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RESEARCH ARTICLE

Seasonal altitudinal movements of birds in Brazil: a review

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ABSTRACT. Birds' seasonal altitudinal movements in Brazil are poorly understood. The main source of information and has fostered interest since the 1980s. However, most of the available information is anecdotal, sources are repeatedly cited, and the information provided is quite superficial and speculative. Through bibliographic searches, we found 107 studies, 83 (77%) of which we consider valid, and only 63 (59%) were peer-reviewed. Most studies were carried out in southern and southeastern Brazil. Only 11 studies explicitly addressed seasonal altitudinal movements. Surprisingly, none of the studies simultaneously comprised a full year of study, standardized sampling methods, and encompassed the entire altitudinal range through which the birds might have moved. As a consequence, the quality of the data is questionable, and the expression "altitudinal migration" is unlikely to be accurate and has never been unequivocally demonstrated for birds in Brazil. Mention of "altitudinal migration" was found for 68 bird species, but these must be more clearly defined and appropriately tested.

KEY WORDS. Altitudinal migration, altitudinal movement, conservation.

INTRODUCTION

Altitudinal migration occurs in mountainous regions around the world, where birds and other animals move up or down slopes as they follow the seasonal variations in weather, food abundance, and other factors (Johnston-Stewart 1988, Hayes 1995, Faaborg et al. 2010, Boyle 2017, Hsiung et al. 2018). This migration can be total, when the entire population moves, or partial, involving only a fraction of the individuals (Boyle 2011). There are also local, seasonal, movement patterns that are not migration *per se*, but that in mountainous regions can also be altitudinal movements simply due to the nature of the topography (Winkler et al. 2016). While altitudinal migration is known to occur, it is far from being well-studied in most places. In Brazil, the concept of altitudinal migration in birds has been used for many years by many authors. The earliest record in the 1800s, was based on observations of toucans whose altitudinal movements were described in response to changing fruit availability (Descourtilz 1854). Subsequently, Goeldi (1894) described this behavior as a kind of migration, in which birds seasonally moved from the higher elevations in the mountains of the Serra dos Órgãos (Rio de Janeiro state) to the coastal lowlands, and back. Santos (1940) and Berla (1944) affirmed that these movements from highlands to lowlands were a strategy to avoid colder regions (highlands) during the winter. Davis (1945) described the movements of 11 species from highlands to lowlands, also within the Serra dos Órgãos.

Reports continued to comment on these movements until altitudinal migration per se was more thoroughly examined in publications by the ornithologist Helmut Sick (1910–1991). Sick published studies on birds in the mountainous regions of southern and southeastern Brazil (Sick 1968, 1979, 1983, 1985, 1997) in which he described altitudinal migration in 17 species (mostly in Trochilidae, Psittacidae, Tyrannidae, and Cotingidae). To date, these studies remain the most important references on this topic in Brazil. These publications, together with some studies by a handful of authors at the same time (including Willis 1979, Gonzaga 1983, Scherer Neto and Müller 1984, Belton 1985), supported Santos's (1940) and Berla's (1944) view that altitudinal migration occurred in the mountains of southern Brazil as a response to colder weather during the austral winter, where birds descended the mountains in search of food and warmer weather.

The term "altitudinal migration" was increasingly mentioned in the literature from the 1990s, arising from studies in mountainous southeastern Brazil, especially in the states of Rio de Janeiro, São Paulo, and Paraná (e.g., Gonzaga et al. 1995, Straube and Scherer Neto 1995, Aleixo and Galetti 1997), but also including some from other mountainous states with Atlantic Forest (e.g., Bencke and Kindel 1999, Willis and Oniki 2002, Vasconcelos 2003, Nascimento et al. 2005), and elsewhere. Evidence for altitudinal migration is also found in the Amazon, at the borders between the Amazon and the Guyana highlands in the state of Roraima, and in other high plateaus and isolated mountains, as at Carajás, in the state of Pará. The handful of studies is evidence of the limited knowledge of potential altitudinal migration in Brazil and illustrates the absence of good information on the subject (Silva 1993, 2000). Even with an increasing number of references over time, most studies only cited information presented by Sick (1985, 1997). Although many authors have recommended increased research (e.g., Silva 1992 Paccagnella et al. 1994, Aleixo and Galetti 1997, Silva et al. 2002, Vasconcelos 2003, Carrara and Faria 2012, Somenzari et al. 2018), few studies have taken up the call to produce data-driven studies of altitudinal migration in mountainous regions in Brazil (e.g., Silva 1993, Galetti 2001, Guaraldo et al. 2022, this last study cites partial altitudinal migration in Brazil).

In Brazil, studies that attempted to examine altitudinal migration often calculated the proportion of species that migrated in any given region, without following standardized methods (e.g., Willis 1988, Pedrocchi et al. 2002). Information about altitudinal movements from a variety of sources has been summarized, but not tested (e.g., Collar et al. 1992, Kirwan and Green 2012, Somenzari et al. 2018). Additionally, some compilations on migration, that include altitudinal migration as a subject, commented on species previously mentioned in the literature (e.g., Alves 2007, Barçante et al. 2017, Somenzari et al. 2018, Jahn et al. 2020). However, information about migration in Brazil is often anecdotal, coming from traditional communities and their observations while hunting, usually from coastal and southeastern regions of the country (e.g., Santos 1940, Sick 1968, 1985,1997, Willis 1988, Albuquerque and Brüggemann 1996).

While information about altitudinal migration of Brazilian birds has been circulating since at least 1854, this information has never been brought together, organized, and technically evaluated, thereby limiting our understanding of this behavior. Thus, here we review publications that include altitudinal migration in Brazil and summarize the relevant information therein. We summarize the methods used to study migration, along with the species, and geographic regions of Brazil in which altitudinal migration occurs, and make recommendations for how to improve this field of research.

MATERIAL AND METHODS

Information on altitudinal migration was taken from scientific journals, books, book chapters, theses, dissertations, monographs, technical publications, websites, summaries from meetings, and complete studies published in scientific meetings. We used the Web of Science, Scopus, and Google (through May 2022), with the following keywords (alone and in combination) in both Portuguese and English: birds, altitude (and its derivations), elevation, slope, movement, migration, local, and regional. When published studies summarized others without doing the primary research (e.g., Alves 2007, Maciel 2009, Barçante et al. 2017, Jahn et al. 2020), we only cite the information of the species from the original study. We did not use references where the information was ambiguous or imprecise (e.g., Roth et al. 1984, Forrester 1993 apud Willis and Oniki 2002, Pizo et al. 1995). Some publications contained similar or repeated information, and therefore it was treated as a single source (e.g., Sick 1985, 1997). Sequential publications of the same study were treated as individual publications, but without repeating the same count data (e.g., Sick 1968, 1983, Gouvêa et al. 1996, Aleixo 1997, Aleixo and Galetti 1997, Gouvêa 2006). We excluded literature reviews that did not include the data from the original study, but merely gave credit in the references (e.g., Juniper and Parr 1998, Isler and Isler 1999, Billerman et al. 2021).

Data compilation

Our search criteria were limited to references that reported altitudinal movements (including migration), and they were organized into two groups: 1) valid references, i.e.; studies carried out in the context of differences in relief (mountain ranges, slopes, valleys, and their variations); 2) non-valid references, i.e.; studies carried out elsewhere, that is, without large differences in relief, or those generically described, and in which it would be difficult to demonstrate altitudinal migration.

References

The references obtained were evaluated based on five criteria: 1) data (source, type, technical area, taxonomic level); 2) inclusiveness and geographic relief potential (regions, biomes, geological formations and their altitudinal ranges); 3) technical breadth (six categories of the technical profile); 4) technical terminology; 5) species, and field data collection (methods, standardization, seasonal-temporal breadth, altitudinal range, season, justification, movement direction). These criteria are explained more fully in Supplementary material – Table S1.

Species and maps

Taxonomy follows the Brazilian Committee of Ornithological Records (Pacheco et al. 2021). Endemism follows Silva (1995) and Vale et al. (2018). Endangered status follows IUCN (2022) and Brazilian (MMA 2022) red lists. Maps were generated using QGis 2.14, with the cartographic base from the Brazilian Institute of Geography and Statistics (https://www.ibge.gov.br), and elevation from Global Climate Data with 30" resolution (WorldClim 2015, https://www.worldclim.org). When sources reported ambiguous location information, we assumed the geographic center of the municipality as the location. The Kinglet Calyptura *Calyptura cristata* (Vieillot, 1818) and Gray-winged Cotinga *Lipaugus conditus* (Snow, 1980) were attributed to the location Serra dos Órgãos (Kirwan and Green 2012).

RESULTS

Database

A total of 107 references were found to meet our criteria, including valid and non-valid sources. Of those, 77 were field data surveys and 30 were data complications. Fifty-nine were peer-reviewed publications, 18 books, nine master's theses, seven summaries from scientific meetings, six book chapters, three web articles, two doctoral dissertations, one undergraduate monograph, one technical publication, and one complete presentation from a scientific meeting. Of the field studies, 46 included bird communities, 14 of smaller groups (e.g., families), and 17 of individual species. Compilations included 13 references of communities, 14 of smaller groups, such as families or migratory species, and three of individual species. These studies spanned a total of 168 years (1854 to 2022), with a greater number of studies after 1980 (Fig. 1, Supplementary material – Tables S2 and S5).

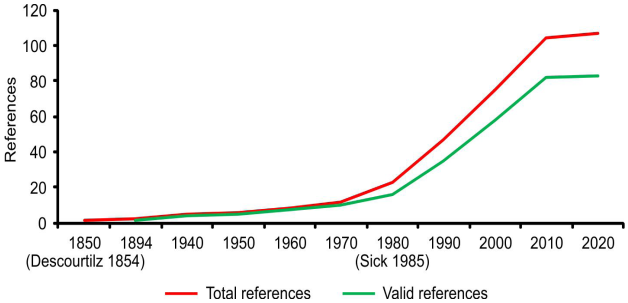

Figure 1. Cumulative curve of number of publications citing some form of altitudinal movement in Brazilian birds since 1854.

Scope and geographic potential

Sources with one or more defined locations (n = 94) included 13 states, most in the southeast (79), followed by the south (21), northeast (4), north (2), and west central (2) of Brazil. Biomes included the Atlantic Forest (98), Cerrado (9), Caatinga (3), and the Amazon (2). Mountains included Serra do Mar (56), Serra da Mantiqueira (12), Serra do Espinhaço (6), Serra Geral (5), and the Serra Capixaba (5). Among the 107 references obtained, 83 were considered valid (regions with well-defined geological formations such as mountains) including 66 field studies and 17 compilations, with 45 scientific articles. The other 24 sources considered non-valid (regions without altitudinal potential) included 11 field studies, and 13 compilations with 14 articles (Fig. 2, Supplementary material – Tables S2 and S5, Fig. S1).

Technical breadth

Twenty-five studies mentioned seasonal altitudinal movements (SAM) only superficially (e.g., Berla 1944). Another 31 technical studies were superficial in their comments on SAM (e.g., Davis 1945). Nine studies specifically addressed SAM data (e.g., Gonzaga 1983). Eleven technical studies were specifically designed to study SAM (e.g., Galetti 2001). Another 12 studies were compilations of other studies of SAM (e.g., Sick 1985, 1997, Kirwan and Green 2012). Finally, 19 studies were compilations of other studies that only superficially addressed SAM (e.g., Santos 1940, Supplementary material – Tables S2 and S5).

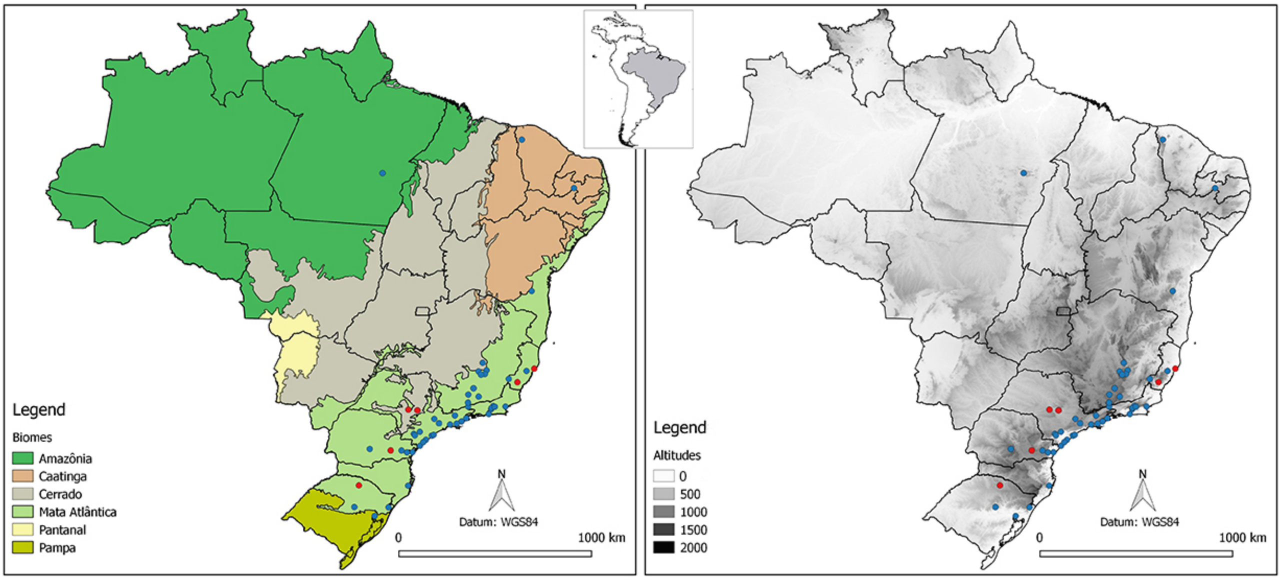

Figure 2. Map showing where studies found in the literature search were carried out, including all references to seasonal altitudinal movement of birds in Brazil. On the right, topography, and on the left plant formations or biomes. Blue circles are studies carried out where altitudinal movements could possibly be studied, while red circles are those studies that were unable to test, but nonetheless claim, altitudinal movements.

Terminology

References included a total of 312 citations referring to altitudinal migration using 16 distinct terminologies, which made it confusing due to language and translation issues. Aside from the correct altitudinal migration (or altitudinal migrant) which was cited 104 times (33% – including the citation of partial altitudinal migration by Guaraldo et al. 2022). Other terms were found as follows: altitudinal movement or displacement (each, 35, 11%), vertical migration (10), descending vertical migration (8), altitudinal wanderer (3), lowland winter migrant (2), inverted altitudinal migration (1), altitudinal displacement (35), vertical displacement (5), vertical movement (2), ascending vertical movement (2), descending vertical movement (3), altitudinal displacement movement (1), altitudinal migration movement (2), elevational movement (1) and others (98, e.g.; from low to high or vice versa). Some studies were variable in the terms they used (e.g., Sick 1985, 1997, Willis and Oniki 2003, Areta and Bodrati 2010, Kirwan and Green 2012). The synonyms of these terms allow us to essentially reduce them to migration (127) and all other types of movement (86, Supplementary material – Table S3).

Species

The 107 sources mentioned some kind of seasonal altitudinal movement in 113 species in 10 orders and 24 families. Families most often mentioned were Thraupidae (23 references), Tyrannidae (21), Trochilidae (19), Psittacidae and Cotingidae (8 each), Tityridae (5), Turdidae (4), and Fringillidae (4). This includes 28 species from typically frugivorous families (e.g., Cotingidae). Endemic species are reported, with one from the Cerrado and 42 from the Atlantic Forest (Silva 1995, Vale et al. 2018). Thirteen species are threatened, with 11 globally (4 EN, 6 VU, 1 CR – IUCN 2022), and 10 nationally (4 EN, 5 VU, 1 CR – MMA 2022). Of these 113 species, 100 were based on field studies, and 48 were based on compilations (often from multiple sources, and some from both compilations and field studies), as follows (number of species-source): 19-Bauer (1999), 17-Sick (1985, 1997), 12-Willis and Oniki (2003), 11-Davis (1945), 10-Kirwan and Green (2012), 9-Sigrist (2007), 8-Bencke and Kindel (1999), and 8-Ruschi and Simon (2012). The species most often mentioned are (number of references) the Yellow-legged Thrush *Turdus flavipes* Vieillot, 1818 (25), Shrike-like Cotinga *Laniisoma elegans* (Thunberg, 1823) (10), Swallow-tailed Cotinga *Phibalura flavirostris* Vieillot, 1816 (9), Bare-throated Bellbird *Procnias nudicollis* (Vieillot, 1817) (9), Shear-tailed Gray Tyrant *Muscipipra vetula* (Lichtenstein, 1823) (9), Blue-bellied Parrot *Triclaria malachitacea* (Spix, 1824) (8), Black-and-gold Cotinga *Lipaugus ater* (Ferrusac, 1829) (7) and Sharpbill *Oxyruncus cristatus* Swainson, 1821

(7; Appendix 1, Supplementary material – Table S3).

Studies considered valid (83 – from mountainous regions) comprised 96 species distributed in nine orders and 23 families, of which 68 (83%) were published in peer-reviewed articles. The most cited species come from Trochilidae (13), Thraupidae (12), Tyrannidae (10), Cotingidae (7), Psittacidae (5), Tityridae (3), and Turdidae (3). These families include 28 (34%) endemic species (one from the Cerrado, 27 from the Atlantic Forest, Silva 1995, Vale et al. 2018), 11 (13%) endangered species (nine globally, 4-EN, 5-VU, IUCN 2022; eight in Brazil, 4-EN, 4-VU, MMA 2022), and 18 frugivores (22%). The most often cited species are the *T. flavipes* (9), *T. malachitacea* (5), *M. vetula* (5), Green-crowned Plovercrest *Stephanoxis lalandi* (Vieillot, 1818), *P. flavirostris* (4), *L. elegans* (4), Black Jacobin *Florisuga fusca* (Vieillot, 1817), Hooded Berryeater *Carpornis cucullata* (Swainson, 1821), *P. nudicollis*, Black-legged Dacnis *Dacnis nigripes* Pelzeln, 1856 and Diademed Tanager *Stephanophorus diadematus* (Temminck, 1823) (all with three citations each, Appendix 1, Supplementary material – Table S3).

Data collection from field studies

The methods of the 77 field studies were divided into 67 direct observation studies (of which 23 used the method exclusively), 23 that used mist-nets (two exclusively), 11 using transects, and nine using point counts (one exclusively). Also, the field studies that cited literature included seven based on museum specimens, 7 with collections in the field, two using Mackinnon lists, and one butterfly net. Many studies used more than one method (Supplementary material – Table S1). Data collection was standardized in 23 studies, and was not standardized in 40. Seventeen studies were carried out for a full year, divided into four "seasons"; one study over a year was divided into wet and dry seasons, and other four studies were carried out throughout the year, but seasonality was not mentioned. Twelve studies were carried out for more than a year, with the year divided into four seasons, and 10 lasted less than a year, with sampling during a single season. Another 21 studies were conducted over several years, with sporadic or repeated visits during similar months each year. Altitudinal gradients of these studies were also variable, with 14 complete (including the gradient over which the species moved), and 40 incomplete. As for the season of the year attributed to the record, we have Winter (112 – 92 of which are exclusive to this period); Fall (28 – two of which are exclusive); Spring (7 – one being exclusive); Summer (19 – two exclusive). Justification (hypothesis) for SAM was stated as food availability (22 studies, 17 of which only stated this reason), of which seven stated that birds were dependent upon the fruiting seasonality (phenology) of the palm *Euterpe edulis* Martius, 1824. Climate was mentioned in 10 (of which six claimed climate was the only cause) and one study stated habitat, suggesting that the proximity of mountains and plains influenced movements. The direction of SAM was from high to low (39 studies) or vice versa (9). Another 23 did not state direction. Another five sources mention the absence of SAM based on field data, with two suggesting the altitudinal migration hypothesis (Supplementary material – Table S3).

DISCUSSION

Essentially, all altitudinal movements reported for Brazilian birds were supported by little or no scientific evidence, and they varied from anecdotal to having incomplete evidence when studies were carried out. Many species were reported repeatedly, in more than one source, mostly as a consequence of the propagation of information by citing previous studies that also cited previous studies. Thus, the nature of, and species associated with, altitudinal movements in Brazil, remain largely uncertain. Associated with this uncertainty is the varied terminology and methodology used.

Data set

The total number of references obtained (107) reveals a broad yet poorly known scenario about the sources having been produced since 1854 (due to the absence of extensive data compilations), that mention possible seasonal altitudinal movements of birds in Brazil. This finding is somewhat similar to that of Sick (1968, 1979, 1983), who gathered information on migratory birds in South America and Brazil, and Boyle (2017), who organized studies on altitudinal migrations of birds in North America. The data obtained over the years has only been partially, and seldom, mentioned (e.g., Sick 1985, 1997, Alves 2007, Barçante et al. 2017). Lack of knowledge of the existing literature meant that few references (e.g., Sick 1985, 1997, Collar et al. 1992) and because most sources are unavailable in digital format, including little-known and non-periodical scientific journals (mainly because they are secondary information randomly contained in most of the existing studies). Only 59% of the references were published in peer-reviewed scientific articles, which indicates that much of the existing literature was not properly evaluated and made available to the scientific community, to the detriment of development of this subject area of ornithology. A broad and continuous historical-scientific rescue of information is needed, and which focuses on regional, older, and restricted literature, including publications from the 19th century. This activity is fundamental to guiding and supporting future studies related to the altitudinal migrations of birds in Brazil.

Field studies comprised the majority of the publications (73%), and they tended to focus on communities, followed by families or species. Also, compilations were common (27% of the publications), which suggests that there is scientific interest in this topic. These compilations were either regionally focused (e.g., Belton 1985), or on restricted groups (e.g., Snow 1982) and migratory birds (e.g., Somenzari et al. 2018, Jahn et al. 2020). A world wide compilation on "altitudinal migration" cited less than 5% of the studies available for Brazil (Barçante et al. 2017), highlighting the recommendation made by Alves (2007), on the importance of organizing and maintaining an updated database on the knowledge produced in the country.

The growing number of references on seasonal altitudinal movements of birds, beginning in the 1980s, is likely to be due to 1) the influence of Sick's (1985) book, in which 17 species were described as having seasonal altitudinal movements, and 2) the maturation of the ornithology in Brazil, with many new researchers beginning to publish their studies from fieldwork (Figueiredo 2007). The importance of Sick's book (1985) in popularizing Brazilian ornithology cannot be overstated, as shown by the number of times it has been cited and by the growth in the number of studies on altitudinal migration based on the list of species that he provided as performing seasonal, altitudinal movements.

Scope and geographic potential

The large number of references citing the southeastern (79) and southern (20) regions of the country can be attributed to two basic reasons: 1) geological altitudinal potential and 2) natural areas near large urban centers (Fig. 2, Supplementary material – Fig. S1D,E). The first is because the south and southeast include the Serra do Mar, Serra da Mantiqueira, Serra do Espinhaço and Serra Geral, all extensive geological formations with altitudinal gradients ranging from zero to 2891 m a.s.l. and thus offer a great potential for birds to migrate altitudinally. Second, these mountainous regions are relatively close to some of Brazil's largest cities (e.g., São Paulo, Rio de Janeiro, Belo Horizonte, Curitiba, Porto Alegre), which together include many scientific institutions and ornithologists. Here, there are roads that offer easy access to study areas, including some that cross mountain ranges, in addition to many conservation units and the largest remnants of Atlantic Forest (Ribeiro et al. 2009). We propose three reasons for the few studies in the central-western, northeastern, eastern and northern regions: 1) a lack of large mountain ranges; 2) fewer ornithological studies carried out in mountainous areas; and 3) fewer research institutions and ornithologists (Fig. 2, Supplementary material – Fig. S1A,B,C).

The central-western region has different geological formations with research potential (e.g., Chapadas), but so far with few basic ornithological studies (e.g., Pivatto et al. 2006, Lopes et al. 2009). Geological formations in the northeastern region (with significant altitudinal differences) are also available, but what stands out is the existence of many references that mention seasonal and regional movements (but not altitude) of birds, mainly between the dry and rainy seasons (e.g., Sick 1985, 1997, Pereira and Azevedo Júnior 2013, Marcondes et al. 2014). The main reason for the lack of research on altitudinal bird migration in the northern region of the country, which includes the western part of Amazonia with Pico da Neblina, the highest mountain in Brazil, is almost certainly due to geographic isolation (and its consequences, such as limited access and the lack of infrastructure in the few reserves).

We highlight an important issue: that the potential is great for studies on seasonal altitudinal movements of birds throughout Brazil. The Atlantic Forest domain is the best studied to date, due to the concentration of studies in the southern and southeastern regions of the country, followed by the Cerrado, where altitudinal movements have been studied in a few places in the Serra do Espinhaço (e.g., Vasconcelos and Lombardi 1999, Vasconcelos 2000, Carrara and Faria 2012). The Cerrado, Caatinga, and Amazon remain the least studied, making them priorities for future research.

We have two possible explanations for references that found some type of seasonal altitudinal displacement for regions that do not have high relief and, thus, are not considered valid: 1) justification to explain the seasonal absence of some species that perform regional movements, such as hummingbirds in the state of São Paulo (e.g., Willis 1979, Magalhães 1999), with poorly-known movement patterns in much of Brazil (Sick 1985, 1997) and 2) citation of a species as an "altitudinal migrant" only because it was considered as thus in the literature (mainly in Sick's book) (e.g., Bauer 1999), and so may not be based on standardized data collection.

Fifty-six studies retrieved treated seasonal altitudinal movements superficially. Some were rapid assessments, not designed to address the question, and the authors are likely to have based their assessment solely on the literature. Another 31 studies were conducted over the course of a year but did not address this question. Thus, in many cases, addressing altitudinal movements was not the objective of the study, even though the authors commented about the importance and necessity of addressing the question (e.g., Paccagnella et al. 1994, Aleixo and Galetti 1997, Silva 2000, Silva et al. 2002, Vasconcelos 2003). Only 20 field studies discussed seasonal altitudinal movements in Brazil, and these also tended to superficially address the question, usually in the discussion or in figures. Twelve of them (14%) were specifically focused on altitudinal movements, and only five were published in peer-reviewed journals or chapters, and these only comprise 6% of the field studies (Silva 1993, Galetti 2001, Pedrocchi et al. 2002, Hasui et al. 2012 Guaraldo et al. 2022). The remainder are in unpublished master theses and doctoral dissertations (e.g., Oliveira 2012, Barçante 2013, Lopes 2014, Reis et al. 2017, Silva et al. 2017).

Variability is common in seasonal altitudinal movement terminology and reflects confusion as to what is being studied, and the superficiality with which it has been treated in Brazil. Variable terminology seems to be associated with the lack of clear hypotheses being tested, along with the appropriate study design to test those hypotheses. Also, the terminology suggests that terms were used in other references and repeated without critical evaluation. For example, the term "altitudinal migration" was used often (103), without considering the basic technical definitions of the term "migration" (population displacement between regions during a specific period of the year) and basic data to support the claim was not presented. Migration is the seasonal movement of organisms from the breeding ground to other areas during the non-breeding season, and subsequent return (Alerstam and Hedenström 1998). The use of the term "altitudinal migration" without appropriate scientific methods seems to have begun with Mitchell (1957), after which it was continued by Sick (1968, 1983, 1985, 1997), from which it received attention and began to be applied to many species. As the main hypothesis, altitudinal migration was often poorly supported by often incomplete data, and its interpretation was not well-founded. Nonetheless, the citation of these incomplete data has continued to the present (e.g., Stotz et al. 1996, Alves 2007, Barçante et al. 2017, Jahn et al. 2020, Guaraldo et al. 2022). This highlights the fundamentally importance of using correct definitions is for understanding this subject, especially when a variety of movement types have fallen under the same rubric. Furthermore, altitudinal migration is one of among four kinds of migration described for the Neotropical region and so should be appropriately used in any study that purports to examine it (Faaborg et al. 2010).

Terminology that is used has consequences for understanding the process. For example, both Barçante et al. (2017) and Boyle (2017) used the "altitudinal migration" among other keywords in their literature review and retrieved only three (Silva 1993, Alves 2007, Areta and Bodrati 2008) or two references (Bencke and Kindel 1999, Galetti 2001) from Brazil. These five references are fewer than 5% of the studies we found in our wider search, which examined altitudinal migration in various literature sources.

The use of variable terminology is not exclusive to Brazil, but is widespread (Barçante et al. 2017), and some confusion may arise due to the different languages involved. Three terms often used in the literature are "displacement", which is seldom used in English (more often with respect to dominance behavior), but is often used in Portuguese (deslocamento) and Spanish (desplazamiento), "movement", and "migration". The first two terms are essentially synonyms and are more variable in their meanings than migration. If the movement is seasonal and is to and from specific locations, then the appropriate term is "migration". Adjectives that modify those terms are also possible, and so movement or migration can be partial or differential and suggests that not all individuals of the species move the same distance, as has been found in a variety of species and places (e.g., Berthold 2001, Boyle 2011). Another adjective, "facultative", is usually associated with movement, not migration, and refers to situations in which a bird may move at any time simply to avoid occasional extreme weather (Hahn et al. 2004).

The adjective "altitudinal" is clear and precise, but in the literature is occasionally substituted with the term "vertical", which is less precise and should be avoided. Similarly, "upwards" and "downwards" (and synonyms) are also used, but the direction can only be stated with reference to where breeding occurs. Regardless, the terminology used should be clear and correctly applied and only claimed if study design allowed determination of the kind of movement. Similarly, if a reference speculates on (rather than clearly demonstrates) the kind of movement patterns they observe, that speculation should also be clear in the study that cites the reference.

A total of 113 species have been attributed with exhibiting seasonal altitudinal movement in Brazil, with 96 species in regions with the appropriate altitudinal description, and that have significant altitudinal differences (e.g., mountains). In a single field study, Davis (1945) mentions more species

(11) than any other field study to date. More species are only mentioned in studies that compiled information from others (e.g., Sick 1985, 1997, Willis and Oniki 2003). Species with putative altitudinal movements comprise 28 frugivores (e.g., Cotingas, Sick 1985, 1997), with inclusion of some species perhaps due to extrapolation from studies that were carried out in the Andes (e.g., Loiselle and Blake 1991). Additionally, species belonging to Tinamidae, Accipitridae, Picidae, Dendrocolaptidae, and Rhynchocyclidae (uncommon in studies of altitudinal migration) are also sometimes mentioned (Barçante et al. 2017).

Endemics also seem to comprise a large number of species (43) that move altitudinally, along with 13 threatened species, and so altitudinal movements may have important conservation implications. Conservation issues are especially important because some of these species are targeted by hunters or by the illegal pet trade in Brazil (e.g., Sick 1985, 1997, Willis and Oniki 2003), or will be subject to current and future climate change.

Turdus flavipes is included in most references as an altitudinal migrant, yet without sufficient evidence. Studies that examined its altitudinal migration (e.g., Castro et al. 2012, Guaraldo et al. 2022) had inconclusive results or different results from the literature, indicating a partial altitudinal migration. Guaraldo et al. (2022) considered two locations at different latitudes of the Serra do Mar and two altitudinal ranges that contemplated the extremes of the altitudinal gradient, with an absence of data in the central part, in addition to the reduced number of samples in the lower part of the gradient, totaling less of one year of sampling. Even with a small sample size, this is the most complete study carried out on the movement of this species in the Atlantic Forest.

Many other widespread South American species are mentioned as being altitudinal migrants, such as the Bearded Bellbird *Procnias averano* (Hermann, 1783) (Kirwan and Green 2012), but have not been described as such in the literature in Brazil. Nonetheless, the literature must be read with caution to clearly evaluate the evidence for the claims. For widespread species, we cannot attribute altitudinal migration to Brazilian birds based on studies done elsewhere, because the phenomenon might be closely linked to the geographic region and the same species may migrate in one place and not another. Apparently, this wrong attribution of widespread species may have occurred in the study by Barçante et al. (2017), which used another nomenclature than Brazilian Committee of Ornithological Records and thus included species with unconfirmed occurrences in Brazil according to Pacheco et al. (2021).

The field studies we reviewed used well-known methods in the study of birds, with the exception of the butterfly net. Mist nets, used for mark-recapture for migration studies (e.g., Gonzaga 1983, Sick 1983, Alves 2007), remain among the most important (Hsiung et al. 2018). Despite the broad use of mark-recapture methods, only Gouvêa et al. (1996), Gouvêa (2006), Barçante (2013), and Souza (2014) used this method in their studies of seasonal altitudinal movements, and their data have not been made available to the public in the format of a peer-reviewed scientific article. Telemetry (both radio and GPS) is absent from seasonal altitudinal movement studies in Brazil, yet offers the most promise and has been used elsewhere – e.g.; Three-wattled Bellbird *Procnias tricarunculatus* (Verreaux & Verreaux, 1853) in Costa Rica, Young and McDonald 2000 –. Similarly, geolocators have not been used even though they were recommended long ago in Brazil (e.g., Aleixo and Galetti 1997), perhaps as a consequence of the logistical difficulties and costs of the equipment.

Standardization of data collection and the performance of seasonal sampling did not meet minimum recommended standards in most of the studies in this review. Standardized sampling should include at least one 12-month temporal-seasonal cycle to address cyclic biological phenomena such as migration or seasonal displacements (Bibby 2004). The failure to meet these criteria precludes adequate and unbiased interpretation of field data.

The amplitude of altitudinal gradients was also not ideal, with few complete gradients (i.e., across the entire altitudinal geographical range), making it difficult to properly interpret the results. At least two different situations exist in this regard: 1) mountainous regions, in which area decreases with altitude (typical mountains); and 2) mountainous regions without area reduction (i.e., with high elevation plateaus). In the first case, a single study area located at the top of the mountain is inadequate, since any type of seasonal displacement performed by the birds will necessarily be downslope, due to the lack of other options (e.g., Inouye et al. 2000, Morrissey et al. 2004). The reverse movement is difficult to interpret, as the birds can go either towards the top or towards other regions of the lower part, and thus requires more than one study area. In the second case, we have the classic example of Serra do Mar, which is an Atlantic slope located in eastern Brazil, between the lower coastal plain and the higher plateau, a geological formation that does not necessarily present an integral reduction in the area with altitude (Almeida and Carneiro 1998).

The disappearance or variation in the abundance of a particular species at the top or bottom of the slope, in isolation, does not necessarily indicate that these birds moved altitudinally and necessarily between these regions, as many authors claim based on just one area/sampling altitude (e.g., Sick 1997, Lima 2012). Hence the importance of performing simultaneous temporal samplings in the regions where the birds are expected to have moved to. There are at least two other plausible displacement options for the Atlantic Coast: 1) latitudinal displacement at the same altitude, as recorded with the *P. tricarunculatus* in Costa Rica (Young and McDonald 2000), which is plausible because the Serra do Mar extends over a wide range in latitude; and 2) longitudinal-altitudinal displacement, which would be carried out in an east-to-west direction, between the Serra do Mar and inland regions, a type of movement sometimes mentioned to explain both the seasonal appearance of some species in the interior of the state of São Paulo (e.g., Willis 1979, Magalhães 1999) and in Argentina (Areta and Bodrati 2010). These displacements can also happen in the opposite direction, west-to-east, as considered for Brazil by Serpa et al. (2014) for the Black-backed Grosbeak *Pheucticus aureoventris* (d'Orbigny & Lafresnaye, 1837), Dull-colored Grassquit *Asemospiza obscura* (d'Orbigny & Lafresnaye, 1837), and Subtropical Doradito *Pseudocolopteryx acutipennis* (Sclater & Salvin, 1873). However, longitudinal-altitudinal displacements include more than one rugged geological formation (i.e., wide altitudinal range). Given that a typical seasonal altitudinal displacement is defined by several authors, such as Hayes (1995), as occurring between the higher and lower parts of a well-defined region makes an assessment of each case necessary.

In Brazil (mainly in the southern and southeastern mountain regions), the timing of the direction and season of movements tends to follow the pattern of presence at higher elevations in summer (breeding period) and presence at lower elevations (non-breeding period) in winter, apparently correlated with the evident change in climatic conditions and availability of food resources. Inclement weather and frosts, rarely snow, all generate extreme conditions making conditions less hospitable for many species (noted by Sick 1985, 1997, Albuquerque and Brüggemann 1996, Pedrocchi et al. 2002 – without hypothesis testing), similar to the scenario described in the Andes (O'Neill and Parker 1978). However, these hypotheses are based exclusively on data from the southern and southeastern regions of the country, from studies with methodological limitations and anecdotal data, and so requiring new, standardized, approaches to test their validity. For some species, this kind of movement may be facultative, in that the birds apparently flee the arrival of the inclement weather, but only temporarily and not for the entire season (Hahn et al. 2004). In addition to the most cited patterns, we also find references to movements carried out in the opposite direction (from lower to higher elevations) in Spring-Summer, described as "movements of wandering birds" or "reproductive movements", since only some individuals of such species reproduce, for example, in the upper part of the Serra do Mar (Sick 1997).

The breeding hypothesis (when birds move altitudinally to breed) to explain seasonal altitudinal migration, is usually referred to in passing, with the exception of Somenzari et al. (2018), referring to *D. nigripes*. Yet, the cause of movement of the dacnis remains inconclusive, because it appears that only a part of the population moves seasonally to reproduce. The hypothesis of foraging movements to higher altitudes, where fruits are seasonally abundant, has received more attention, and was reported from the Andes and elsewhere (e.g., Loiselle and Blake 1991, Wright 2005). This idea has also received attention in Brazil, usually associated with the study of fruiting palms (Supplementary material – Table S3). However, fruiting seasonality (phenology) also varies by region of the country and altitude (Galetti et al. 1999, Fisch et al. 2000, Bencke and Morellato 2002, Castro et al. 2007). To date, the idea that fruit phenology is a driver of seasonal movements of birds has not yet been adequately tested and evidence has been circumstantial (e.g., Castro et al. 2012, Hasui et al. 2012). In addition to Hasui et al. (2012), eight other studies mention the absence of seasonal altitudinal movements of birds in some mountainous regions, but these results were produced without a specific sampling design. Partial migration has also been mentioned in Brazil for the Black-goggled Tanager *Trichothraupis melanops* (Vieillot, 1818) – Mallet-Rodrigues and Noronha 2003 and for *T. flavipes* – Somenzari et al. 2018, Guaraldo et al. 2022. Partial altitudinal migration has also been described elsewhere (e.g., Berthold 2001), but its observation in tropical regions is difficult for the reasons described here (Willis 1988, Pedrocchi et al. 2002).

Only four of the 77 field studies had a specific sampling design to detect altitudinal movements (Fernandes 2013, Cavalcante 2014, Lopes 2014, Souza 2014, Supplementary material – Table S4). Those are graduate theses and an undergraduate monograph that have not been published in peer-reviewed journals. Thus, standardized studies of seasonal altitudinal movements in Brazil remain as gray literature. Recognizing and mapping areas where seasonal altitudinal movements may occur is of primary importance for further scientific research in this area, as well as for conservation reasons. With this, the creation of protected areas should consider including the entire altitudinal gradient to protect those species that seasonally use the entire range of altitudes (e.g., Willis and Schuchmann 1993, Stotz et al. 1996). Forest fragmentation and climate change are the primary threats to the conservation of that altitudinal gradient, not just in the Americas, but worldwide (Guillaumet et al. 2017, Inouye et al. 2000, Şekercioğlu et al. 2012).

Recommendations for appropriate methods in the study of SAM

Bird studies that fulfill all the basic technical requirements to demonstrate clearly that bird seasonal altitudinal movements occur in Brazil have not yet been carried out. Therefore, the first consideration for studying seasonal altitudinal movement patterns (and not long-distant migration) is to select species and locations in which seasonal altitudinal movement is possible and likely (Hayes 1995). Sampling design requires simultaneous and standardized observations carried out for at least a year throughout the hypothesized altitudinal range of the species of interest, with a minimum of two sampling altitudes – the predicted lowest and highest regions (in the case of Serra do Mar, which is an Atlantic slope, the locations need to be as close as possible latitudinally, due to biological, geographic and climatic variations) – and two sampling periods – the climatic extremes, typically breeding and non-breeding seasons. A more efficient method is to use a mark-recapture/resighting protocol (e.g., using color bands to identify individual birds, when resighting) making it is possible to track individuals. Even better would be the use of radio or satellite telemetry or geolocators. Additionally, the terminology must be consistent and unambiguous (use of standardized terms), and statistical analysis must be rigorous.

The main hypothesis for seasonal altitudinal movements in southeastern Brazil has been climate seasonality forcing birds to descend to lowlands in the winter, returning in the summer. While there is not yet strong evidence to support this hypothesis, improved studies are required to clearly test it. The question is clearly important because the 68 species that are strong candidates for seasonal altitudinal movement comprise both endemic and threatened species in the Atlantic Forest. Thus, there are both scientific and conservation reasons to better understand seasonal altitudinal movement patterns.

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FS: conception of the research framework, data collection and manuscript preparation. LFS and CCC: contributed the text and manuscript review.

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SUPPLEMENTARY MATERIAL*

Supplementary material 1

Table S1. Information used to evaluate validity and usefulness of references.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Technical categories.
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Supplementary material 2

Table S2. Sources that mention seasonal altitudinal movements of Brazilian birds.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Literature data.
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Supplementary material 3

Table S3. Groups or species of birds mentioned in their respective texts and with respect to altitudinal movements in Brazil. Repeated data refers to information published in more than one study by the same author.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Literature data.
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Supplementary material 4

Table S4. Basic criteria defined for the references of field work obtained to have the technical conditions to identify possible seasonal altitudinal movements of birds. Black cells indicate that the criterion was attained while blank cells indicate that they either were not attained, not informed or otherwise inapplicable.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Technical categories.
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Supplementary material 5

Table S5. Literature obtained, organized and cited in the Tables S2, S3 and S4.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Bibliographical references
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Supplementary material 6

Figure S1. Regional maps of Brazil illustrating the locations of the various study sites included in this review. Blue circles indicate valid studies, and red circles not valid studies, and white circles indicate state capitals.
Authors: F. Schunck, L.F. Silveira, C. Candia-Gallardo
Data type: Maps.
Link: https://doi.org/10.1590/S1984-4689.v40.e22037

Appendix 1. List of bird species considered valid altitudinal migrants in Brazil (i.e., based on studies carried out in the context of differences in relief, with mountain ranges, slopes, valleys, and their variations), and of those that are non-valid (studies carried out in areas without large differences in relief, or those generically described, and for which it would be difficult to demonstrate altitudinal migration). Threatened species according to International Union for Conservation of Nature and Ministério do Meio Ambiente: (EN) endangered, (VU) vulnerable, (CR) critically endangered, (PEX) probably extinct in nature. Endemic species of the Cerrado (CE, Silva 1995) and Atlantic Forest (MA, Vale et al. 2018). Taxonomy following Pacheco et al. (2021). The data in the References' column is in Supplementary material (Table S5).

Taxon	English name	Threatened		Endemic		Field study	Literature review	Data			References
		IUCN 2022	MMA 2022	MA	CE			Valid	Non valid	Articles	
Tinamiformes											
Tinamidae (1)											
Tinamus solitarius	Solitary Tinamou			X		X		X		X	34
Galliformes											
Cracidae (1)											
Aburria jacutinga	Black-fronted Piping-Guan	EN	EN	X		X	X	X		X	18,28,33,42
Columbiformes											
Columbidae (1)											
Patagioenas plumbea	Plumbeous Pigeon					X	X	X		X	18,39,51
Apodiformes											
Apodidae (1)											
Streptoprocne biscutata	Biscutate Swift					X		X		X	53
Trochilidae (19)											
Florisuga fusca	Black Jacobin			X		X	X	X	X	X	5,54,76,104
Phaethornis ruber	Reddish Hermit					X		X		X	87
Phaethornis pretrei	Planalto Hermit					X					105
Phaethornis eurynome	Scale-throated Hermit			X		X		X		X	21,87
Phaethornis margarettae	Margaretta's Hermit		EN	X		X		X		X	87
Augastes scutatus	Hyacinth Visorbearer					X					104
Colibri serrirostris	White-vented Violetear					X	X	X		X	18,40,47,61,104
Polytmus guainumbi	White-tailed Goldenthroat					X		X		X	87
Chrysolampis mosquitus	Ruby-topaz Hummingbird					X		X		X	87
Lophornis magnificus	Frilled Coquette					X		X		X	87
Heliodoxa rubricauda	Brazilian Ruby			X		X	X	X			18,62,104
Chlorostilbon lucidus	Glittering-bellied Emerald					X		X	X	X	47,97,104
Stephanoxis lalandi	Green-crowned Plovercrest			X		X	X	X	X	X	7,15,18,18,21,61,85
Stephanoxis loddigesii	Violet-crowned Plovercrest			X		X	X	X	X	X	7,15,18,44
Campylopterus diamantinensis	Diamantina Sabrewing					X		X			104
Leucochloris albicollis	White-throated Hummingbird					X	X	X			18,104
Chionomesa lactea	Sapphire-spangled Emerald					X					104
Hylocharis sapphirina	Rufous-throated Sapphire					X		X		X	87
Chlorestes notata	Blue-chinned Sapphire					X		X		X	87
Accipitriformes											
Accipitridae (1)											
Leptodon cayanensis	Gray-headed Kite					X		X		X	69
Trogoniformes											
Trogonidae (1)											
Trogon chrysochloros	Southern Black-throated Trogon					X		X		X	78
Piciformes											
Ramphastidae (2)											
Ramphastos dicolorus	Red-breasted Toucan			X		X		X	X	X	34,38,39,48
*Pteroglossus aracari**	Black-necked Aracari					X			X		43
Picidae (2)											
Picumnus nebulosus	Mottled Piculet					X		X		X	78
Colaptes campestris	Campo Flicker					X		X		X	44

Continues

Appendix 1. Continued.

Taxon	English name	Threatened		Endemic		Field study	Literature review	Data			References
		IUCN 2022	MMA 2022	MA	CE			Valid	Non valid	Articles	
Falconiformes											
Falconidae (1)											
Micrastur semitorquatus	Collared Forest-Falcon					X			X		43
Psittaciformes											
Psittacidae (8)											
Touit melanonotus	Brown-backed Parrotlet	VU	VU	X		X		X		X	88
Pionopsitta pileata	Pileated Parrot			X		X	X		X		16,72
Triclaria malachitacea	Blue-bellied Parrot			X		X	X	X	X	X	7,9,15,24,32,36,37,41, 44
Pionus maximiliani	Scaly-headed Parrot						X	X			96
Amazona vinacea	Vinaceous-breasted Parrot	EN	VU	X		X		X		X	34,80
Amazona pretrei	Red-spectacled Parrot			X			X		X		103
Amazona brasiliensis	Red-tailed Parrot			X		X		X		X	30
Forpus xanthopterygius	Blue-winged Parrotlet					X		X		X	41
Passeriformes											
Scleruridae (1)											
Geositta poeciloptera	Campo Miner					X		X			101
Dendrocolaptidae (2)											
Dendrocincla turdina	Plain-winged Woodcreeper					X		X			68
Xiphocolaptes albicollis	White-throated Woodcreeper					X		X		X	60
Pipridae (1)											
Chiroxiphia caudata	Swallow-tailed Manakin			X		X		X			35,95
Cotingidae (8)											
Carpornis cucullata	Hooded Berryeater			X		X	X	X	X	X	31,39,57,58,67
Phibalura flavirostris	Swallow-tailed Cotinga					X	X	X	X	X	13,18,31,39,43,50,62,76,83
Pyroderus scutatus	Red-ruffed Fruitcrow			X		X	X	X	X	X	31,38,39,52,57,67,72
Lipaugus ater	Black-and-gold Cotinga			X		X	X	X	X	X	4,13,18,72,83,83,85
Lipaugus conditus	Gray-winged Cotinga	VU	VU	X		X	X	X			77,83
Lipaugus lanioides	Cinnamon-vented Piha			X			X	X		X	10,83
Procnias albus	White Bellbird		VU			X		X		X	26
Procnias nudicollis	Bare-throated Bellbird	VU		X		X	X	X	X	X	5,18,31,39,43,55,56,83, 86
Tityridae (5)											
Laniisoma elegans	Shrike-like Cotinga			X		X	X	X	X	X	5,19,43,43,59,65,71,72, 79,83
Iodopleura pipra	Buff-throated Purpletuft	EN	EN	X		X	X	X	X	X	18,72,74,83
Tityra cayana	Black-tailed Tityra					X		X			6
Pachyramphus viridis	Green-backed Becard					X			X		46
Pachyramphus polychopterus	White-winged Becard					X		X		X	5
Oxyruncidae (1)											
Oxyruncus cristatus	Sharpbill					X	X	X	X	X	26,34,43,62,83,83,83
Pipritidae (1)											
Piprites pileata	Black-capped Piprites	VU		X		X	X	X		X	83,85
Platyrinchidae (1)											
*Calyptura cristata**	Kinglet Calyptura	CR	CR (PEX)	X			X	X			83
Rhynchocyclidae (3)											
Mionectes rufiventris	Gray-hooded Flycatcher					X		X	X	X	5,35,60,68,95
Phylloscartes ventralis	Mottle-cheeked Tyrannulet						X		X		72
Phylloscartes paulista	Sao Paulo Tyrannulet			X			X	X			24
Tyrannidae (21)											
Euscarthmus meloryphus	Tawny-crowned Pygmy-Tyrant					X			X		43
Tyranniscus burmeisteri	Rough-legged Tyrannulet						X	X	X		18,72
Camptostoma obsoletum	Southern Beardless-Tyrannulet					X		X		X	44
Elaenia mesoleuca	Olivaceous Elaenia						X		X		72
Phyllomyias fasciatus	Planalto Tyrannulet					X			X		43

Continues

Appendix 1. Continued.

Taxon	English name	Threatened		Endemic		Field study	Literature review	Data			References
		IUCN 2022	MMA 2022	MA	CE			Valid	Non valid	Articles	
Phyllomyias griseocapilla	Gray-capped Tyrannulet			X		X			X		46
Culicivora caudacuta	Sharp-tailed Tyrant	VU			X	X		X		X	85
Serpophaga nigricans	Sooty Tyrannulet						X	X			62
Serpophaga subcristata	White-crested Tyrannulet					X	X	X		X	8,18,18
Attila rufus	Gray-hooded Attila			X		X		X	X		46,95
Ramphotrigon megacephalum	Large-headed Flatbill						X	X			62
Myiarchus swainsoni	Swainson's Flycatcher					X			X		43
Myiarchus ferox	Short-crested Flycatcher					X		X		X	5
Myiodynastes maculatus	Streaked Flycatcher					X		X		X	5
Myiozetetes cayanensis	Rusty-margined Flycatcher					X			X		43
Tyrannus savana	Fork-tailed Flycatcher					X		X		X	8
Muscipipra vetula	Shear-tailed Gray Tyrant			X		X	X	X	X	X	18,23,25,31,39,44,62,73,76
Lathrotriccus euleri	Euler's Flycatcher					X		X		X	5,68
Contopus nigrescens	Blackish Pewee					X		X		X	26
Knipolegus cyanirostris	Blue-billed Black-Tyrant					X	X	X	X		25,31,46
Knipolegus nigerrimus	Velvety Black-Tyrant			X		X	X	X	X	X	18,31,64
Turdidae (4)											
Cichlopsis leucogenys	Rufous-brown Solitaire	EN	EN			X		X		X	29
Turdus flavipes	Yellow-legged Thrush					X	X	X	X	X	2,3,4,6,8,15,25,31,38, 43,45,46,55,60,63,67,71,72,81,92,100,102,103,106,107
Turdus amaurochalinus	Creamy-bellied Thrush					X	X	X	X	X	8,15,17,54,55
Turdus albicollis	White-necked Thrush					X		X	X		68,89,95
Fringillidae (4)											
Spinus magellanicus	Hooded Siskin					X		X		X	8,44
Cyanophonia cyanocephala	Golden-rumped Euphonia					X	X	X	X	X	44,62,76
Chlorophonia cyanea	Blue-naped Chlorophonia					X	X	X			62,84
Euphonia chalybea	Green-throated Euphonia			X		X	X	X			62,84
Thraupidae (23)											
Tersina viridis	Swallow Tanager					X		X	X	X	8,43
Dacnis nigripes	Black-legged Dacnis			X		X	X	X	X	X	14,19,71,72,84,103
Saltator similis	Green-winged Saltator					X		X		X	5
Saltator maxillosus	Thick-billed Saltator			X		X	X	X	X	X	22,85
Coereba flaveola	Bananaquit					X		X	X		20,68
Trichothraupis melanops	Black-goggled Tanager					X		X	X	X	43,60,71,95
Tachyphonus coronatus	Ruby-crowned Tanager			X		X		X	X		35,43
Sporophila frontalis	Buffy-fronted Seedeater	VU	VU	X		X		X		X	5
Sporophila nigricollis	Yellow-bellied Seedeater					X			X		55
Sporophila ardesiaca	Dubois's Seedeater						X	X	X	X	7,15
Sporophila caerulescens	Double-collared Seedeater					X	X	X	X	X	7,15,44
Microspingus lateralis	Buff-throated Warbling-Finch			X		X		X			40
Haplospiza unicolor	Uniform Finch			X		X	X	X		X	5,98
Pipraeidea melanonota	Fawn-breasted Tanager					X	X	X	X		43,46,62
Stephanophorus diadematus	Diademed Tanager					X	X	X	X	X	21,22,34,40,85
Schistochlamys ruficapillus	Cinnamon Tanager					X		X	X		40,43
Thraupis cyanoptera	Azure-shouldered Tanager			X			X	X			62
Thraupis ornata	Golden-chevroned Tanager					X			X		43
Stilpnia peruviana	Black-backed Tanager			X		X		X			84
Stilpnia preciosa	Chestnut-backed Tanager					X		X			84
Stilpnia cayana	Burnished-buff Tanager					X		X	X	X	34,43
Tangara cyanocephala	Red-necked Tanager			X		X		X		X	34
Tangara desmaresti	Brassy-breasted Tanager			X			X	X			62