

# EXTRA-MARINE OCCURRENCE OF THE MAGNIFICENT FRIGATEBIRD *FREGATA MAGNIFICENS* IN THE METROPOLITAN REGION OF SÃO PAULO, SOUTHEAST BRAZIL

FABIO SCHUNCK<sup>1</sup>, FÁBIO TOLEDO DAS DORES<sup>2</sup>, NATÁLIA DANTAS PAES<sup>3</sup>, MARCOS ANTÔNIO MELO<sup>4</sup>,  
BIANCA MATINATA<sup>5</sup>, MARCELO BOKERMANN<sup>6</sup> & INGO GRANTS AU<sup>7</sup>

<sup>1</sup>*Comitê Brasileiro de Registros Ornitológicos, Avenida Eugênio Bartolomai, 386, São Paulo, São Paulo, 04785-040, Brazil  
(fabio\_schunck@yahoo.com.br)*

<sup>2</sup>*Centro de Triage de Animais Silvestres, Parque Ecológico do Tietê, São Paulo, São Paulo, Brazil*

<sup>3</sup>*Laboratório de Interações Vertebrados-Plantas, Instituto de Biologia, UNICAMP, Campinas, São Paulo, Brazil*

<sup>4</sup>*Departamento de Conservação da Biodiversidade do município de Guarulhos, Guarulhos, São Paulo, Brazil*

<sup>5</sup>*Seção de Aves, Museu de Zoologia da Universidade de São Paulo, São Paulo, São Paulo, Brazil*

<sup>6</sup>*Reserva Natural do Serviço Social do Comércio Bertioga, Bertioga, São Paulo, Brazil*

<sup>7</sup>*Departamento de Parques Municipais e Gerência de Unidades de Conservação, Secretaria do Meio Ambiente,  
Prefeitura de Santo André, Santo André, São Paulo, Brazil*

Received 17 October 2022, accepted 28 December 2022

## ABSTRACT

SCHUNCK, F., DORES, F.T., PAES, N.D., MELO, M.A., MATINATA, B., BOKERMANN, M. & GRANTS AU, I. 2023. Extra-marine occurrence of the Magnificent Frigatebird *Fregata magnificens* in the Metropolitan Region of São Paulo, Southeast Brazil. *Marine Ornithology* 51: 55–60.

The Magnificent Frigatebird *Fregata magnificens* (MAFR) has the largest area of occurrence of any species in the Fregatidae family, with a large nesting colony in Southeast Brazil. However, studies with birds that occur on the coastal plain and in other areas of the continent are lacking. We organized information obtained in the field, from the literature, and from online ornithological platforms, and we evaluated the occurrence of MAFR on the plateau of the Metropolitan Region of São Paulo (MRSP), the largest urban area in South America. A total of 31 records were obtained dating back to 1960. Twelve of the records are concentrated near large reservoirs. The records indicate homogeneous seasonality over the years and occasional occurrence in a little-known extra-marine domain on the MRSP plateau. This occurrence has been detected in medium- and long-term field studies and by both photographers and bird watchers. Occurrence can be attributed to the proximity of this region to the coast and to the high flight capacity of these birds, in addition to the female and juvenile behavior of flying great distances, although these hypotheses need to be tested with new information.

**Key words:** Atlantic Forest, distribution, ornithological data, sea birds

## INTRODUCTION

The family Fregatidae contains at least five species (perhaps up to 12; see Martins *et al.* 2022) found in subtropical and tropical seas. The species spends long periods at sea, resting on coastal and oceanic islands when possible, especially at night. Frigatebirds are highly aerial and spend long periods aloft, never landing on the water. Although commonly considered to be kleptoparasites, they obtain most of their food by capturing marine vertebrates and invertebrates (Rattenborg *et al.* 2016, Diamond & Schreiber 2020, Winkler *et al.* 2020). Frigatebirds also readily take discards from fishing boats, a factor that may have subsidized the growth of the largest colony in the Southwest Atlantic (Muscat *et al.* 2014).

Magnificent Frigatebird (MAFR) *Fregata magnificens* by far has the most widespread distribution of the four frigatebird species recorded in Brazilian waters (Carlos 2009, Diamond & Schreiber 2020, Pacheco *et al.* 2021). It occurs along the entire coast of the state of São Paulo (Willis & Oniki 2003). The species has a wingspan that can exceed two meters in length, with long and thin wings. It shows great flight ability and moves over great distances, often taking advantage of ascending air currents (thermals) and

reaching altitudes of up to 2800 m (Sick 1997, Weimerskirch *et al.* 2003, Diamond & Schreiber 2020). The largest breeding colony in Brazil is located at Alcatrazes Island, off the north-central coast of São Paulo. The colony holds about 7000 sexually mature individuals and 2500 nests, and its reproductive period extends throughout the entire year but is concentrated between May and October (Muscat *et al.* 2014).

Studies on MAFRs in the state of São Paulo have covered diet (e.g., Rezende 1987), reproduction (e.g., Campos *et al.* 2004), occurrence and relationship with fishing activity (e.g., Barbieri 2010), health aspects (e.g., Saviolli *et al.* 2016), population genetics (e.g., Nuss *et al.* 2016), and behavior (e.g., Macarrão 2008).

MAFR records in extra-marine domains (i.e., outside of the Brazilian coastal region) are scarce in the literature, with one of the first reports being in the mountainous region of Rio de Janeiro (Serra dos Órgãos), 130 km from the coast (Silveira 1991). Here we organize and evaluate data on the unpublished occurrence of MAFR in the Metropolitan Region of São Paulo (MRSP) to discuss possible causes of its occurrence away from the coast, in an area on top of a plateau and next to the largest urban area in South America.

## METHODS

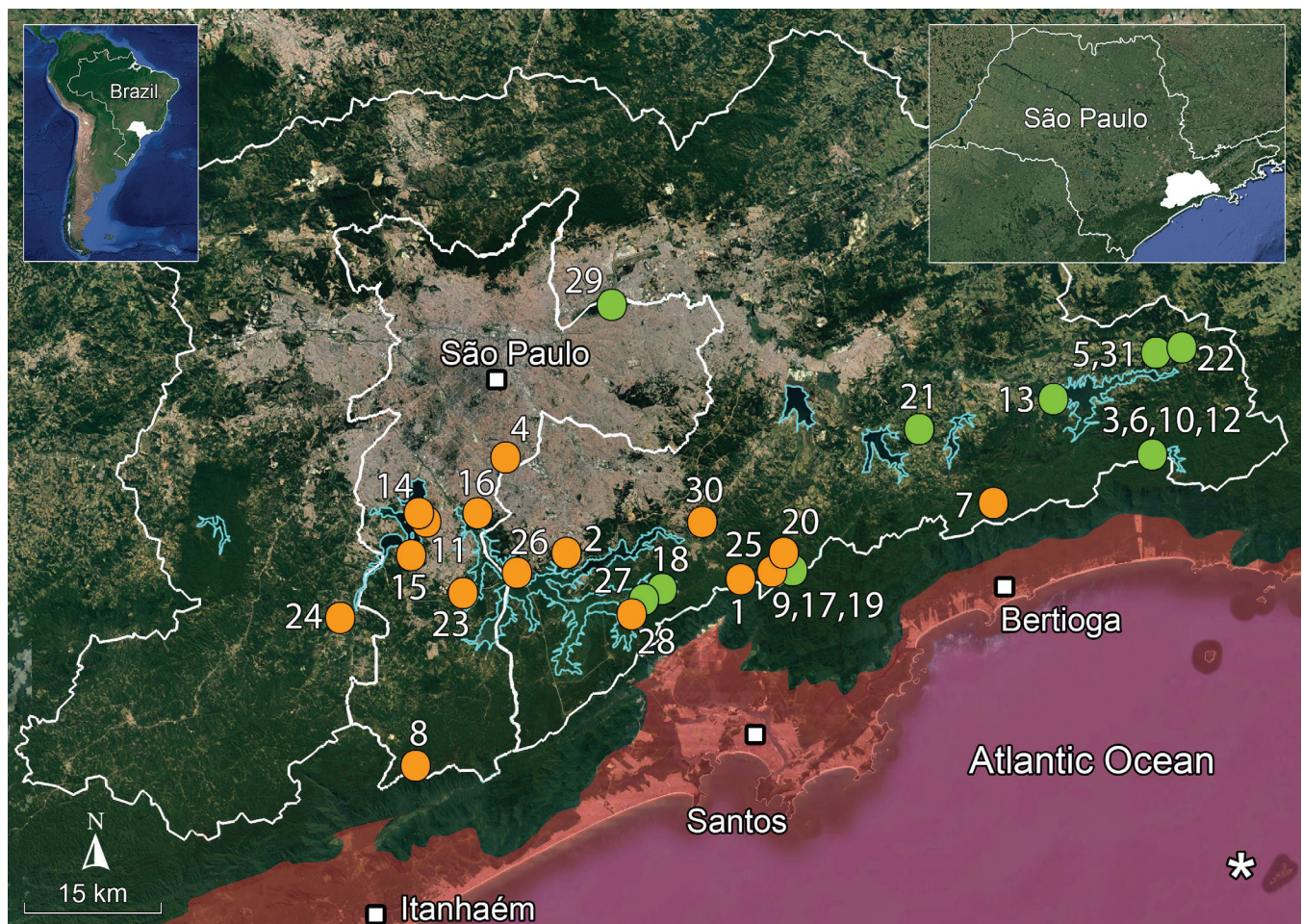
### Study area

This study area covers the MRSP, which encompasses 7944 km<sup>2</sup> in the eastern part of the state of São Paulo, Southeast Brazil (Fig. 1). Covering 39 municipalities and with around 22 million inhabitants, it is the largest urban area in South America (EMPLASA 2022; IBGE 2022). The MRSP has several water reservoirs of various sizes that make up the Alto Tietê watershed system; the Billings, Guarapiranga, Ponte Nova, Paraitinga, Taiaçupeba, Biritiba, Jundiá, Morro Grande, and Ribeirão do Campo reservoirs are the largest and most important in supplying water to the population. The region is part of the Atlantic Forest domain and is surrounded by native forests, forming a green belt part of the Atlantic Forest Biosphere Reserve (Costa 1997). The southeastern and southern limits of the MRSP are located at the top of the Serra do Mar (~700–800m average altitude) and are parallel to the coast, with an average altitude of 800 m relative to sea level; some points of this border are only 9 km from the ocean (straight-line distance, Figs. 1 and 2). The climate is humid subtropical or

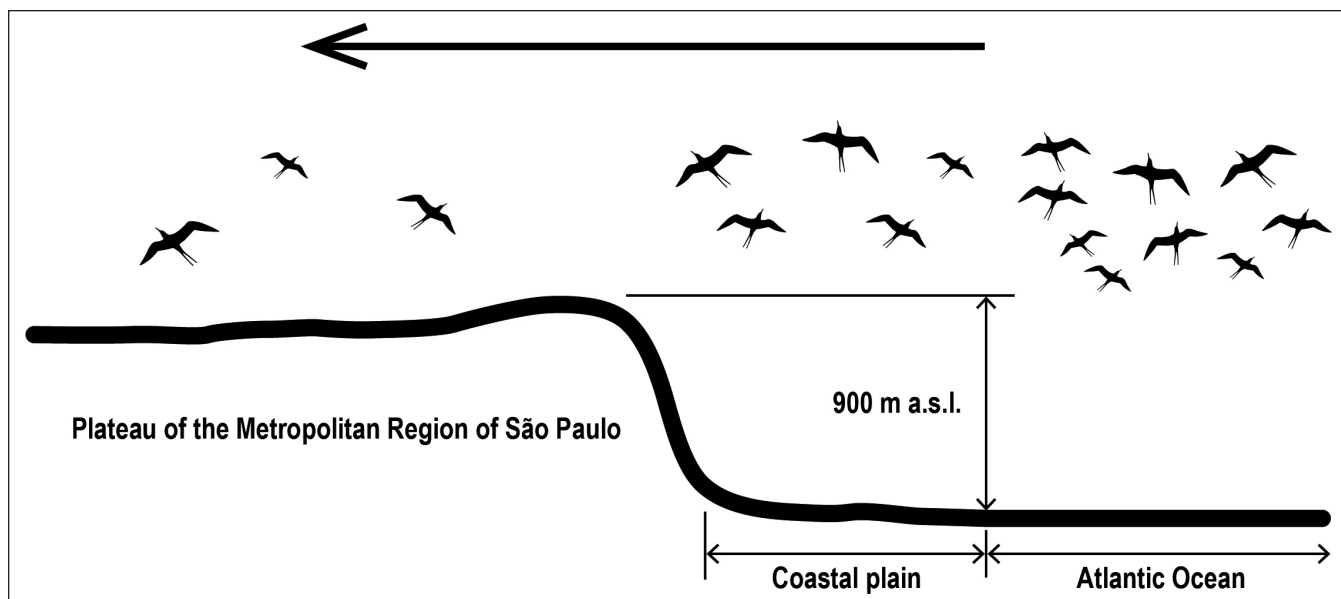
warm temperate, and temperatures vary between 0° C in winter and above 27° C in summer (Alvares *et al.* 2013). The MRSP receives many cold fronts, which are stronger during the austral winter, and sea breezes, due to altitudes above 700 m and proximity to the ocean (Morais *et al.* 2010). This region was pre-selected for study due to the amount of existing data for MRSP and the absence of data for other regions of the state of São Paulo, in addition to the experience of the authors, who carry out their field research in the MRSP.

### Secondary data

Records were gathered from scientific articles, books, and gray literature (i.e., theses, dissertations, and technical reports). Digital databases, such as Web of Science, Scopus, and Google, were searched using combinations of keywords in Portuguese and English: *Fregata magnificens*, fragata/frigate, and tesourão/frigatebird. Ornithological collections were checked through the online platform Global Biodiversity Information Facility (GBIF; <https://www.gbif.org/>). Online platforms, such as WikiAves (WA; <https://www.wikiaves.com.br/>), e-Bird (S/ML; <https://ebird.org/>),



**Fig. 1.** Map of records for Magnificent Frigatebird (MAFR) *Fregata magnificens* in the Metropolitan Region of São Paulo (MRSP) in Brazil. The white area on the map of South America indicates the state of São Paulo, and that on the map of the state of São Paulo indicates the MRSP. The white polygon within the limits of MRSP indicates the municipality of São Paulo. The polygons outlined in green indicate medium and large water reservoirs. The red area on the map represents the coastal plain and oceanic region, which is the typical occurrence area of MAFR on the coast of São Paulo, according to Willis & Oniki (2003). Orange circles denote records without photographic documentation; green circles denote documented records with photographic support. The asterisk in the oceanic region indicates the location of Alcatrazes Island. Satellite images were taken from Landsat/Copernicus 2015.



**Fig. 2.** Altitudinal profile of the Metropolitan Region of São Paulo in Brazil. The arrow indicates the direction of movement of birds from the ocean to the plateau. a.s.l. = above mean sea level

and iNaturalist (<https://www.inaturalist.org/>), were also consulted up to 27 July 2022. Records without georeferences were assigned to the administrative headquarters of the respective municipality.

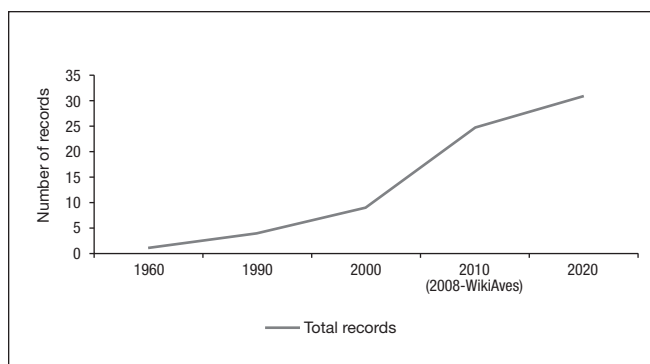
#### Field data

Records were also obtained during ornithological work by the authors in different locations within MRSP over the last three decades. Third-party field data were also considered, when reliable due to observer experience.

## RESULTS AND DISCUSSION

### General patterns

Thirty-one MAFR records were obtained, with 10 documented by photographs. The first record was made in the 1960s, followed by



**Fig. 3.** Cumulative graph showing growth in the frequency of Magnificent Frigatebird *Fregata magnificens* records for the Metropolitan Region of São Paulo in Brazil. The year in which the WikiAves online ornithological platform started activities is included in the time scale.

seven occasional records in the 1990s and 2000s (until 2008); most detections (23) occurred after 2008. Among the 31 records assessed, four were published in scientific articles and technical works, 16 were found on online platforms (11 on e-Bird, four on WikiAves, and one on both), and 11 were field records (nine made by the authors [three of which were posted on both WikiAves and e-Bird] and two made by collaborators; see Fig. 1, Fig. 3, Appendix 1). Another 12 e-Bird records were disregarded, as they came from lists of coastal locations or contained unreliable data.

The 31 records represent 10 municipalities and 25 locations in the MRSP. Twelve of the records are concentrated in the Billings (eight) and Guarapiranga (four) reservoirs, which are the largest in the region. Sixteen records were within a protected area or other environmental protection area (Fig. 1; Appendix 1).

Among the 25 records with a specific date (i.e., including day, month, and year), 10 occurred in winter, eight in summer, four in spring, and three in autumn. Among the 15 records with plumage data (i.e., photographs), nine described females, two described juveniles, one described an adult male and female together, and one described a female and juvenile together; juvenile sex cannot be determined by plumage. Among the 25 records with numbers of individuals, 21 report singles, while the other four records reported two (WA1372118), three, four (WA2496529), and eight individuals. Among the 22 field records containing the period and time of detection, 13 were in the morning (7 between 10h00 and 11h30) and nine were in the afternoon (six between 15h30 and 17h30). Among the 11 field records made by the authors, all were of individuals who flew high and quickly, in typical displacement behavior. No data on feeding, bathing, or resting behavior were obtained (Fig. 1; Appendix 1).

### Specific patterns

Records show that MAFR occur occasionally in the MRSP. While they were first observed in the 1960s by naturalist Rolf Grantsau

(1928–2015), who was surprised to find a seabird flying over the montane forests of Paranapiacaba (Rolf Grantsau pers. comm.), detection frequency increased only from 2008 (53%) onward. The increase likely was a direct result of the popularization of bird watching and photography in Brazil, resulting from the emergence of online ornithological platforms such as WikiAves. The use of the WikiAves platform and others has been previously applied in studies carried out in MRSP (e.g., Dores & Melo 2020). However, part of the data produced by new observers and photographers (12 records) had erroneous information, such as mistaken location (in this case, coastline switched with plateau) and typing errors (often resulting from the preference for the use of popular names), and thus were disregarded. The low number of documentations overall (33%) may be associated with the occasional and unexpected occurrence of the species on the plateau, which is mainly due to its behavior of always moving relatively quickly and at considerable altitude over MRSP. The low number of records available in the literature (13%) and in the field data obtained by the authors confirmed the occasional occurrence of this species in MRSP, since six of the eight records were the only observations made in the monitored locations over several years: Paranapiacaba, Parque Estadual das Fontes do Ipiranga, Guarapiranga and Billings reservoirs, and Parque Ecológico do Tietê (PET). However, Donatelli *et al.* (2011) considered the species to be common in

Parque das Neblinas, which is located in the region of Mogi das Cruzes, and in the upper part of Bertioga, which is atop Serra do Mar (Fig. 1).

The cluster of records to the southeast and south of MRSP, mainly around the Billings and Guarapiranga reservoirs (40%) and the localities located atop Serra do Mar (such as in Paranapiacaba and Boracéia, 33%), indicated a link between the presence of the reservoirs and MAFR proximity to the coast; freshwater reservoirs in this region are relatively close to the coast (Figs. 1, 2). There are also some records of individuals observed flying over the slope of Serra do Mar, between the coast and MRSP (FS pers. obs.; e.g., S31959191, S43602121). The record made at PET drew attention (Fig. 4; Appendix 1), as it is a protected area located in the north of MRSP—this region has no medium or large water reservoirs and contains only artificial lakes and the Tietê river; it is the most distant point of occurrence from the coast (56 km).

Seventy-two percent of the occurrence records of MAFR in MRSP that had season data (25 of 31 records) were in winter (40%) and summer (32%), with the other 28% in spring and autumn combined. MAFR is not a migratory species, and seasonal movements were ruled out. Peak breeding at Alcatrazes Island is in winter, with fewer nests in summer (Campos *et al.* 2004).



**Fig. 4.** Three different images of a young Magnificent Frigatebird *Fregata magnificens* documented in Parque Ecológico do Tietê, São Paulo, Brazil, flying together with an individual Black Vulture *Coragyps atratus*. (Photos: Fábio Toledo das Dores.)

This site is about 50 km away from MRSP, so birds may come from MRSP either during the winter reproduction period (females looking for food) or in the summer (females alone or trailed by juveniles). The larger number of females in MRSP may be related to: (1) females being more common; and/or (2) their higher wing load, which allows them to be less dependent on thermal currents while flying and thus forage in a larger area—an advantage, considering that they are responsible for the continuous parental care of the young (Diamond 1972, Pennycuik 1983, Trivelpiece & Ferraris 1987, Sigrist 2006).

Most records in the MRSP (57%) were in the morning when thermals begin to appear, usually at the hottest times of the day (10h00–12h00; Sick 1997). It may be that some coastal frigatebirds use thermals above 700 m and end up being carried towards the interior of the continent, entering the plateau of MRSP, exploring the region, and returning to the coast (Fig. 2). The PET record clearly shows a frigate flying alongside a Black Vulture *Coragyps atratus* in a thermal current at 11h30 (Fig. 4). As most of the authors' records and available images were documented on days of favorable weather (i.e., without wind and rain), observations were taken in all weather and frigate sightings in MRSP are not related to storms and cold fronts as they are for other coastal species (e.g., Sanderling *Calidris alba*) detected in recent years on the plateau after storms (Schunck *et al.* 2021).

Other occurrences in extra-marine areas have been made available on online platforms by bird observers and photographers in recent years. These areas include Vale do Rio Paraíba do Sul (to the east of MRSP and parallel to Serra do Mar; e.g., S99886432, S62817355) and regions that are even further inland and at higher altitudes, such as the Serra da Mantiqueira mountains in the states of Rio de Janeiro and Minas Gerais (e.g., WA501436, WA2866109). The knowledge that will be produced in the coming years, together with the data already organized in the present study, can be used to test the hypotheses raised for the MRSP and other regions of Brazil in further studies.

#### ACKNOWLEDGEMENTS

We thank Fernando Pacheco, Henrique Van Deursen, and Rolf Grantsau (in memoriam) for providing information; Paulo Rogerio for finalizing the map and Figure 2; Fábio Olmos and an anonymous reviewer for reviewing the final version of the manuscript; and the library team of the Museu de Zoologia da Universidade de São Paulo. We thank reviewers and the editor for their helpful comments which served to improve this paper.

#### REFERENCES

- ALVARES, C.A., STAPE, J.L., SENTELHAS, P.C., DE MORAES GONÇALVES, J.L. & SPAROVEK, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711–728. doi:10.1127/0941-2948/2013/0507
- BARBIERI, E. 2010. Abundância temporal de *Fregata magnificens* (Pelecaniformes: Fregatidae) na Ilha Comprida (São Paulo, Brasil) em 2006 e sua relação com barcos de pesca. *Revista Brasileira de Ornitologia* 18: 164–168.
- CAMPOS, F.P., PALUDO, D., FARIA, P.J. & MARTUSCELLI, P. 2004. Aves insulares marinhas, residentes e migratórias, do litoral do Estado de São Paulo. In: BRANCO, J.O. (Ed.) *Aves Marinhas e Insulares Brasileiras: Bioecologia e Conservação*. Itajaí, Brazil: Editora da Univali.
- CARLOS, C.J. 2009. Seabird diversity in Brazil: A review. *Sea Swallow* 58: 17–46.
- CAVARZERE, V., MORAES, G.P. & SILVEIRA, L.F. 2010. Boracéia Biological Station: an ornithological review. *Papéis Avulsos de Zoologia* 50: 189–201. doi:10.1590/S0031-10492010001300001
- COSTA, J.P.O. 1997. *Avaliação da Reserva da Biosfera da Mata Atlântica: Cinco anos depois de seu reconhecimento pelo programa MaB-UNESCO*. Série Gestão da RBMA, Caderno nº 6. São Paulo, Brazil: Conselho Nacional da Reserva da Biosfera da Mata Atlântica.
- DIAMOND, A.W. 1972. Sexual dimorphism in breeding cycles and unequal sex ratio in Magnificent Frigate-birds. *Ibis* 114: 395–398. doi:10.1111/j.1474-919X.1972.tb00839.x
- DIAMOND, A.W. & SCHREIBER, E.A. 2020. Magnificent Frigatebird (*Fregata magnificens*), version 1.0. In: POOLE, A.F. & GILL, F.B. (Eds.) *Birds of the World*. Ithaca, USA: Cornell Lab of Ornithology. doi:10.2173/bow.magfri.01
- DONATELLI, R.J., FERREIRA, C.D. & COSTA, T.V.V. 2011. Avian communities in woodlots in Parque das Neblinas, Bertioga, São Paulo, Brazil. *Revista Brasileira de Biociências* 9: 187–199.
- DORES, F.T. & MELO, M.A. 2020. Revisão dos registros do cabecinha-castanha, *Pyrrhocomma ruficeps* (Passeriformes: Thraupidae) para a Região Metropolitana de São Paulo, SP, Brasil. *Atualidades Ornitológicas* 216: 8–12.
- EMPLASA (EMPRESA PAULISTA DE PLANEJAMENTO METROPOLITANO). 2022. *Região Metropolitana de São Paulo*. [Accessed at <http://catalogo.governoaberto.sp.gov.br/organization/empresa-paulista-de-planejamento-metropolitano-s-a-emplasa> on 29 July 2022.]
- IBGE (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA). 2022. *Cidades e estados do Brasil*. Rio de Janeiro, Brazil: Government of Brazil. [Accessed at <https://cidades.ibge.gov.br> on 29 July 2022.]
- MACARRÃO, A. 2008. Comportamento de “brincar” em jovens fragatas *Fregata magnificens* (Fregatidae). *Atualidades Ornitológicas* 142: 20.
- MARTINS, F.M.S., GODINHO, R. & PALMA, L. 2022. Cores, edges and beyond: insights into the phylogeography of frigatebirds with a focus on ultraperipheral and endemic populations. *Conservation Genetics* 23: 1011–1025. doi:10.1007/s10592-022-01466-2
- MORAIS, M.A., CASTRO, W.A.C. & TUNDISI, J.G. 2010. Climatologia de frentes frias sobre a Região Metropolitana de São Paulo (RMSP), e sua influência na limnologia dos reservatórios de abastecimento de água. *Revista Brasileira de Meteorologia* 25: 205–217. doi:10.1590/S0102-77862010000200005
- MUSCAT, E., SAVIOLLI, J.Y., COSTA, A. ET AL. 2014. Birds of the Alcatrazes archipelago and surrounding waters, São Paulo, southeastern Brazil. *Check List* 10: 729–739. doi:10.15560/10.4.729
- NUSS, A., CARLOS, C.J., MORENO, I.B. & FAGUNDES, N.J.R. 2016. Population genetic structure of the Magnificent Frigatebird *Fregata magnificens* (Aves, Suliformes) breeding colonies in the western Atlantic Ocean. *PLoS One* 11: e0149834. doi:10.1371/journal.pone.0149834
- PACHECO, J.F., SILVEIRA, L.F., ALEIXO, A. ET AL. 2021. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee—second edition. *Ornithology Research* 29: 94–105. doi:10.1007/s43388-021-00058-x

- PENNYCUICK, C.J. 1983. Thermal soaring compared in three dissimilar tropical bird species, *Fregata magnificens*, *Pelecanus occidentalis* and *Coragyps atratus*. *Journal of Experimental Biology* 102: 307–325. doi:10.1242/jeb.102.1.307
- RATTENBORG, N.C., VOIRIN, B., CRUZ, S.M. ET AL. 2016. Evidence that birds sleep in mid-flight. *Nature Communications* 7: 12468. doi.org/10.1038/ncomms12468
- REZENDE, M.A. 1987. Comportamento associativo de *Fregata magnificens* (Fregatidae, Aves) e *Sula leucogaster* (Sulidae, Aves) no litoral centro-norte do Estado de São Paulo. *Boletim do Instituto Oceanográfico* 35: 1–5. doi:10.1590/S0373-55241987000100002
- SANTO ANDRÉ. 2008. *Atlas do Parque Natural Municipal Nascentes de Paranapiacaba: Revelando o nosso parque. 2a Edição*. Santo André, Brazil: Prefeitura do Município de Santo André.
- SAVIOLLI, J.Y., CUNHA, M.P.V., GUERRA, M.F.L., IRINO, K., CATÃO-DIAS, J.L. & CARVALHO, V.M. 2016. Free-ranging frigates (*Fregata magnificens*) of the southeast coast of Brazil harbor extraintestinal pathogenic *Escherichia coli* resistant to antimicrobials. *PLoS One* 11: e0148624. doi:10.1371/journal.pone.0148624
- SCHUNCK, F., NUCITELLI, C. & MIX, P. 2021. A importância das praias fluviais urbanas para as aves da cidade de São Paulo, sudeste do Brasil. *Atualidades Ornitológicas* 217: 33–58.
- SCHUNCK, F., SILVEIRA, L.F. & NASCIMENTO, V.S. 2019. 118 years of ornithological knowledge of a forgotten region of the Atlantic Forest near the largest city in South America. *The Wilson Journal of Ornithology* 131: 758–773. doi:10.1676/1559-4491-131.4.758
- SICK, H. 1997. *Ornitologia Brasileira*. Rio de Janeiro, Brazil: Nova Fronteira.
- SIGRIST, T. 2006. *Aves do Brasil: Uma Visão Artística. 2a Edição*. São Paulo, Brazil: Avisbrasilis.
- SILVEIRA, E.K.P. 1991. Troncos evolutivos em aves. *Papéis Avulsos de Zoologia* 1: 1–4.
- TRIVELPIECE, W.Z. & FERRARIS, J.D. 1987. Notes on the behavioural ecology of the Magnificent Frigatebird *Fregata magnificens*. *Ibis* 129: 168–174. doi:10.1111/j.1474-919X.1987.tb03198.x
- WEIMERSKIRCH, H., CHASTEL, O., BARBRAUD, C. & TOSTAIN, O. 2003. Flight performance: frigatebirds ride high on thermals. *Nature* 421: 333–334. doi:10.1038/421333a
- WILLIS, E.O. & ONIKI, Y. 2003. *Aves do Estado de São Paulo*. Rio Claro, Brazil: Ed. Divisa.
- WINKLER, D.W., BILLERMAN, S.M. & LOVETTE, I.J. 2020. Frigatebirds (*Fregatidae*), version 1.0. In: BILLERMAN, S.M., KEENEY, B.K.; RODEWALD, P.G. & SCHULENBERG, T.S. (Eds.) *Birds of the World*. Ithaca, USA: Cornell Lab of Ornithology. doi:10.2173/bow.fregat1.01