São Paulo, Recife and Porto Alegre, it is possible to count different pairs or individuals in the same wintering period (Pereira *et al.* 2006, Mestre 2007), in Tocantins there have been no more than four sightings of the species. These are in chronological order: in April 2006, a female was spotted atop a large dry tree on the banks of the Araguaia River, on the edge of Cantão State Park (Dornas & Pinheiro 2011). Between 18–22 November 2010, Brito *et al.* (2016) mention a sighting in the region of Presidente Kennedy, north central Tocantins, in areas of transitional Cerrado-

Amazon (semideciduous-ombrophilous) forests near power transmission line towers. On 07 November 2015, another sighting was reported by Marcelo Barbosa (eBird list S25770349) in Lagoa da Confusão municipality, in a circular and naturally fragmented forest formation, locally called “ipuca”, adjacent to rice fields and a few kilometers from the Javaés River and Bananal Island, at the western portion of Tocantins.

T.J. and E.F.S. conducted a regular series of observations of *F. peregrinus* in the urban area of Goiânia, capital of the state of Goiás, between 2016 and 2018, and from January to April 2019. Sightings of this species at the top of buildings in the urban center of Goiânia from 27 October 2017 to 20 March 2018, demonstrated the perennial use of this urban complex during wintering period (Table 1).

At the end of the austral spring, on 20 November 2018, the species was again detected by T.J. on the same perch on top of buildings in Goiânia city center. Sighting of the species on these buildings continued until 25 December 2018. After that date, no further sighting and/or photographic records were shared on citizen science platforms. T.J. observed a female *Falco rufifigularis* sharing the same perch used by *F. peregrinus*, from December 2018 through January 2019. Apparent interspecific competition, or even frequent harassment by *F. rufifigularis* (mobbing behavior), forced *F. peregrinus* to find another hunting and resting perch.

However, on 20 February 2019, E.F.S. spotted an individual on another building tower in the urban center of Goiânia. The individual used this perch for three consecutive days. In the evening it was catching bats, returning to the same perch to consume the prey. The same perch was used in 2016, when E.F.S. documented the individual at the same time of the year (Table 1; WA2125588). The E.F.S. sighting point (16°42'06"S;



Figure 1. Male *Falco peregrinus* registered on the banks of the North-South Railroad, in Oliveira de Fátima, Tocantins state, Brazil. Photo author: Túlio Dornas.

Table 1. Compiled records of *Falco peregrinus* for the state of Goiás, Brazil, through sightings and media deposited on the Wikiaves database.

Date (dd/mm/yyyy)	Autor	Municipality	Source	Coordinates
19/04/2019	Jayrson Araújo	Goiânia	WA3338803	16°48'S; 49°16'W
22/02/2019	Estevão F. Santos	Goiânia	Sighting	16°42'S; 49°17'W
21/02/2019	Estevão F. Santos	Goiânia	Sighting	16°42'S; 49°17'W
20/02/2019	Estevão F. Santos	Goiânia	Sighting	16°42'S; 49°17'W
25/12/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
14/12/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
13/12/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
12/12/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
10/12/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
29/10/2018	André Siade	Anápolis	WA3161421	16°19'S; 48°56'W
25/10/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
24/10/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
23/10/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
20/10/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
20/03/2018	Igor Oliveira	Goiânia	WA2918299	16°36'S; 49°17'W
04/02/2018	André De Lucca	Goiânia	Sighting	16°37'S; 49°15'W
30/01/2018	Tiago Junqueira	Goiânia	Sighting	16°40'S; 49°16'W
26/01/2018	Igor Oliveira	Goiânia	WA2861801	16°40'S; 49°16'W
30/12/2017	Matheus dos Santos	Goiânia	WA2829930	16°40'S; 49°16'W
23/12/2017	Kennedy Road	Goiânia	WA2823841	16°40'S; 49°16'W
22/12/2017	Kelrene Lara	Goiânia	WA2858406	16°40'S; 49°16'W
13/12/2017	Ivo Zecchin	Goiânia	WA2814435	16°40'S; 49°16'W
30/10/2017	André Mendonça	Goiânia	WA2757513	16°40'S; 49°16'W
30/10/2017	Márcia Bessa	Goiânia	WA2823575	16°40'S; 49°16'W
27/10/2017	Jayrson Oliveira	Goiânia	WA2759201	16°40'S; 49°16'W
27/10/2017	Marcelo Dionísio	Goiânia	WA2766727	16°40'S; 49°16'W
26/10/2017	Marcelo Dionísio	Goiânia	WA2753124	16°40'S; 49°16'W
24/10/2017	Tiago Junqueira	Goiânia	WA2749446	16°40'S; 49°16'W
25/12/2016	Rodolfo P. Oliveira	Rio Verde	WA2412786	17°47'S; 50°52'W
25/12/2016	Rodolfo P. Oliveira	Rio Verde	WA2412785	17°47'S; 50°52'W
30/10/2016	Geraldo Moraes	Aparecida de Goiânia	WA2353219	17°49'S; 49°14'W
14/02/2016	Estevão F. Santos	Goiânia	WA2125588	16°42'S; 49°17'W
15/03/2013	Rafael Pedra	Itumbiara	WA909996	18°24'S; 49°13'W
15/03/2013	Rafael Pedra	Itumbiara	WA909995	18°24'S; 49°13'W

Date (dd/mm/yyyy)	Autor	Municipality	Source	Coordinates
31/10/2012	Felipe Zenha	Aparecida do Rio Doce	WA1913644	18°17'S; 51°08'W
05/04/2012	Juliano Mafra	Corumbaíba	WA1027528	18°23'S; 48°39'W
05/04/2012	Juliano Mafra	Corumbaíba	WA616728	18°23'S; 48°39'W
07/02/2010	Tiago Junqueira	Itumbiara	WA546620	18°15'S; 48°53'W
30/11/1999	Milton Melo	Itumbiara	WA907270	18°24'S; 49°13'W

49°17'10"W) is located just over 3 km from the T.J. perch (16°40'55"S; 49°16'10"W). After the last E.F.S. sighting of 20 February 2019, only one additional record was made for Goiânia on citizen science platforms (WA3338803). It was assumed that the species would stay in mid-March and April 2019 in Goiânia, before it returns to the Northern Hemisphere.

Between 1999 and 2013 in southern Goiás, there are at least six records of the species between the cities of Itumbiara and Corumbaíba, near the banks of the Paranaíba River, in November, February, March and April (Table 1). Although there is no synthesis of records with better temporal representativeness, it is remarkable that *F. peregrinus* used this southern region of Goiás for prolonged periods during the wintering period.

DISCUSSION

Although some maps show the southern center of Goiás as a wintering area of the species, apparently the result of cartographic artifact due to the delimitation of polygons of occurrence of the species in Brazil, evidence of *F. peregrinus* wintering in the state of Goiás was not known previous to this work. The region has been assumed to be a zone of passage or stopover site for the species (Erize *et al.* 2006, White *et al.* 2019). Our systematic monitoring and the compilation of records from citizen science platforms for the state of Goiás strongly confirm that both the city of Goiânia and the southern portion of Goiás are wintering sites of *F. peregrinus* in central Brazil.

Therefore, the *F. peregrinus* records for Tocantins and Goiás explains the use of the Tocantins-Araguaia River Basin as a migratory route by the species, which apparently has a preference for the areas near and adjacent to the two large rivers of the region (Fig. 2). The migratory movements resulting from the sightings of Dornas & Pinheiro (2011) and the documented records presented in this study in municipality of Oliveira de Fátima coincide with the species returning to the Northern Hemisphere to start the next reproductive period (White *et al.* 2013). This migration route is reinforced by records at Fazenda Fartura, on 02 and 03 February 2014, on the left bank of

the Araguaia River, in the state of Pará (Ariane Gouvea, eBird lists S50980498 and S51300295).

On the other hand, the record presented by Brito *et al.* (2016) in November 2010 in the region of Presidente Kennedy and at the "ipuca" forest fragment in Lagoa da Confusão (Marcelo Barbosa, eBird list S25770349), in November 2015, reveal the use of the region as a stopover site for the species in its migration to the southernmost regions. The use of the Araguaia Valley and Bananal Island region is further reinforced by records of the species in São Félix do Araguaia, Mato Grosso, on the left bank of the Araguaia River, on 30 November 2008 (Bradley Davis, eBird list S14459547).

Other records made in south of Pará state: Marabá, (Silva-e-Silva 1996), Canaã dos Carajás, (WA1523550), Santana do Araguaia (Somenzari *et al.* 2011), Paragominas (Lees *et al.* 2012); and Maranhão state: Sambaíba (Tatiana Pongiluppi, eBird List S41906604), support this trajectory through central Brazil as migratory route of the species, demonstrating arrival at the end of the southern winter towards the south of the continent, with a later return towards the Northern Hemisphere in late Austral Summer. It is assumed that this route via central Brazil, using the Tocantins-Araguaia Basin, has been used by individuals during the wintering period in the Goiás region, especially in Goiânia, as previously presented.

A behavioral characteristic of *F. peregrinus* in its migratory movements is the use of landscape macroelements as references in their flights (White *et al.* 2013). Goodrich & Smith (2008) point out that some species of migratory birds of prey use riverbeds as a guide in their migration. However, in the migration route along central Brazil, in addition to the use of riverbeds, we hypothesized that *F. peregrinus* uses the newly built North-South Railroad (NSR) as a macroelement in the landscape to aid migration. The NSR is a Brazilian longitudinal railroad, expected to be 4155 km long when it is completed and designed to connect the southern and northern ends of the country, as well as the main east-west projected railroads in different regions of the country (Valec 2018). The stretch of tracks already completed and in partial operation consist of almost 1600 km between the region of Anápolis, in Goiás, and Açailândia, in

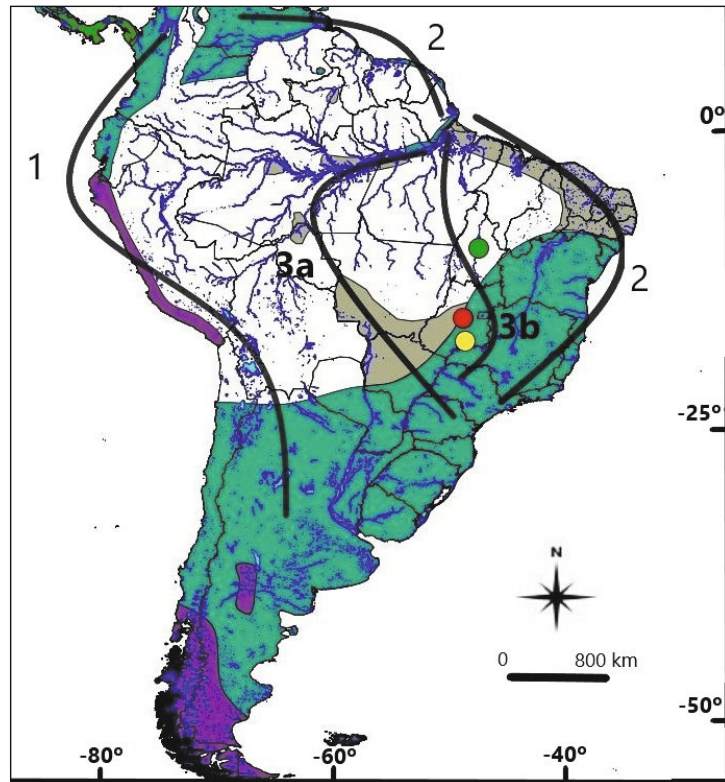


Figure 2. Known wintering areas (green polygon), wintering areas updated (beige polygon – records from the Wikiaves portal, Mestre 2007 and this survey) and the migratory routes of *Falco peregrinus*: 1) Pacific Coast Route; 2) Atlantic Coast Route; and 3) Continental Route, 3a) Amazonia-Pantanal Route and 3b) Central Brazil Route. Locations: Oliveira de Fátima, Tocantins (green circle); Goiania, Goiás (red) and Itumbiara, Goiás (yellow). Purple polygon indicates resident populations.

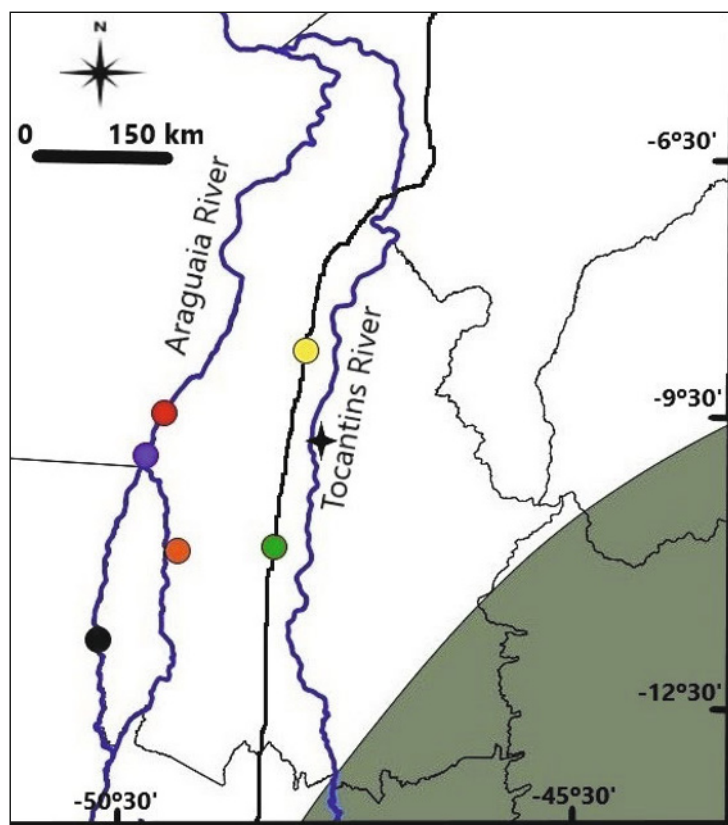


Figure 3. Localities of registration of *Falco peregrinus* in Tocantins state and the west banks of the Araguaia River, in Pará and Mato Grosso states. Green point: Oliveira de Fátima, Tocantins; yellow: Presidente Kennedy, Tocantins; orange: Lagoa da Confusão; red: Parque Estadual do Cantão; blue: Fazenda Fartura, Pará state; black: São Félix do Araguaia, Mato Grosso state. The black star is Palmas city. The black line is NRS railroad route. The green spot shows part of the wintering area recognized by White *et al.* (2019).

Maranhão, crossing the north-center of Goiás, all of the state of Tocantins and part of Maranhão (Valec 2018).

In the rainy season, between November and April, it was found that the railroad edges, especially near streams and rivers, concentrate an abundance of different bird species, including passerines, small doves, parrots and ducks. This accumulation of water marginally to the railroad, attracting the birds in a remarkable way, as observed at a several points in the fieldwork by the authors, was analogous to the ecological role played floodplains and riparian forests along large rivers. At the time of record, 20 minutes before nightfall, the presence of vocally restless passerines (*Turdus leucomelas*, *Salpator maximus* and *Ramphocelus carbo*), parrots and columbids (*Brotogeris chiriri* and *Columbina talpacoti*, respectively) signaled a possible falcon attack before their sleeping perch, however aborted due to our approach and presence.

Similarly, the role played by large rivers as a macroelement of the landscape, where potential prey for *F. peregrinus* concentrate due to the inherent biological characteristics of these environments, can also be attributed to the railroad. The NSR is an almost linear north-south line, similar to the routes used by the species during its migratory movements through central Brazil. Thus, *F. peregrinus* would have a projected landscape view of a large longitudinal section, at least 1600 km, and 100 m wide on average.

The use of highways as macroelements is also possible. However, we did not search or sample areas of influence of local highways. We assume that the structure of the highways appears to be different, besides they do not have the same linear route as the NRS, the intense and continuous traffic of vehicles could prevent a systemic use of the marginal roadside by Peregrine Falcon. Moreover, we suggest that the earthworks system applied to the NRS railroad is different than the highways, providing in the railroad a greater retention of water from streams, forming frequent and extensive flooding along the route, implying greater abundance and availability of prey in the railroad than on the highways.

We also believe that the species may be found in the future in the urban limits of Palmas city (Fig. 3). The emergence of large buildings and urban characteristics of large Brazilian megacities, such as Goiânia, São Paulo and Recife, together with large flocks of Feral Pigeons (*Columba livia*) and/or parrots such as *B. chiriri* and *Eupsittulla aurea*, may support our prediction.

However, the confirmation of all these assumptions will depend on more systematic studies and programs to monitor prey along the railway and highways line and in the urban boundaries of Palmas city. The growth in birdwatching can reduce the time needed to receive information about these assumptions, given the massive contribution that citizen science platforms, mostly

supplied by birdwatchers, offered to this synthesis presented.

Therefore, we conclude that these records consolidate the Tocantins-Araguaia River Basin as a migration route of *F. peregrinus*, confirming definitively that the central portion of Brazil is a wintering site of the species. Finally, it is worth mentioning the importance of Brazil in the global maintenance of this emblematic bird of prey, especially regarding the migrant subspecies that are established in South America.

ACKNOWLEDGEMENTS

T.D. thanks by scholarship postdoc PNPd/CAPES granted since April 2019 and W.M. thank *Biota Soluções Ambientais* for logistical support for the fieldwork. E.F.S. thanks Jadir R. Santos (his father) for all his support and encouragement on sightings and documentation. We thanks the English review made for Alexander Lees, Amy Uppgren and Peter Wennerhag. We thanks two reviewers for excellent contributions. The authors appreciate the performance of the Goiaves birdwatching group, based in Goiânia city, for the consistent records of the species in the state of Goiás. The group's proactivity reflects the importance of popular actions in the generation of scientific knowledge. This is also true for eBird and Wikiaves users, whose shared records also represent the application of citizen science.

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Associate Editor: Marcos P. Dantas.