Original Article

RESEARCH INTO BRAZILIAN THRUSHES: BIBLIOGRAPHIES, SPECIES AND NEXT STEPS

PESQUISAS COM SABIÁS NO BRASIL: BIBLIOGRAFIAS, ESPÉCIES E PRÓXIMOS PASSOS

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ABSTRACT: Synthesis studies are essential for detecting subjects that have not yet been fully explored. Therefore, a scientiometric study was conducted in order to evaluate the state of knowledge about the Turdidae bird family in Brazil. Searches were performed using the software Publish or Perish©. We found 23 papers from the period January 1990 to August 2012 directly involving the bioecological study of thrushes. Some studies were carried out on more than one species, giving a further 31 papers in which taxa of the Turdidae family were included. Using the dominance index, *Turdus albicollis*, *T. amaurochalinus*, *T. leucomelas* and *T. rufiventris* were considered eudominants. There was a greater frequency of studies based on *T. leucomelas* ($\chi^2_{c.\ (11.07)} = 15.55$, df = 5, $P < 0.05$). *Turdus subalaris* and *Catharus ustulatus* have also been studied and found to be subdominant. It was possible to define seven categories as areas of knowledge. From the spatial distribution of the localities (biomes) sampled by studies involving thrushes it was inferred that the most studied species are those having a greater distribution in Brazil. Finally, species naturally more restricted to northern Brazil have been less studied, mainly because most studies involving thrushes have been performed in southern and southeastern Brazil, mainly in the Atlantic Forest and Cerrado biomes.

KEYWORDS: *Catharus. Cichlopsis.* Neotropical birds. Turdidae. *Turdus.*

INTRODUCTION

The group Turdidae Rafinesque 1815 (Aves: Passeriformes) encompasses approximately 300 species distributed in approximately twenty-four genera (CLEMENT, 2000; COLLAR, 2005). This family occurs in Africa, most of the Atlantic islands, the Caribbean, Americas and Eurasia, including Japan and the Philippines (COLLAR, 2005). It is believed that the group arrived in the Neotropics through the Nearctic biogeographical region, and has its evolutionary origins in the "old world". Some fossils from California (USA) were dated as being 20 million years old (SICK, 1997), while fossils of recent species, such as *Turdus merula* and *Turdus iliacos*, have been found in areas where there were broadleaved and conifer forests in Kozarskat (Bulgary), with a Pleistocene age of between 11 and 1.8 million years (BOEV, 2001).

There are 17 species of the Turdidae family in Brazil (CBRO, 2011) or 18 taken into consideration when a new species recently described (O'NEILL et al., 2011). These species are distributed across three genera: *Cichlopsis* (one specie), *Catharus* (n = 3) and *Turdus* (n = 14). *Cichlopsis leucogenys* forms a monotypic genus (CLEMENT, 2000) restricted to the Brazil, while the three species of the genus *Catharus* are seasonal visitors from the Northern Hemisphere (REMSEN, 2001).

In general, this is an excellent group to use in ecological studies, in particular because of its occurrence and abundance in urban as much as in natural environments. The family also includes species that are very susceptible to changes in the environment (*e.g. Cichlopsis leucogenys*), as well as some that are more resistant to such alterations, for example, *Turdus rufiventris* (VOGEL et al., 2012). Some species of this family have widely known biological aspects, *e.g. Turdus merula*. A study undertaken in Spain on this species tested the effect of habitat features on the recruitment of juveniles (FERNÁNDEZ-JURICIC; TELLERÍA, 1999). Another study, on sexual selection processes, was carried out in France (FAIVRE et al., 2001). Studies developed in New Zealand evaluated the effect of feather pigmentation on the reproductive success of the species (BRIGHT; WASS, 2002). Another well-studied species is *Turdus migratorius*, which, due to its migratory behaviour, is often the object of virology (KILPATRICK et al., 2009) and zoonosis studies (MEDLOCK; JAMESON, 2010).

For most Turdidae species occurring in Brazil, part of the available information is found in

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textbooks (see SICK, 1997; CLEMENT, 2000; RIDGELY; TUDOR, 2001; COLLAR, 2005; SIGRIST, 2006). However, these mostly comprise general information about the species, and further natural history studies focusing on diet, areas used for reproduction, migration routes, sexual selection and nest predation, among others, are still fundamental to knowledge about the group. Evidence shows that this family is little studied in Brazil, an intriguing fact given its wide distribution (RIDGELY; TUDOR, 2001).

In the Neotropical region, Mares (1986) identified that the disproportionate production of scientific research involving ornithological studies between American countries was a result of the low number of specialized human resources. However, at present, there is an increase in research involving birds, especially in postgraduate programmes (BORGES, 2008). It is unknown if the study of birds in general comprises all groups to the same extent or has the same amplitude of geographic influence. Therefore, it can be stated that synthesis studies on the state of knowledge of zoological groups are fundamental to identifying gaps in knowledge. Hence, the aim of this study was to quantify studies undertaken in Brazil on the family Turdidae, identifying: a) which species are most and which are less often studied; b) which are the main areas of knowledge covered in these studies; and c) the gaps in spatial distribution of study the sites.

METHODS

Description of biomes from where data originate

We considered studies regarding thrushes in the six great Brazilian biomes. The Brazilian Amazon Forest (4.196,943 km²) covers nearly 40% of all the national territory, with about 20% legally preserved areas (RANTA et al., 1998). The Cerrado (2.036,448 km²) is the second largest ecological domain of Brazil, in which a continuous herbaceous stratum is connected to an arboreal stratum. The Cerrado covers a surface area of approximately 25% of Brazilian territory (DINIZ-FILHO et al., 2009). The Caatinga (884.453 km²) extends over the areas of some of the states of northeastern Brazilian and is characterized by xerophytic vegetation typical of a semi-arid climate (OLIVEIRA et al., 2012).

The Atlantic Forest (1.110,182 km²) extends over nearly the whole Brazilian coastline, and is one of the most endangered ecosystems of the world, with less than 10% of the original vegetation remaining (RANTA et al., 1998). The Pantanal (150.355 km²) is a geologically low land area filled with sediments that have settled in the Paraguay River basin. The flora in the Pantanal biome is formed of species from both the Cerrado and the Amazon Forest (RANTA et al., 1998; DINIZ-FILHO et al., 2009). Finally, the Pampa biome (176.496 km²) covers the southern half of the Brazilian State of Rio Grande do Sul, occupying about 63% of its territory. Ecologically, the Pampa is a biome characterized by vegetation composed of grasses, low plants, some scarce trees, and bushes near watercourses (ROESCH et al., 2009).

Data collection

The software Publish or Perish© (HARZING, 2007) was used for the bibliographic research. This search tool uses the database of Google Scholar, crossing-checking information with many indexing search bases, such as the Directory of Open Access Journals (DOAJ), Thomson-Reuters (SCOPUS), Scientific Electronic Library Online (SciELO) and the Institute for Scientific Information (ISI). The use of this software was essential as many articles were indexed in local journals and were not accessible through the large indexing databases. The temporal window for this search was 22 years (from January 1990 to August 2012). The search was made based on the general citation option, using as keywords the scientific name of each species occurring in Brazil, including older names.

Articles to be analysed were selected based on the following criteria: a) that they were only studies made wholly in Brazil; b) the research involved at least one species of wild Turdidae that naturally occur in continental biomes of the Brazilian territory; c) they were only specific studies, excluding species lists, inventories, community structure, frugivory and dispersion studies that did not focus exclusively on Turdidae; and d) they only articles published in journals with an ISSN (International Standard Serial Number).

Data analysis

We used the dominance index ($D\%$ = (i/t) x 100) proposed by Palissa et al. (1977), considering each work as an independent sample, where i = total number of times a species was considered in a study and t = total citation of species, and with nomenclatural proposals for the dominant category where: eudominant is $D \geq 10\%$; dominant, D = 5–10%; subdominant, D = 2–5%; recessive, D = 1–2%; and rare, D = < 1%. This index is directly related with chance in species selection. The proportions of the frequencies obtained from the dominance index of the species studied in relation to the total number of studies were tested using a Chi-

squared (χ^2) test, with a null hypothesis of equal proportions and significance level of $\alpha = 0.05$.

After the selection of bibliographic material, the papers were categorized according to subfields contained in the large area named Biological Sciences, as proposed by the Joint Academic Coding System (JACS, 2012), with each paper inserted into the sub-field as specifically as possible, according to the author's focus. The geographical distribution of sample points took into account the number of points (sites) sampled in the biome, and was subsequently used to calculate the density (a measure of correction depending on the area of each biome in km²).

RESULTS

Only six (33%) of the 18 species that occur in Brazilian biomes were the object of some kind of specific study. Twenty-three papers were found that directly related to the family Turdidae (Table 1). As many studies involved more than one species, the Turdidae species were in fact cited a total of 31 times. The frequency with which these species were used showed *T. leucomelas* to be dominant (n = 12; D = 38.70%; χ^2 $c._{(11,07)}$ = 15,55, gl = 5, P < 0,05), followed by *T. rufiventris* (n = 7; D = 22.58%), *T. amaurochalinus* and *T. albicollis* (n = 6; D = 19.35%); these species were eudominant. *Turdus subalaris* and *C. ustulatus* were each only described in one study (D = 3.22% for each) and were considered to be subdominant.

It was possible to define seven categories regarding the areas of scientific discipline covered by the papers. Behavioural Biology was the most represented (n = 9; 39.13%), followed by Parasitology (n = 5; 21.73%), mode details in Table 1. Considering the geographic distribution of the studies, 14 papers (60.86%) were exclusive to the Atlantic Forest biome and six (26.08%) to the Cerrado. The other biomes (Pampa, Caatinga, Pantanal and Amazon Forest) represented 13.06% of the studies (Table 1). The greatest density of sampled localities per biome was observed to be the Atlantic Forest biome (n = 20 localities; 1.80 x 10^{-5} localities/km²), followed by the Pampa biome (n = 2; 1.13 x 10^{-5}), the Pantanal (n = 1; 6.65 x 10^{-6}), Cerrado (n = 8; 4.41 x 10^{-6}), Caatinga (n = 3; 3.39 x 10^{-6}) and Amazon Forest (n = 1; 2.38 x 10^{-7}).

Table 1. List of studies involving species of the family Turdidae, in chronological order, carried out in Brazil. **Codes and the disciplines of Biological Sciences**, according to JACS (2012), were classified: Genetics not elsewhere (C111); Parasitology (C120); Behavioural Biology (C170); Population Biology (C181); Biodiversity (C191); Biometry (C300); Zoology (C450); Genomics; and Genetics(C490). **Species** (ascending degree of dominance): 1 = *Catharus ustulatus*; 2 = *Turdus subalaris*; 3 = *Turdus albicollis*; 4 = *Turdus amaurochalinus*; 5 = *Turdus rufiventris*; and 6 = *Turdus leucomelas*. **Biomes**: Ca = Caatinga; Ce = Cerrado; Am = Amazon Forest; Af = Atlantic Forest; Pa = Pampa; and Pt = Pantanal.

References	Discipline	Species	Biomes
Gianonni et al. (1990)	Genetics (4.35%)	3, 4, 5 and 6	Ce
Bencke and Grillo (1995)	Population Biology (4.35%)	6	Pa
Guerrero and Figueiredo (1997)	Biodiversity (17.40%)	5	Ce
Ferreira and Bagno (2000)	Behavioural Biology (39.13%)	2	Ce
Silva et al. (2000)	Behavioural Biology	5	Ca, Ce, Af, Pa and Pt
Tomazi and Figueiredo (2002)	Biodiversity	4	Af
Ritter et al. (2003)	Biometry (8.7%)	3	Af
Hernandes and Valim (2005)	Parasitology (21.73%)	6	Af
Rodrigues (2005)	Behavioural Biology	6	Ce
Storni et al. (2005)	Parasitology	3	Af
Bochkov et al. (2007)	Parasitology	6	Ce
Alves et al. (2008)	Biodiversity	3 and 4	Af
Gonçalves-Júnior et al. (2008)	Zoology (4.35%)	5	Af
Enout et al. (2009)	Parasitology	6	Af
Gasperim and Pizo (2009)	Biodiversity	3, 4, 5 and 6	Pa
Leite et al. (2010)	Behavioural Biology	5	Af

Kaminski (2011)	Behavioural Biology	1	Af
Lobato et al. (2011)	Parasitology	6	Af
Sazima and D'Angelo (2011)	Behavioural Biology	6	Am
Silva et al. (2011)	Biometry	3	Af
Vogel et al. (2011)	Behavioural Biology	5 and 6	Af
Almeida and Câmara (2012)	Behavioural Biology	6	Af
Santos and Vaz-Silva (2012)	Behavioural Biology	6	Ce

DISCUSSION

We observed that *Turdus leucomelas* and *Turdus rufiventris* were involved in the greatest number of studies. This result can be justified by the broad distribution of these species in Brazil (RIDGELY; TUDOR, 2001; SIGRIST, 2006). Data from south Brazil indicate that these species are among the three most abundant thrushes in the region (GASPERIN; PIZO, 2009; VOGEL et al., 2012). The evidences therefore shows that the choice of species for scientific studies can be a function of the abundance of the species in the environment, in such a way that, at random, the most abundant species are also those most subject to scientific study. A large proportion of Brazilian Turdidae that were not well represented in the studies are naturally distributed in the north and northeast, in the Caatinga, Cerrado and Amazon Forest biomes (COLLAR, 2005; SIGRIST, 2006).

A complementary explanation serving to elucidate the preference for the most studied species (*T. albicollis*, *T. amaurochalinus*, *T. leucomelas*, *T. rufiventris*, *T. subalaris* and *C. ustulatus*) in ornithological studies could be their spatial distribution, as most of the cited species are more restricted to the south, southeast and mid-west of Brazil, where the Atlantic Forest, Cerrado and Pampa biomes are found (CLEMENT, 2000; RIDGELY; TUDOR, 2001). Most studies involving this group were developed in these regions (Figure 1).

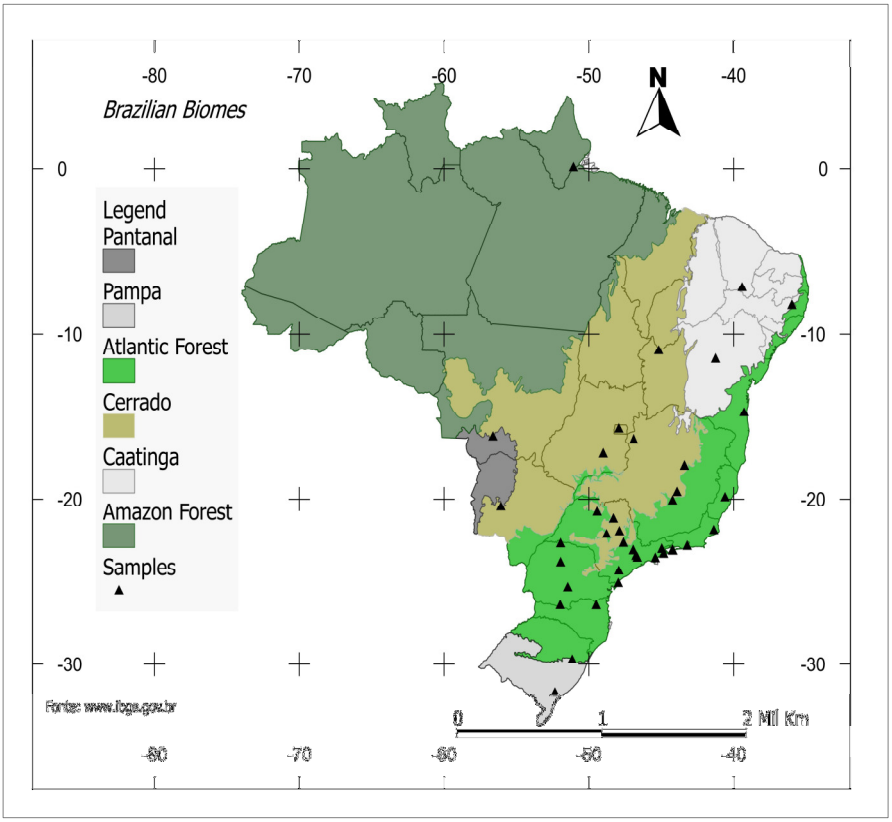

Figure 1. Brazilian biomes and political boundaries of the States, indicating the specific regions where the studies were developed or where information about Turdidae was collected (note the increased density of sites in the Atlantic Forest and Cerrado when compared to other biomes).

The largest number of studies on thrushes is therefore concentrated in the Atlantic Forest and Cerrado biome, and the low number of studies in the Amazon Forest is associated with the highest concentration of Brazilian human populations being near the coast and the low population density and low number of universities and research centres in the Amazon region (see MARTINE; CAMARGO, 1998). This trend of ornithological studies being concentrated on the Atlantic Forest and Cerrado is also well evidenced by Borges (2008): in general, the largest post-graduate programmes in Brazil are mostly hosted in these regions, leading to the greater number of ornithological studies. This same author also determined there to be a trend in diversity studies on birds in southeastern Brazil.

Considering the scientific disciplines within which each study was developed, parasitology studies have a requirement for a minimum number of individuals for statistical analysis, as much as they do for the capture of specimens. As a result, the high capturability of thrushes species (PIRATELLI; PEREIRA, 2002; EFE et al., 2007) could stimulate parasitological studies that would not be possible with groups of birds of lower rates of capture. In the same sense, studies involving frugivory (categorized in this work as Biodiversity) receive special attention due to the ability of the turdid species to act as dispersal agents of native and exotic flora (SCHEIBLER; MELO-JUNIOR, 2003; GASPERIN; PIZO, 2009).

Studies within other areas, such as Population Biology, Biometry and Genetics, demonstrate a different tendency in relation to current studies in other countries. Recently, works developed abroad (outside Brazil) entail the trade-off mechanisms of *Turdus merula* (KROVETZ, 2000), habitat use during the reproductive period of *Turdus assimilis* (COHEN; LINDELL, 2004) and the decline of *Turdus torquatus* in the face of the substitution of natural landscapes by agriculture (BURFIELD; BROOKE, 2005), together with even more up-to-date studies involve egg predation, environment effects and reproductive success (KURUCZ et al., 2010; ROBINSON et al., 2010) in more experimental approaches.

In this sense, the next steps or goals in the area of thrush research is to highlight the lack and necessity of studies on biological aspects of thrushes occurring in the Amazon Forest biome. Recently, O'Neill et al. (2011), who described *Turdus sanchezorum* based on individuals of Peruvian origin, have pointed out that there still exist many gaps in knowledge of the basic biology of turdid species. A key need is to deepen knowledge to some degree of the biology of endangered or sensitive species, as some turdid species can suffer from the effects of habitat fragmentation (BURFIELD; BROOKE, 2005; COLLAR, 2005); among these can be highlighted *Cichlopsis leucogenys*, which is endemic and locally endangered (OLMOS, 2005) and *Turdus fumigatus*, which strongly depends on the integrity of the habitat (SICK, 1997). However, this fact does not seem to have led to the development of studies focused on the conservation of these species, as we did not find any papers directly involving these taxa.

Some other studies developed in Brazil involving the family Turdidae have also utilized data from other countries of the Neotropical region. Among these, we can cite Remsen (2001), who evaluated the importance of wintering areas for *Catharus fuscescens* in South America, and Capllonch et al. (2008), who studied the occurrence pattern of *T. amaurochalinus* in Argentina. These works did not meet our criteria and were not included in the analysis. However, they are papers of great importance understanding the biology of the species concerned.

The synthesis of data allowed us to observe which are the species of the Turdidae family for which there is less information available in Brazil (*Cichlopsis leucogenys*, *Turdus fumigatus*, *T. hauxwelli*, *T. ignobilis*, *T. lawrencii*, *T. leucops*, *T. nudigenis* and *T. olivater*). The analysis allowed us to see that little is known about the two species of thrushes that are the most threatened (*C. leucogenys* and *T. fumigatus*). These species are more susceptible to local processes of extinction, providing evidence of the need for understanding how such organisms respond to processes of habitat modification. This study also showed that the next steps for scientific studies on the Turdidae family should be to focus strongly on the Amazonian turdid species, an urgent requirement given the scarcity of information on these species.

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Aquicultura (NUPELIA) provided logistical support.

RESUMO: Trabalhos de síntese são fundamentais para a detecção de campos ainda pouco explorados na ciência. Neste sentido, foi efetuado um estudo cienciométrico avaliando o estado de conhecimento da família de aves Turdidae no Brasil. Foram efetuadas buscas de trabalhos desenvolvidos no Brasil sobre sabiás, para tais buscas foi utilizado o *Software Publish or Perish*© no recorte temporal de janeiro de 1990 até agosto de 2012. Foram encontrados 23 artigos envolvendo diretamente o estudo bioecológico de sabiás. Alguns destes, efetuados abordando mais de uma espécie, totalizando 31 vezes em que os táxons da família foram contemplados. Através do índice de dominância, *Turdus albicollis*, *T. amaurochalinus*, *T. leucomelas*, e *T. rufiventris* foram consideradas eudominantes. Houve maior frequência de estudo de *T. leucomelas* ($\chi^2_{c.\,(11,07)} = 15{,}55$, gl = 5, $P < 0{,}05$). *Turdus subalaris* e *Catharus ustulatus* também foram contempladas e consideradas subdominantes. Foi possível definir sete categorias considerando as áreas de conhecimento. É possível inferir através da espacialização dos locais (biomas) amostrados pelos estudos envolvendo turdídeos, que as espécies mais estudadas são também as que possuem maior distribuição no Brasil. Finalmente, espécies com distribuição restrita ao norte brasileiro foram pouco estudadas, devido principalmente, ao fato que a maioria dos estudos envolvendo turdídeos estão concentrados na região Sul e Sudeste do Brasil, desenvolvidos principalmente nos biomas Mata Atlântica e Cerrado.

PALAVRAS-CHAVE: *Catharus. Cichlopsis.* Aves neotropicais. Turdidae. *Turdus*.

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Appendix - List of birds of the Turdidae family with occurrence records in Brazil, or without records but mentioned in the text. **Brazil:** *Catharus fuscescens* (Stephens, 1817), *Catharus minimus* (Lafresnaye, 1848), *Catharus swainsoni* (Tschudi, 1845), *Turdus albicollis* Vieillot, 1818, *Turdus flavipes* Vieillot, 1818, *Turdus leucomelas* Vieillot, 1818, *Turdus rufiventris* Vieillot, 1818, *Turdus fumigatus* Lichtenstein, 1823, *Turdus nudigenis* Lafresnaye, 1848, *Turdus olivater* (Lafresnaye, 1848), *Turdus amaurochalinus* Cabanis, 1850, *Turdus ignobilis* Sclater, 1858, *Turdus hauxwelli* Lawrence, 1869, *Turdus leucops* (Taczanowski, 1877), *Turdus lawrencii* Coues, 1880*, Turdus subalaris* (Seebohm, 1887), *Cichlopsis leucogenys* Cabanis, 1851 and *Turdus sanchezorum* O'Neill, Lane & Naka, 2011. **Cited in the text:** *Turdus merula* (Linnaeus, 1758), *Turdus migratorius*, Linnaeus, 1758 and *Turdus iliacos* Linnaeus, 1766.