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ARTICLE

Breeding biology of Neotropical Accipitriformes: current knowledge and research priorities

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ABSTRACT: Despite the key role that knowledge on breeding biology of Accipitriformes plays in their management and conservation, survey of the state-of-the-art and of information gaps spanning the entire Neotropics has not been done since 1995. We provide an updated classification of current knowledge about breeding biology of Neotropical Accipitridae and define the taxa that should be prioritized by future studies. We analyzed 440 publications produced since 1995 that reported breeding of 56 species. There is a persistent scarcity, or complete absence, of information about the nests of eight species, and about breeding behavior of another ten. Among these species, the largest gap of breeding data refers to the former "*Leucopternis*" hawks. Although 66% of the 56 evaluated species had some improvement on knowledge about their breeding traits, research still focus disproportionately on a few regions and species, and the scarcity of breeding data on many South American Accipitridae persists. We noted that analysis of records from both a citizen science digital database and museum egg collections significantly increased breeding information on some species, relative to recent literature. We created four groups of priority species for breeding biology studies, based on knowledge gaps and threat categories at global level. Group I (great scarcity of information, plus higher categories of threat): *Leptodon forbesi*, *Cryptoleucopteryx plumbea*, and *Buteogallus lacernulatus*; Group II (breeding data have recently increased, but threat categories are high): *Spizaetus isidori*, *Accipiter gundlachi*, *Buteogallus coronatus*, *Pseudastur occidentalis*, and *Buteo ventralis*; Group III ("Near Threatened" species with still scarce breeding information): *Accipiter poliogaster*, *Accipiter collaris*, *Buteogallus aequinoctialis*, and *Pseudastur polionotus*; and Group IV (other priority cases): *Buteo ridgwayi*, *Buteo galapagoensis*, four eagles (*Morphnus guianensis*, *Harpia harpyja*, *Spizaetus ornatus* and *Buteogallus solitarius*), *Leptodon cayanensis*, *Accipiter superciliosus*, *Buteogallus schistaceus*, and the three *Leucopternis* hawks (*L. semiplumbeus*, *L. melanops* and *L. kuhli*). We also discuss the way that novel breeding data can show in what manners different species and populations are responding to environmental changes.

KEY-WORDS: eagles, hawks, information gaps, life history, raptors, reproduction.

INTRODUCTION

Accipitriformes (osprey, kites, hawks, and eagles; families Pandionidae and Accipitridae) is an extremely diversified and successful clade of diurnal raptors (Ferguson-Lees & Christie 2001, Márquez *et al.* 2005, Amaral *et al.* 2009, Dickinson & Remsen-Jr. 2013). These predators have a noteworthy participation in trophic webs, being able to mediate the whole structure and diversity of a community (Bierregaard-Jr. 1995, Touchton *et al.* 2002), and are also relevant indicators of environmental quality (Jullien & Thiollay 1996, Blendinger *et al.* 2004, Thiollay 2007) and providers of important environmental services (Estes *et al.* 2011). Breeding biology of this clade is widely varied (Newton 2010, Whitacre & Burnham 2012), and knowledge about the breeding patterns of each species and subspecies plays a central role in their effective conservation (de Labra *et al.* 2013).

Many breeding aspects of Accipitriformes are in fact important parameters for management and conservation programs. For instance, clutch size is directly related to population size, and this is related with extinction risk of species (Krüger & Radford 2008). Conversely, their reproductive rates are related to population density (Krüger 2000). Also, nest site choices reveal habitat selection by these raptors (Ferguson-Lees & Christie 2001), and therefore make evident their sensitivity to environmental changes (Trejo 2007a).

According to the latest classification adopted by the American Ornithologists' Union (NACC 2017, Remsen-Jr. *et al.* 2018 – therefore, AOU), there are 28 genera and 67 species of Accipitriformes occurring in the Neotropical region. Nonetheless, most Neotropical breeding data presented in some key references on diurnal raptors (*e.g.*, Ferguson-Lees & Christie 2001, del Hoyo *et al.* 2016) have important limitations. Information often consist of no more than anecdotal breeding records coming from scattered studies, or are generalizations based other tropical regions of the world (*e.g.*, Newton 2010), largely unverified to occur in the Neotropics (Whitacre & Burnham 2012).

Bierregaard-Jr. (1995) reviewed the state of the knowledge available addressing various aspects of the biology of 81 diurnal raptors that breed mainly in Central and South America. Regarding the breeding biology, the author showed that nests of 11 species of Accipitriformes and breeding behavior of 15 were not described. Moreover, most research concentrated on a few regions, such as further north of the Neotropics (*e.g.*, southern part of North America, and Guatemala). He also mentions that breeding data on most of South American species and subspecies of raptors is lacking (Bierregaard-Jr. 1995).

More recently, similar reviews were done only on a few South American countries (Pardiñas & Cirignoli 2002, Trejo *et al.* 2006, Trejo 2007a, b, Raimilla *et al.* 2012, Cortés *et al.* 2013). These studies assessed from four to 28 species, and just two reviews (Trejo 2007a, b) dealt with a larger amount (55 species). All these analyses comprised only studies conducted in the specific country (ies) (*i.e.*, Argentina, Chile and Uruguay), and so none included raptors that occur north of the Southern Cone of South America. Consequently, these surveys left out the Amazon Basin, one of the world's most deficient areas on bird breeding data, and around 20 species of Accipitriformes (Whitacre & Burnham 2012, del Hoyo *et al.* 2016, Xiao *et al.* 2016).

Countries that produce most scientific publications on breeding biology of Neotropical birds do not have english as their native language (Heming *et al.* 2013, Freile *et al.* 2014). For instance, all recent reviews on South American raptor research were written in Spanish (save their abstracts), with the exception of Trejo *et al.* (2006). Yet, there is still a visibility bias affecting science made in such countries (Cabot & de Vries 2004, Lortie *et al.* 2007), making such publications not easily accessible for researchers that do not read spanish or portuguese (see Bierregaard-Jr. 1995).

Moreover, many information on the natural history of Neotropical raptors come from studies not specifically designed for this aim (Cortés *et al.* 2013). Such studies often are published at small, local journals or bulletins (Figueroa, *in litt.*). Thus, important advances in knowledge are hardly visible to ornithologists from other countries. Indeed, Bierregaard-Jr. (1995) mentioned that "inaccessibility" of certain Latin American journals may have prevented him from collecting information from them. However, since then, internet access to many of these journals greatly improved (*e.g.*, *Hornero*, from Argentina; http://digital.bl.fcen.uba.ar), allowing more complete reviews to be made. Also, during the last two decades, the ornithological community of South America increased considerably, boosting the number of publications (Vuilleumier 2004, Freile 2005, Freile *et al.* 2014).

Scrutiny of oological (egg) collections from museums could also be useful for avian breeding biology research (McNair 1987). Yet, very few researchers in the Neotropics used museum eggs for analyzing breeding traits of diurnal raptors (*e.g.*, Denis *et al.* 2013, Hayes 2014), the most frequent approach being the presentation of revised summaries of some specific collections (*e.g.*, Román & Wiley 2012). Also, Bierregaard-Jr. (1995) did not provide information on museum eggs when evaluating knowledge on breeding biology of diurnal raptors, although such data is to some extent included in past literature (*e.g.*, Belcher & Smooker 1934). The amount of information (unpub. data) that we and other authors (Murphy 1989, Olsen & Marples 1993) obtained from museum egg sets strongly suggests that such sources could provide data not easily obtainable from other sources.

Considering the above, there is a need for a new comprehensive survey to access the state of the knowledge on the breeding biology of Neotropical Accipitriformes, and an update on research priorities. So, our main objective was to make a comprehensive analysis of the literature on breeding biology of Neotropical Accipitriformes produced after Bierregaard-Jr.'s (1995) review, and thus, to define the taxa that should be prioritized by future studies. We created an updated classification of current levels of knowledge of the breeding biology of these raptors, evaluating the progress made in the last decades. We also discuss the information gaps, ponder on their possible causes, implications, and potential solutions to the lack of breeding data, and present additional information obtained from alternative sources such as a citizen science database and museum collections. To conclude, we briefly exemplify how breeding data can show the ways that different species and populations are responding to environmental changes.

METHODS

Taxa

We follow Bierregaard-Jr.'s (1995) criteria by not including species with centers of distribution outside the Neotropics (see below), and Nearctic taxa that do not breed in there (which excluded the family Pandionidae from the analysis). Thus, we perform a comprehensive recent review of Neotropical raptors, including 56 species. Our subspecies division follows Dickinson & Remsen-Jr. (2013).

Categories and scoring criteria, and major changes in classification

We used two categories concerning reproduction, largely based on Bierregaard-Jr. (1995) and Trejo (2007a). Under "nest", the information that we analyzed includes the physical description of the nest, as well as its seasonality and location, clutch size, and description of eggs. That is, all aspects, mostly "physical", related to the early nesting stage. Under "breeding behavior", we included breeding displays of adult birds; descriptions of copulating and parental behaviors; incubation and fledging times; development of the young (both morphological and behavioral); the period of dependence of juvenile(s) after its first flights (post-fledging dependency period); and more detailed information – provided by relatively few studies – such as spatial distribution of breeding pairs, rate of reproductive success, nest productivity, and subsequent dispersal and survival of juveniles.

The numerical scores assigned in the classificatory scale of knowledge also follow the criteria of Bierregaard-Jr. (1995) and Trejo (2007a): (0) no information; (1) only anecdotal/scattered reports; (2) detailed study of one breeding pair or event; (3) study of more than one pair in the same population, and/or a substantial amount of anecdotal reports of representative areas of the species range; (4) detailed studies of separate populations in different portions of the species range; and (5) detailed information from the entire range of the species.

Besides producing an updated classification of current levels of knowledge about the breeding biology of these raptors, these scores act as an intuitive measuring scale to signal whether some reproductive aspects and taxa still need more studies (see also "Research recommendations and conservation relevance"). More importantly, they allowed a comparison between our scores and those reported by Bierregaard-Jr. (1995), to assess whether levels of knowledge changed in the last decades, and thus identify persistent gaps.

Classification had to be evaluated and updated, due to changes since 1995. Two of these changes were the recent splits of the "Gray Hawk" complex (*Buteo nitidus*/*Buteo plagiatus*; Millsap *et al.* 2011), and of Cuban Black Hawk *Buteogallus gundlachii* and Common Black Hawk *Buteogallus anthracinus* (Wiley & Garrido 2005). On the first case, the split of the taxon into southern and northern forms facilitates the evaluation of its case, and we chose to consider the scores attributed to "*Buteo nitidus*" by Bierregaard-Jr. (1995), as default for both *B. nitidus* and *B. plagiatus*. For the Black Hawks, Bierregaard-Jr. did not report a separate score for the then subspecies *gundlachii*, what prevented us from making a comparison of levels of knowledge about this taxon then and now. Nevertheless, we briefly discuss the status of Cuban Black Hawk on Appendix III.

Bierregaard-Jr. (1995) reported different scores for the taxa *Accipiter ventralis*, *Accipiter chionogaster* and *Accipiter erythronemius*, but these are currently classified as subspecies of the Sharp-shinned Hawk *Accipiter striatus* (Remsen-Jr. *et al.* 2018). In turn, Sharp-shinned Hawk was not included in Bierregaard-Jr.'s review, for having a center of distribution outside Central and South America. Ferguson-Lees & Christie (2001) already argued that this so-called "Central and South American group" of Sharp-shinned Hawk's subspecies (that is, *A. s. ventralis*, *A. s. chionogaster* and *A. s. erythronemius*) is so divergent, that treatment at species level should be considered for at least some of these, but not for other groups of subspecies such as the Caribbean. Since Remsen-Jr. *et al.* (2018) acknowledge that the taxonomic status of *A. striatus* still needs clarification, we comment on the knowledge on those three subspecies on Appendix III.

Other hawk species with some breeding populations in the Neotropics (mostly in the Caribbean) but centers of distribution in the Nearctic were excluded from our analysis. We based such decision not only because comparing scores of knowledge then and now was impossible, since Bierregaard-Jr. (1995) also excluded those from his assessment. Most importantly, we rely on evidence of little divergence between some of such disjunct populations and its Nearctic counterparts, on respect of phenotypic traits (Ferguson-Lees & Christie 2001), especially most breeding aspects (*e.g.*, Santana & Temple 1988). Likewise, such findings are being further supported by an ongoing meta-analysis of geographical variation on these species breeding patterns (author's unpub. data).

Other splits adopted by Bierregaard-Jr. (1995), but not maintained on current classification, are "*Accipiter chilensis*" (subspecies of Bicolored Hawk *A. bicolor*), "*Buteogallus subtilis*" (included three subspecies of Common Black Hawk) and "*Buteo poecilochrous*" (subspecies of Variable Hawk *Geranoaetus* [*Buteo*] *polyosoma*). We ignored the scores that Bierregaard-Jr. separately assigned to each of these taxa, and analyzed only those ascribed to the currently recognized species. Yet, we commented on the status of some of these subspecies when relevant.

Literature search methods and sources

We screened the Global Raptor Information Network (GRIN; http://www.globalraptors.org/grin/indexAlt.asp) until October 2016. This database focus only on raptors, concentrating information on diurnal species from around the world and includes bibliography of other renowned databases on raptors such as The Peregrine Fund and Raptor Information System. We analyzed the literature on reproduction of the 56 species after 1994, indicated in the section "Breeding" in the species accounts. We also searched for other studies whose titles refer to reproductive aspects, mainly the bibliography contained in the topic "Breeding biology". In some isolated cases, we considered in this review breeding data not published in other sources and made available by researchers in the GRIN database.

We chose to use Google Scholar (http://scholar.

google.com/) as the main tool to complement GRIN reference search because we noted it was able to locate the same references found with Scopus and Searchable Ornithological Research Archive (SORA; http://elibrary.unm.edu/sora), search tools also chosen by almost all recent revisions (Trejo 2007a, b, Raimilla *et al.* 2012, Cortés *et al.* 2013). The search terms we used were all possible scientific names recently assigned for these species (except for those variables only in the suffix, which were already supplied by the search heuristic), combined with each of the following terms: nest, ninho, nido, nidificação, anidamiento, anidación, reprodução, reproducción, breeding, and biologia reprodutiva. The great redundancy of results when using somewhat similar terms indicated the effectiveness of the choices, and terms like "nesting" and "biología reproductiva" were discarded.

We searched for all kinds of references, from articles in any category of scientific journal, through monographs, conference abstracts and posters, to technical reports and unpublished manuscripts. We reviewed citations contained in the references, even though most were already found in key word searches. Yet, we could not retrieve 19 (4.1%) of the 459 references produced between 1995–2016 (Appendix IV), neither through requesting directly from their authors nor from databases such as The Peregrine Fund.

We also screened and retrieved information from a bibliographical review of Brazilian birds (Oniki & Willis 2002), and the following books: Bird *et al.* (1996), Sick (1997), Machado *et al.* (1998), Arballo & Cravino (1999), Naka & Rodrigues (2000), Höfling & Camargo (2002), Fontana *et al.* (2003), Reichle *et al.* (2003), Wheeler (2003), Willis & Oniki (2003), Antas (2004), Mikich & Bérnils (2004), de la Peña (2005), Márquez *et al.* (2005), Angehr (2006), Sigrist (2006), Eisermann & Avendaño (2007), Gussoni & Guaraldo (2008), Whitacre (2012), Santos (2014), Straube *et al.* (2014), and Alvarado *et al.* (2015).

Exclusion and inclusion search criteria

As previously mentioned, Bierregaard-Jr. (1995) claimed that antiquity or "obscurity" of certain journals, particularly Latin American's, prevented him from gathering information from them. Yet, he did include some of these studies that were cited in more broadly distributed journals. We verified that some of these Latin American journals (*e.g.*, *Hornero*) were already scrutinized by recent reviews (Trejo 2007a, b, Raimilla *et al.* 2012). Notwithstanding, we could not determine with certainty which studies prior to 1995 were not included by Bierregaard-Jr., given that his study lacks a complete list of references. So, we opted to consider only papers published from 1995 on, to avoid repeating data already collected. After all, one of our aims was to get a clear picture of the amount of research done in the last decades, and not previously.

We also assume that papers from 1995 would not have been included by Bierregaard-Jr. Depending on the date of completion of his search (not stated in the paper), the author could have included at least some of these studies, but information contained in such papers is not consistent with certain scores assigned by him [*e.g.*, the Gray-backed Hawk *Pseudastur occidentalis*, studied by Vargas (1995)]. This fact suggests that in most cases the inclusion of these papers in that review may not have occurred. Nevertheless, only a few studies from 1995 were found in our review, suggesting that the influence of possible duplicate data on the different species would be irrelevant.

Some books contain secondary information often without direct citation of the original data (*e.g.*, Ferguson-Lees & Christie 2001, Márquez *et al.* 2005, Sigrist 2006). Because of lack of clear indication of each of their sources in the text, we could not retrieve the original studies year or sometimes even the geographic region. Thus, we also chose to not include such breeding reports, except when it was clearly indicated in the text that it was an original data.

Research recommendations and conservation relevance

We created a four-group classification of research priorities on species breeding aspects, based mostly on knowledge gaps (by means of the assigned numerical scores), but also considering current threat categories at the global level (IUCN 2017). Group I includes species with great scarcity of available information about their reproduction, combined with higher categories of threat. Group II comprises species whose studies have advanced, although very little since Bierregaard's (1995) review, but which are at some higher threat category. Group III includes species whose knowledge is still scarce and are currently "Near Threatened" according to IUCN. Finally, Group IV represents species framed in three possible situations: *i*) the knowledge about their breeding has not increased (although it was already very high, *i.e.* scores of 4 or 5) and also are in some greater category of threat; *ii*) the remaining species considered "Near Threatened"; or *iii*) species not threatened, but of which nothing or practically nothing is known about their reproduction and/or have at least one of the topics of breeding aspects classified as 1 (see "Categories and scoring criteria, and major changes in classification").

Screening of the Handbook of Birds of the World and WikiAves

The Handbook of Birds of the World (HBW) was the baseline for Bierregaard-Jr.'s (1995) gap analysis and until today is considered a reference for current knowledge about biology of bird species (*e.g.*, Trejo *et al.* 2006, Xiao *et al.* 2016). Thus, we opted to review information in the online version "HBW Alive" (http://www.hbw.com). Our purpose was to determine if data available regarding reproductive aspects (topic "Breeding", in each species account) were commensurate with the actual state of knowledge about these subjects.

The online database WikiAves (www.wikiaves.com) is a collaborative tool launched in 2008 that allows posting of photographic records of bird species that occur in Brazil. This initiative has a great advantage over other popular citizen science platforms, such as eBird (ebird.org), by working with digital records and not lists. Also, we are not aware of initiatives from other Neotropical countries (*e.g.*, http://www.wikiaves.com.ar/inicio.php) that are equally reliable and allow similar content-based searches of their records.

Considering the enduring scarcity of avian breeding records from South American mid-latitudes (Baker 1938, Heming *et al.* 2013), the fact that WikiAves focus on Brazil is particularly convenient. We searched for breeding records of 25 species in this database. The low number of species was due primarily to the scope of WikiAves, which only contains species recorded in Brazil. In addition, we chose to review only species that obtained scores less than 3 in at least one of the categories, or those with values equal to or greater than that, but for which there was a marked relative scarcity of South American data. In the "Advanced Search" tool for photos, we used (separately) the filters: egg, nest, juvenile, copulating, incubating, courting, caring/feeding its chick(s), and making nest. The search was made in October 2016 and we included only records whose identification was considered secure – both at specific level and, in the case of breeding behaviors and/or stages that were clearly illustrated in the photographic records. Records already present in papers located in the survey were discarded.

Museum egg records

Eggs and labels were photographed in the following egg collections between 2014–2017 at Western Foundation of Vertebrate Zoology - WFVZ (Camarillo, USA), Natural History Museum - NHMUK (Tring, UK), National Museum of Scotland - NMS (Edinburgh, UK), Muséum national d'Histoire Naturelle - MNHN (Paris, France), Naturhistoriches Museum - NMW (Wien, Austria), Instituto de Investigación de los Recursos Biológicos "Alexander von Humboldt" - IAVH (Villa de Leyva, Colombia), Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" - MACN (Buenos Aires, Argentina), Museo de Ciencias Naturales de La Plata - MLP (La Plata, Argentina) and in Brazil, Museu de Zoologia da Universidade de São Paulo - MZUSP (São Paulo), Museu Nacional do Rio de Janeiro - MN (Rio de Janeiro), Museu Paraense "Emilio Goeldi" - MPEG (Belém), and Coleção Ornitológica "Marcelo Bagno" - COMB (Brasília). We also visited the online egg collections of the Field Museum of Natural History - FMNH (Chicago, USA), and the Arctos Collaborative Collection Management Solution (arctos.database.museum), and had access to data of the egg collection of the Smithsonian Institution (USNM, Washington, D.C., USA), and the American Museum of Natural History (AMNH, New York, USA). Finally, we consulted the catalog of the Cris-Rivers Region Museum (CRRM, Oradea, Romania; Béczy 1971).

These author's previous experience suggests that diurnal raptor's eggs collected in the United States can outnumber those from all other new world countries together, on a ratio of roughly nine to one (authors' unpub. data). Also, Bierregaard-Jr. (1995) verified that when the distribution of a species reaches the southern part of North America, it tends to be much more studied there than in the rest of its range. Considering the above, we opted to not include museum data from eggs collected in the USA in this analysis. Breeding information from that country certainly is already overly represented in literature, and augmenting it with museum records would only exacerbate this bias.

Museum egg sets are a proven reliable source (McNair 1987), but a few inconsistencies in the records of certain collectors have been reported (Hellmayr & Conover 1949, Thorstrom & Kiff 1999). Thus, we carefully validated species identification based on our own experience, on remarks from other researchers, and also resorting on other references that provide clutch sizes, egg measurements and descriptions (*e.g.*, the GRIN database). A few species suffer from faulty information about their eggs and clutches in the literature, and these cases are still being validated by us. Such egg sets are not assigned to any species here but are included in the total number of sets we found from the Neotropics. In the process of validating eggs' identification, measurements were standardized using the software ImageJ (Bridge *et al.* 2007, Troscianko 2014).

RESULTS

Bierregaard-Jr.'s (1995) review found 431 references of 81 species and included information about various aspects of Neotropical raptor biology. Meanwhile, our research found 440 references exclusively about breeding biology of 54 species (out of 56 studied taxa – as we did not find any published records for two species).

Such results are presented in Appendix I, with complete reference list on Appendix II. This represents an increase in the number of published references since Bierregaard-Jr.'s review, especially since he covered many other aspects of biology, included also Falconidae, and had no date limitation (unlike our scope of 22 years). We found 11 references and citations referring to data from captive birds, but these were not included in our review given the uncertainty involving raptor's breeding aspects in unnatural conditions (Cabot-Nieves *et al.* 2013).

Much of the breeding data we found came from inventories that provide a list of species for one or more localities, often highlighting new occurrences or noteworthy records (*e.g.*, Bodrati *et al.* 2010), or research addressing ecological aspects of bird communities of a given region (*e.g.*, Cintra & Naka 2012). Observations on the breeding activity of some species are frequently included in such studies (*e.g.*, Hennessey *et al.* 2003), and it is common for raptors to receive some prominence (*e.g.*, Greeney & Nunnery 2006). However, such reports still remain mostly anecdotal (*e.g.*, Ruvalcaba-Ortega & González-Rojas 2009). For instance, nest records often do not provide any information on nest content or stage (*e.g.*, Bodrati *et al.* 2010), frequently because the nest was presumably inaccessible to the researchers (*e.g.*, Bellatti 2000). Many times all that can be concluded is that the species was "nesting" in a given locality, during a quite long period of time (*e.g.*, Cavicchia & García 2012).

Of the 11 species of Neotropical accipitrids for which the nest had not been described prior to 1995, six remain undescribed and two present only anecdotal/scattered reports (Table 1). Of 15 species with no information about their breeding behavior (*e.g.*, *Leptodon cayanensis*, *Cryptoleucopteryx plumbea, Leucopternis melanops*) in 1995, little or no additional information is still not available for 10. Also, in 1995 only anecdotal descriptions were available for the nests of 15 species, and breeding behaviors of another 14 species. This case remains the same for the Tiny Hawk *Accipiter superciliosus* and Rufous Crab Hawk *Buteogallus aequinoctialis*, which have no recent published information. Yet, 66% of the analyzed species (n = 37) showed an increase in knowledge, of these, nearly half (n = 19) showed an increase in only one of the categories, and the remaining in both.

Probably the most significant increases in knowledge were for Barred Hawk *Morphnarchus princeps* and White-throated Hawk *Buteo albigula,* followed by Gray-bellied Hawk *Accipiter poliogaster*, Chaco Eagle *Buteogallus coronatus*, Gray-backed Hawk and Rufous-tailed Hawk *Buteo ventralis*, and also Rufous-thighed Kite *Harpagus diodon.* The following species also had a significant increase in knowledge about the two breeding categories: Black-and-white Hawk-Eagle *Spizaetus melanoleucus*, Black-collared Hawk *Busarellus nigricollis*, Long-winged Harrier *Circus buffoni*, Crane Hawk *Geranospiza caerulescens*, Solitary Eagle *Buteogallus solitarius* and Short-tailed Hawk *Buteo brachyurus*. On the other hand, very scant information was found for the former "*Leucopternis*" hawks, currently classified in five genera. Even the best-known species in this polyphyletic group of 10 species (Amaral *et al.* 2009), the Barred Hawk and the White Hawk *Pseudastur albicollis*, either have only anecdotal reports in distinct areas of the species distribution range, or detailed studies of nests from just one population (*e.g.*, Muela & Valdez 2003, Cisneros-Heredia 2006, Gelis & Greeney 2007, Draheim 2012).

As Bierregaard-Jr. (1995) also noted, we found a longstanding concentration of studies further north of the Neotropics (*i.e.*, southern United States), as well as in the northern portion of this region. For instance, Guatemala still stood out due to the quantity and quality of research developed by the Peregrine Fund's Maya Project, which resulted in a large number of published studies on raptor biology (*e.g.*, Seavy & Gerhardt 1998, Seavy *et al.* 1998, Thorstrom & Quixchán 2000, Sutter *et al.* 2001, Panasci & Whitacre 2002), ultimately leading to the publication of a book (Whitacre 2012). The Southern Cone of South America also have a large amount of research developed in Chile, already emphasized by Bierregaard-Jr. (1995), and Argentina (*e.g.*, Jiménez 1995, Trejo *et al.* 2001, Ojeda *et al.* 2003, Medel-Hidalgo *et al.* 2015, Pérez 2015, Rivas-Fuenzalida *et al.* 2015).

Even for species considered already relatively well known, with both categories scoring 3 or 4, there is a lasting shortage of research on South American populations or subspecies. This was the case for the White-tailed Kite *Elanus leucurus*, the Swallow-tailed Kite *Elanoides forficatus*, and the Zone-tailed Hawk *Buteo albonotatus*, among others. We also found little or no information about the breeding biology of some subspecies of some polytypic species, including the Cuban Kite (*Chondrohierax uncinatus wilsonii*), considered a full species and "Critically Endangered" by IUCN (2017); Mangrove Black Hawk (*Buteogallus anthracinus subtilis*), included in a separate species by Bierregaard-Jr. (1995); Pearl Kite (*Gampsonyx swainsoni magnus*); and Snail Kite (*Rostrhamus sociabilis major*). Additional comments in Table 1 are given to indicate taxa and/or regions in which research is critically needed.

Although incomplete, some sets of new studies revealed both similarities and divergences in breeding behavior between different populations. For instance, the cooperative behavior of Harris's Hawks *Parabuteo unicinctus,* well known for the subspecies *P. u. harrisi* in the United States, at the time of Bierregaard-Jr.'s (1995) review was not reported anywhere else in the species range. There is now good evidence that cooperative breeding also occurs in at least one population of the nominate subspecies in southeastern Brazil (Silva & Olmos 1997), hence this behavior is not restricted to North America.

Table 1. Assessment of current knowledge on the breeding biology of 56 species of Neotropical Accipitriformes.

Species	Bierr. Nest	Bierr. Behav	Nest	Breeding behavior	Research priority	Comments
Elanus leucurus	4	4	4	4	No	Lack of more detailed data from most regions, mainly South America.
Gampsonyx swainsonii	3	3	3	3	No	Still a lack of behavioral data from most regions, particularly later stages.
Chondrohierax uncinatus	4	3	4	4	No	Most data missing from South America; nothing from subspecies *wilsonii.*
Leptodon cayanensis	1	0	3	1	IV	Detailed data from only two areas; very few behavioral data, particularly later stages.
Leptodon forbesi	0	0	0	1	I	Only breeding displays.
Elanoides forficatus	3	3	4	4	No	Many detailed studies, but there is still a lack of detailed data from other areas.
Morphnus guianensis	2	2	3	3	IV	Some detailed studies, but still a lack of behavioral data in many regions.
Harpia harpyja	4	3	4	4	IV	Still a lack of detailed data from some portions of the range (*e.g.*, Atlantic Forest).
Spizaetus tyrannus	3	3	3	4	No	Still a lack of detailed data from many regions.
Spizaetus melanoleucus	1	1	3	3	No	Isolated cases and incomplete observations.
Spizaetus ornatus	4	4	4	4	IV	New data did not change status.
Spizaetus isidori	3	2	3	3	II	Still a lack of detailed data from many regions.
Busarellus nigricollis	1	1	3	3	No	Still a lack of detailed data from many regions.
Rostrhamus sociabilis	4	4	4	4	No	Many detailed studies, but still missing data from most regions/subspecies.
Helicolestes hamatus	3	3	3	3	No	New data did not change status; only one population studied in detail.
Harpagus bidentatus	3	1	3	3	No	Only one population studied in detail; still a lack of behavioral data.
Harpagus diodon	1	0	3	3	No	Isolated cases and incomplete observations; still a lack of behavioral data.
Ictinia plumbea	3	3	4	3	No	Still a lack of more behavioral data from many regions.
Circus cinereus	3	1	3	3	No	Lack of more detailed data from many regions.
Circus buffoni	1	1	3	3	No	Lack of more detailed data from many regions.
Accipiter poliogaster	0	0	2	3	III	Basically, just one or two pairs studied in detail.
Accipiter superciliosus	1	1	1	1	IV	Still very little information.
Accipiter collaris	0	0	0	1	III	Only information of specimens on breeding condition.
Accipiter gundlachi	3	1	3	3	II	Some detailed studies, but coming from a few areas.
Accipiter bicolor	3	3	3	3	No	Most data missing for two subspecies; new data but several old ones discarded.
Geranospiza caerulescens	1	1	3	3	No	Only one population studied in detail.
Cryptoleucopteryx plumbea	0	0	0	0	I	No new data.
Buteogallus schistaceus	0	0	0	0	IV	No new data.
Buteogallus anthracinus	4	4	4	4	No	Still a lack of South American data, especially from subspecies *subtilis.*
Buteogallus aequinoctialis	1	1	1	1	III	Still very little information.
Buteogallus meridionalis	4	3	4	3	No	New data did not change status; still a lack of detailed data from many regions.
Buteogallus lacernulatus	0	0	0	1	I	Only displays.
Buteogallus urubitinga	3	3	4	3	No	Still a lack of more behavioral data from most regions.
Buteogallus solitarius	1	1	3	3	IV	Data on nests or late stages (nothing in between); lack of data from most regions.
Buteogallus coronatus	1	1	4	3	II	Many detailed studies, but there is still a lack of more behavioral data.

Species	Bierr. Nest	Bierr. Behav	Nest	Breeding behavior	Research priority	Comments
Morphnarchus princeps	0	0	3	3	No	Most data missing from many regions.
Rupornis magnirostris	3	3	4	3	No	Some detailed studies, but still a lack of behavioral data from most regions/subsp.
Parabuteo unicinctus	4	4	4	4	No	New data did not change status; but evidence of cooperative behavior in Brazil.
Parabuteo leucorrhous	1	1	2	3	No	Isolated cases and incomplete observations.
Geranoaetus albicaudatus	3	3	3	3	No	Detailed data only of two subspecies; lack of detailed data from many regions.
Geranoaetus polyosoma	3	3	4	3	No	Still a lack of more behavioral data.
Geranoaetus melanoleucus	3	3	4	3	No	Some detailed studies, but still a lack of more behavioral data from many regions.
Pseudastur polionotus	0	0	1	1	III	Very little information.
Pseudastur albicollis	3	3	3	3	No	New data did not change status; only one population studied in detail.
Pseudastur occidentalis	0	1	3	3	II	Only one population studied in detail.
Leucopternis semiplumbeus	1	0	1	1	IV	No significant advances.
Leucopternis melanops	0	0	?	?	IV	No real advances.
Leucopternis kuhli	0	0	1	0	IV	Only one nest.
Buteo plagiatus	3	3	4	3	No	Still a lack of detailed data from most regions.
Buteo nitidus	3	3	3	3	No	New data did not change status; many missing data, incl. more egg descriptions.
Buteo ridgwayi	5	4	5	4	IV	New data did not change status; still a lack of more behavioral data.
Buteo albigula	1	0	4	3	No	Breeding status in northern range still uncertain; many missing data, incl. on eggs.
Buteo brachyurus	1	1	3	3	No	Lack of more detailed data from most regions, mainly South America.
Buteo galapagoensis	5	5	5	5	IV	-
Buteo albonotatus	3	2	3	3	No	Still limited to the northern range.
Buteo ventralis	1	0	3	3	II	Still limited to Chile; many missing data, including more egg descriptions.

Bierr. Nest and Bierr. Behav = scores assigned by Bierregaard-Jr. (1995), on Nest and Breeding behavior respectively; Nest and Breeding behavior = scores assigned by this study. Scores: (0) no information; (1) only anecdotal/scattered reports; (2) detailed study of one breeding pair or event; (3) study of more than one pair in the same population, and/or substantial amount of anecdotal reports of representative areas of the range; (4) detailed studies of separate populations in different portions of the range; and (5) detailed information from the entire range. Shaded cells denote improvements on knowledge in the last decades. Research priority = whether species should be prioritized by future studies on breeding biology, and for those that should, the priority group (I-IV) to which it was assigned; names of such species are also given in bold letters. Further explanations on the main text. Taxonomic ordering follows AOU (2018).

On the other hand, Short-tailed Hawk's breeding traits such as duration of the post-fledging dependency period and nest defense behaviors diverge not only among the different subspecies but even within the same country (Monsalvo 2012).

The species formerly called the Gray Hawk was separated into two species by Millsap *et al.* (2011), amendment accepted by the AOU (Remsen-Jr. *et al.* 2018). However, most recent studies of *Buteo nitidus*, all published prior to this split (*e.g.*, Patrikeev 2007, Ruvalcaba-Ortega & González-Rojas 2009), focused on the current northern species (Gray Hawk, *B. plagiatus*). Thus, the status of the Gray-lined Hawk (*B. nitidus sensu* AOU) remains the same. Although the number of references found was similar (ten and seven, respectively; Appendix I), information about Gray Hawks comes from almost 100 breeding events, at about ten different locations. Whereas for Gray-lined Hawks, only six records were found, and some of these informations could not have their localities confirmed. Such lack of detail prevented us from determining if data on the eggs of the latter species provided in recent literature (Sick 1997, Reichle *et al.* 2003) do not, in fact, refer to the northern species eggs.

Based on the criteria put forward before (see "Categories and scoring criteria, and major changes in classification" in the Methods), the highest priority species for research on their breeding aspects are, as follow: White-collared Kite *Leptodon forbesi*, Plumbeous Hawk *Cryptoleucopteryx plumbea*, and the White-necked Hawk *Buteogallus lacernulatus* (Group I); Black-and-chestnut Eagle *Spizaetus isidori*, Gundlach's Hawk *Accipiter gundlachi*, Chaco Eagle, Gray-backed Hawk, and Rufous-tailed Hawk (Group II); Gray-bellied Hawk, Semicollared Hawk *Accipiter collaris*, Rufous Crab Hawk and Mantled Hawk *Pseudastur polionotus* (Group III); and the two island species of *Buteo* hawks (Ridgway's *B. ridgwayi* and Galapagos *B. galapagoensis*), four eagles (Crested *Morphnus guianensis*, Harpy *Harpia harpyja,* Ornate Hawk-Eagle *Spizaetus ornatus* and Solitary Eagle), Gray-headed Kite *Leptodon cayanensis*, Tiny Hawk, Slate-colored Hawk *Buteogallus schistaceus*, and the three *Leucopternis* hawks (Group IV).

Despite recent reviews considered HBW as informative of the state-of-the-art (Trejo *et al.* 2006, Xiao *et al.* 2016), we concluded that information provided in the "Breeding" topic in this reference is outdated for at least 18 of the 56 species that we analyzed. In the WikiAves database, we compiled a total of 174 photographic records representing breeding aspects, for 18 of the 25 species surveyed (Appendix V). No reliable records were available for the remainder of the species. For one of these 18 species, Gray-bellied Goshawk, which had detailed literature records of only one or two breeding pairs (de Vries & Melo 2000, Thorstrom 2002, Boesing *et al.* 2012), inclusion of data from WikiAves augmented its assessment score (Table 2).

Another species for which WikiAves allowed a change in the assigned score was the White-collared Kite, whose only nesting record (Brito 2013, also quoted by HBW) is posted on that platform. It is also noteworthy the case of the Rufous-thighed Kite, for which WikiAves provides 42 records of at least 15 distinct breeding events in six different states of Brazil, including pairs with nesting accompanied throughout, and even in consecutive years. In addition to these three species, another five showed a significant increase in breeding records from South America, although these not have allowed an effective change in their scores (Table 2).

We located 729 egg sets from the Neotropical

Table 2. Results of the search for photographic breeding records from the WikiAves database, for 25 species of Neotropical Accipitriformes.

Species	Change in score(s)	Comments
Elanus leucurus	No	Many records of different stages and populations, but did not change status.
Chondrohierax uncinatus	No	Only three or four breeding pairs; always more southernly records.
Leptodon cayanensis	No	Only one nest, not monitored.
Leptodon forbesi	Nest = 1	The first nest of the species, also cited in HBW.
Spizaetus melanoleucus	No	Little informative and poorly distributed records.
Rostrhamus sociabilis	No	Many records of different stages and populations, but did not change status.
Helicolestes hamatus	No	Only two breeding localities, records of later breeding stages.
Harpagus bidentatus	No	Three records from the same locality, presumably of the same pair.
Harpagus diodon	No	Some breeding events monitored thoroughly, including same pair in different years.
Accipiter poliogaster	Nest = 3	Little informative and always more southernly records.
Accipiter superciliosus	No	Nothing.
Accipiter bicolor	No	Only three records, with no new information on subspecies.
Geranospiza caerulescens	No	Very diverse breeding stages, especially of the subspecies *flexipes*.
Buteogallus schistaceus	No	Nothing.
Buteogallus anthracinus	No	Only one nest, no new information.

Species	Change in score(s)	Comments
Buteogallus aequinoctialis	No	One copulation record.
Buteogallus lacernulatus	No	No reliable records.
Parabuteo leucorrhous	No	Nothing.
Pseudastur polionotus	No	Only one nest, not monitored.
Pseudastur albicollis	No	Only two nests, no new information.
Leucopternis melanops	No	Nothing.
Leucopternis kuhli	No	Nothing.
Buteo nitidus	No	Some poorly distributed records.
Buteo brachyurus	No	Many records of different stages and populations, but did not change status.
Buteo albonotatus	No	No reliable records.

Change in score(s) = whether scores assigned previously in our review, for the two categories concerning reproduction ("Nest" and "Breeding Behavior", see Table 1) augmented with inclusion of data from WikiAves. Shaded cells denote any substantial addition of new information, relative to recent literature.

region in egg collections, besides six records of eggs laid in captivity in this same region. Of these 729, 706 could be soundly assigned to some species (Table 3), from which 58% pertain to only four species: White-tailed Kite, Common Black Hawk, Roadside Hawk *Rupornis magnirostris*, and Gray Hawk. Around 88% of the total of clutches of these four species were collected in Mexico. This country is also the origin of almost two-thirds of the egg sets of all 31 species reliably identified in museum collections. Argentina and Chile are respectively the second and third countries with more collected clutches, but each represents less than 10% of the total.

We propose a correction in the identification of four clutches, all in the WFVZ collection and all previously recognized as misidentified by L. Kiff (Appendix VI). From our analyses, we conclude that their correct identifications probably agree with those tentatively suggested by him in the data slips accompanying these egg sets. We highlight the relevance of the egg sets assigned to White-rumped and Gray-lined Hawks, as they almost doubled the number of breeding reports for each of these species. Overall appearance and dimensions from the former's eggs are similar to those reported by Zilio & Mendonça-Lima (2012), the only other clutch known for the White-rumped Hawk, but museum eggs are slightly larger.

Unfortunately, the clutches of Gray-lined Hawk that we located are essentially the same widely used as reference for this species (Belcher & Smooker 1934), yet their measurements are within the range described for the allospecies Gray Hawk *B. plagiatus* (del Hoyo *et al.* 2016).

Also relevant are egg sets from the subspecies *Gampsonyx swainsoni magnus* (*n* = 1) and *Rostrhamus sociabilis major* (*n* = 7), both largely absent in recent literature. We also located five clutches of the Mangrove Black Hawk (former *Buteogallus subtilis*), for which Bierregaard-Jr. (1995) found no breeding information in literature (but see Wetmore 1965). Likewise, in our literature review we located only poorly detailed, scattered reports of nesting in a few localities of its range (Barrantes 1998, Pérez-León 2007, Alava *et al.* 2011). Relative to recent literature, museum eggs allowed a substantial increase in breeding information for a total of six species.

DISCUSSION

Breeding knowledge is not yet uniformly distributed across different regions for most species of Neotropical Accipitridae, with many areas lacking more studies about their populations or subspecies. The main evidence of this poor distribution of breeding data is the fact that we have not assigned any new score of 5 (*i.e.*, detailed information coming from the entire range). Information on many South American Accipitridae is still scant, even after two decades (Bierregaard-Jr. 1995). With exception of a few restricted-range subspecies, most of the least-studied populations occur in mid-latitudes of South America or in the Amazon Basin, a situation that barely improved in the last eight decades (Baker 1938, Xiao *et al.* 2016).

The regions where most quality-research are still concentrated are near the limits of many species ranges.

Table 3. Results of the search for museum egg records of Neotropical Accipitriformes.

Species	No. of sets	Comments
Elanus leucurus	65	Mostly from Mexico; also southern South America.
Gampsonyx swainsonii	2	From Colombia and Peru; the latter of subspecies *G. s. magnus*.
Chondrohierax uncinatus	8	All from Mexico; eggs from Trinidad were misidentified.
Leptodon cayanensis	5	Three of these were misidentified as other species.
Elanoides forficatus	4	From Brazil and Venezuela.
Morphnus guianensis	1	From Panama; presumably from the wild but no further details known.
Harpia harpyja	1	From Amazon Basin; plus 6 clutches laid in captivity.
Spizaetus ornatus	1	From Guatemala, at the same site of Peregrine Fund's Maya Project.
Busarellus nigricollis	4	All sets but one from Paraguay.
Rostrhamus sociabilis	34	Most from South American countries; seven clutches of *R. s. major.*
Ictinia plumbea	18	Records from throughout the species' range.
Circus cinereus	7	All sets from Chile.
Circus buffoni	6	All sets but one from Argentina.
Accipiter bicolor	3	One misidentified clutch was discarded (Lloyd & Kiff 1999).
Geranospiza caerulescens	5	All sets from Mexico.
Buteogallus anthracinus	100	90% from Mexico; five clutches of "Mangrove Black Hawk".
Buteogallus meridionalis	25	Around half from Mexico and the other half from South America.
Buteogallus urubitinga	14	Mostly from Mexico; also northern South America.
Buteogallus solitarius	1	From Mexico.
Rupornis magnirostris	142	Mostly from Mexico; others scattered throughout the species' range.
Parabuteo unicinctus	43	Mostly from Mexico.
Parabuteo leucorrhous	4	Largely increased the total number of breeding reports.
Geranoaetus albicaudatus	10	Records scattered through the species' range.
Geranoaetus polyosoma	43	Only one set from its northern range; 11 from the Falkland Islands.
Geranoaetus melanoleucus	23	All sets from its southern range.
Pseudastur albicollis	1	From Trinidad.
Buteo plagiatus	104	All sets but one from Mexico.
Buteo nitidus	3	All from Trinidad; seemingly no other eggs of the species are known.
Buteo brachyurus	13	All sets but one from Mexico.
Buteo galapagoensis	5	No new information added.
Buteo albonotatus	10	From its northern range.

No. of sets = number of soundly identified egg sets. Shaded cells denote any substantial addition of information, relative to recent literature. Further explanations on the main text.

Some aspects of the behavior of a species could be geographically restricted (Thiollay 1989), and its breeding aspects can be distinct at extreme limits of its geographical distribution (Kennedy *et al.* 1995). Thus, generalizations about the breeding biology of raptors become highly susceptible to errors (Bierregaard-Jr. 1995, Trejo 2007a).

Albeit results show that the informative potential of geographically isolated data and anecdotal descriptions may be important contributions to our knowledge on raptors breeding ecology (Whitacre & Burnham 2012), we emphasize the importance of conducting detailed studies with different populations.

Most recent studies that provide some new information on breeding aspects of Neotropical Accipitriformes are generalist in nature. The lack of detail of anecdotal reports may be due to logistical limitations during field work and to the studies scope, but it is also likely that it is often due to unawareness by local researchers of the relevance of the material. Whichever the reason, an emblematic outcome of this, is one occasional report of "breeding" that, if well described, would be the first description on any reproductive aspect of the Black- faced Hawk *Leucopternis melanops* (Cintra & Naka 2012). Because of the lack of detailed information, this report could not be properly attributed by us to any of the categories assessed (Table 1). Additionally, it is possible that such lack of detail may be caused by imperfections in the peer-review system (Figueroa, *in litt.*), or in publication policies of the journals, that does not give the opportunity to the publishing of complete information on natural history, or disregard the value of local breeding data.

A few of the less abundant and restricted-range species still attract most of the attention of field ornithologists. Bierregaard-Jr. (1995) already remarked on the oddness of a scarcity of breeding information for some common species, while a few, and not necessarily common ones (*e.g.*, Harpy Eagle), are increasingly well studied. For example, knowledge about the breeding behavior of the Gray-headed Kite, a conspicuous and widespread species (Thorstrom *et al*. 2012), is still mostly anecdotal (Table 1, Appendix I). Figueroa (2015) stated that among potential causes for these information gaps of common raptors, may be the species own "commonness", associated with a number of other biases of research focus in ornithology. On the other hand, knowledge of all the former "*Leucopternis*" species still can be considered the largest gap of breeding data among Neotropical Accipitridae, from Bierregaard-Jr.'s 1995 review up to date.

We noted that records posted in the WikiAves database could attenuate gaps in knowledge about some raptors in middle latitudes of South America. However, possibly the weakest point of this database is precisely its geographical limitation to Brazil. We believe that the development of similar initiatives in other Neotropical countries should be helpful as a complementary measure to elucidate diverse information on the biology of this region's avifauna (Lees & Martin 2014). We also stress the importance of the use of digital records in such citizen science tools, making possible for the researchers the correction of misidentifications. It is particularly relevant when it comes to diurnal raptors, a group renowned for having problematic identification in the field (Griffiths & Bates 2002, Seipke *et al.* 2006, 2011), leading to errors in citizen science records (Bailey 2015) and even in published peer-reviewed studies (de Vries & Melo 2002, Alves *et al.* 2017).

We also reinforce the importance of "conventional" records in museums (McNair 1987), as they offer the same benefits as exposed above. They make possible to verify previous identifications (*e.g.*, Griffiths & Bates 2002, Appendix VI) and therefore prevent the perpetuation of cascading errors. By using museum egg sets, this study and others (Murphy 1989, Olsen & Marples 1993, Hayes 2014) also gathered breeding data that could not be obtained from other sources, such as literature. Such fact is clearly illustrated in the cases of taxa with substantial increases in number of breeding records after the scrutiny of oological collections (see Table 3).

Museum data on some diurnal raptors can yet be very limited. For instance, we stress the need for collecting additional information on eggs of both White-rumped and Gray-lined Hawks, since our validation of the identification of their museum sets must be seen as conditional. In fact, sometimes the very same egg sets we analyzed are the only (or at least the major) source for egg measurements of a species provided by any reference. In such cases, only by carefully scrutinizing all references ever produced on a given species, and also by examining closely-related species, it is possible to avoid circular reasoning in validating the identification of these eggs. Perhaps some species' eggs still are unknown, if literature information are based in sets with questionable identification.

We also verified that oological collections undergo the same geographic bias found in both recent and former (Bierregaard-Jr. 1995) literature breeding records. Essentially the same regions (*i.e.*, northernmost and southernmost Neotropical countries, and the United States) predominate with respect to amount of breeding data. Trinidad and Tobago is an exception to this pattern, because the work of egg collectors (*e.g.*, Belcher & Smooker 1934) seems to be the ultimate source of almost all reproductive information on its raptors (Herklotts 1961, Ffrench 1991). In fact, no recent literature reference was found for this country.

Adequate knowledge of breeding parameters is necessary to better understand how different species and populations respond to environmental changes (Marini *et al.* 2010, D'Elia *et al.* 2015). Such information is particularly relevant for diurnal raptors, as they: provide important environmental services, preying upon potential pests and invasive species (Estes *et al.* 2011, Speziale & Lambertucci 2013, Martins & Donatelli 2014); act as flagship species (Sergio *et al.* 2008, Donázar *et al.* 2016); and as indicators of environmental quality (Jullien & Thiollay 1996, Blendinger *et al.* 2004, Thiollay 2007). Recent studies (*e.g.*, Alexandrino *et al.* 2016) are putting in check traditional classifications of sensitivity to disturbance, widely used for Neotropical avifauna, such as the landmark database by Stotz *et al.* (1996). In fact, despite some valuable efforts (*e.g.*, Jullien & Thiollay 1996, Thiollay 2007), little is actually known about the extent to which each species of Neotropical raptor fits in the sensitivity gradient (Bierregaard-Jr. 1995, Touchton *et al.* 2002, Roda & Pereira 2006).

As mentioned before, nest site choices of Accipitridae demonstrate habitat use (Ferguson-Lees & Christie 2001), and so highlight their sensitivity to environmental changes (Trejo 2007a). Then again, recent studies indicate a need to update classifications of sensitivity to habitat change of some Accipitridae. For example, Harpy Eagles and Short-tailed Hawks have an alleged need for nest sites in relatively pristine native forest (Albuquerque 1995). Yet, such allegation does not match a series of recent breeding records that demonstrate a much greater degree of tolerance, with successful nesting reported at human-altered habitats (Silva 2007, Monsalvo 2012, and references therein). These recent reports also showed that both prey delivery rates and fledgling success in such situations are similar or higher than those on more pristine habitats. Nonetheless, nesting in such modified conditions might lead to still undetected impacts, like higher nest predation risks (Newton 2010). Thus, further studies are necessary, to verify the occurrence of possible negative effects.

Open-country raptors are generally considered to be less threatened than forest species (*e.g.*, Piana & Marsden 2014), as mentioned by Bierregaard-Jr. (1995). In fact, recent research shows that suitable habitats for species such as the Roadside Hawk might increase with anthropogenic changes (Carrete *et al.* 2009), and lead to a substantial rise in nest productivity, in human-modified habitats (Panasci & Whitacre 2002). On the other hand, we also retrieved studies that claim that other raptors of open habitats may be negatively impacted by changes in land use. Throughout the Americas, species such as Cinereous Harriers (*Circus cinereus*) (Camilotti *et al.* 2008), Chaco Eagles (Albuquerque *et al.* 2006), and even White-tailed Hawks (Brown & Glinski 2009) are apparently losing breeding areas. In any case, there is a shortage of data about how environmental changes affect the breeding of different species and populations. So, for proper management of such potentially affected populations, additional research on reproductive rates is essential.

The relevance of studying generalist and abundant species should not be disregarded, given the extremely significant participation of raptors in trophic webs (Estes *et al.* 2011). Breeding range expansions have been reported recently for some generalist species, such as some *Buteo* hawks (Williams-III *et al.* 2007, Sandoval 2009). These expansions result in insertion of these raptors into new food webs, interacting with populations of prey species with which they had no previous contact. Some Accipitriformes can prey upon introduced or invasive species (Wheeler 2003, Pineda-López *et al.* 2012, Martins & Donatelli 2014), and the effects of the latter on breeding parameters of native predators still require further research (Speziale & Lambertucci 2013). For instance, in Snail Kite breeding areas the introduction of an alien novel prey increased reproductive success (Cattau *et al.* 2016), highlighting the ecological relevance of raptor species.

This assessment of current knowledge of the breeding biology of Neotropical Accipitriformes indicated that, albeit 66% of the evaluated species had some improvement on levels of knowledge, the scarcity of breeding data on many South American Accipitridae persists. Yet, we noted that records from both a citizen science digital database and oological collections resulted in a significant increase in breeding information for a total of 13 species, relative to recent literature. There is a persistent need for research to be conducted north of the Southern Cone of South America, and we recommend that breeding biology studies should focus on the 24 species selected as research priorities. Knowledge of the breeding biology of Accipitridae not only plays a key role in enabling proper management and conservation of their populations. It also will point the way for more efficient studies in the future, generating better data about the biology of these predators and, in the final analysis, on the functioning of ecosystems as a whole (Bierregaard-Jr. 1995, Trejo 2007a).

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APPENDIX I

Literature references with breeding data of 56 species of Neotropical Accipitriformes, produced between 1995–2016.

Species	Located references
Elanus leucurus	Erichsen *et al.* 1996; McMillian & Pranty 1997; Pranty & McMillian 1997; Sick 1997; Arballo & Cravino 1999; Carvalho *et al.* 2001b; Maceda & Kin 2001; Wheeler 2003; Antas 2004; Leveau *et al.* 2004; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Joppert 2007; Niemela 2007; Pérez-León 2007; Scheibler 2007; Carvalho-Filho *et al.* 2008; Gussoni & Guaraldo 2008; González-Acuña *et al.* 2009; Chatellenaz *et al.* 2010; Furman & Bastías 2012; Montalvo *et al.* 2014; Alvarado *et al.* 2015; Camacho-Varela & Acosta-Chaves 2015; Romano *et al.* 2015; Marsden *et al.* 2016.
Gampsonyx swainsonii	Martínez 1998; Reichle *et al.* 2003; Di Giacomo 2005; Jones 2005; Strewe *et al.* 2009; Sandoval *et al.* 2010.
Chondrohierax uncinatus	Ericson & Amarilla 1997; Di Giacomo 2000; Thorstrom *et al.* 2001; Clark 2002; 2003; Krügel 2003; Reichle *et al.* 2003; Clark 2004; Rappole *et al.* 2007; Carvalho-Filho *et al.* 2008; Thorstrom & McQueen 2008; Canuto 2009; Whitacre 2012; Sampaio *et al.* 2013; Phillips *et al.* 2015.
Leptodon cayanensis	Thorstrom 1997; Bornschein & Reinert 2000; Carvalho-Filho *et al.* 2002; Cabanne 2005; Carvalho-Filho *et al.* 2005; Olmos *et al.* 2006; Carvalho-Filho *et al.* 2008; Canuto 2009; Bodrati *et al.* 2010; Ghizoni-Jr. & Azevedo 2010; Whitacre 2012.
Leptodon forbesi	Pereira *et al.* 2006; Dénes 2009; Dénes *et al.* 2011.
Elanoides forficatus	Meyer & Collopy 1995; Brown *et al.* 1997; Gerhardt *et al.* 1997; Sykes-Jr. *et al.* 1999; Naka & Rodrigues 2000; Coulson 2001; Blihovde 2002; Coulson 2002; Naka *et al.* 2002; Willis & Oniki 2002; Reichle *et al.* 2003; Gerhardt *et al.* 2004; Meyer *et al.* 2004; Soehren 2004; Zimmerman 2004; Azevedo & Di Bernardo 2005; Carvalho-Filho *et al.* 2008; Coulson *et al.* 2008; Crease 2009; Gruber 2009; Lopes *et al.* 2009; Whitehead & Jones 2009; Bodrati *et al.* 2010; Chiavacci *et al.* 2011; Whitacre 2012; Carpenter & Allen 2013; Kjeldsen 2103; Enge *et al.* 2014.
Morphnus guianensis	Whitacre *et al.* 2002; Mikich & Bérnils 2004; Vargas-González *et al.* 2006a; Raine 2007; Cintra & Naka 2012; Whitacre 2012; Crease & Tepedino 2013; Gomes 2014; Gomes & Sanaiotti 2015; Sanaiotti *et al.* 2015.

Species	Located references
Harpia harpyja	Chebez 1995; Alvarez *et al.* 1996; Alvarez-Cordero 1996; de Lucca 1996; Sick 1997; Machado *et al.* 1998; Galetti & Carvalho 2000; Ibáñez *et al.* 2002; Piana 2002; Rettig 2002; Sanaiotti 2002; Hennessey *et al.* 2003; Peterson *et al.* 2003; Willis & Oniki 2003; Mikich & Bérnils 2004; Suárez *et al.* 2004; Luz 2005; Muñiz-López 2005; Silveira *et al.* 2005; Olmos *et al.* 2006; Pereira & Salzo 2006; Vargas-González *et al.* 2006a; b; Giudice *et al.* 2007; Pacheco *et al.* 2007; Piana 2007; Silva 2007; Anfuso *et al.* 2008; Trinca *et al.* 2008; Pinheiro & Dornas 2009; May 2010; Seymour *et al.* 2010; Sánchez-Lalinde *et al.* 2011; Ubaid *et al.* 2011; Vargas-González & Vargas 2011; Aguiar-Silva *et al.* 2012; Cintra & Naka 2012; Muñiz-López *et al.* 2012; O'Shea & Ramcharan 2012; Rotemberg *et al.* 2012; Aguiar-Silva *et al.* 2014; Vargas-González *et al.* 2014; Aguiar-Silva *et al.* 2015; Kuniy *et al.* 2015; Sanaiotti *et al.* 2015; Sousa *et al.* 2015; Watson *et al.* 2016.
Spizaetus tyrannus	Sick 1997; Olmos *et al.* 2006; Sigrist 2006; Lopes & Braz 2007; Canuto 2008; Carvalho-Filho *et al.* 2008; Jones & Komar 2008a; Phillips 2009; Pimentel & Olmos 2011; Canuto *et al.* 2012; Cintra & Naka 2012; Whitacre 2012; Straube *et al.* 2014; Meyer 2016.
Spizaetus melanoleucus	Andrade *et al.* 1996; Sick 1997; Reichle *et al.* 2003; Anderson *et al.* 2004; Eisermann 2007; Canuto 2008; Carvalho-Filho *et al.* 2008; Canuto 2009; Phillips 2009; Phillips & Seminario 2009; Bodrati *et al.* 2010; Canuto *et al.* 2012; Whitacre 2012; Kohler & Rezini 2013.
Spizaetus ornatus	Sick 1997; Thorstrom 1997; Andrade & Andrade 1998; Machado *et al.* 1998; Naveda-Rodríguez 2002; Seipke & Cabanne 2002; Reichle *et al.* 2003; Greeney *et al.* 2004; Mikich & Bérnils 2004; Naveda-Rodríguez 2004; Mendonça-Lima *et al.* 2006; Giudice 2007; Canuto 2008; Carvalho-Filho *et al.* 2008; Canuto 2009; Kirwan 2009; Phillips 2009; Joenck *et al.* 2011; Canuto *et al.* 2012; Cintra & Naka 2012; Whitacre 2012; Joenck *et al.* 2013; Kjeldsen 2013; Phillips & Hatten 2013; Harvey *et al.* 2014.
Spizaetus isidori	Valdez & Osborn 2002; Strewe & Navarro 2003; Valdez & Osborn 2004; Roesler *et al.* 2008; Greeney *et al.* 2011; Castañeda 2012; Araóz & Alvedaño 2013; Zuluaga & Echeverry-Galvis 2016.
Busarellus nigricollis	Sick 1997; Di Giacomo 2000; Reichle *et al.* 2003; Willis & Oniki 2003; Antas 2004; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Márquez *et al.* 2005; Chatellenaz *et al.* 2010; Knight 2010; Bertassoni *et al.* 2012; Evangelista *et al.* 2012.
Rostrhamus sociabilis	Alvarez-López & Kattan 1995; Rodgers-Jr. 1996; Sick 1997; Valentine-Darby *et al.* 1997; Bennetts *et al.* 1998; Palmer 1998; Valentine-Darby *et al.* 1998; Angehr 1999; Arballo & Cravino 1999; Bennetts & Kitchens 1999; Dreitz *et al.* 1999; Bennetts & Kitchens 2000; Dreitz 2000; Dreitz & Duberstein 2001; Dreitz *et al.* 2001; Rodgers-Jr. *et al.* 2001; Welch & Kitchens 2001; Beissinger & Snyder 2002; Bennetts *et al.* 2002; Dreitz *et al.* 2002a; b; Petracci & Basanta 2002; Reichle *et al.* 2003; Rodgers-Jr. & Schwikert 2003; Wheeler 2003; Antas 2004; Dreitz *et al.* 2004; Chatellenaz 2005; de la Peña 2005; Angehr 2006; Jiménez & Zook 2007; Rodgers-Jr. 2007; Carvalho-Filho *et al.* 2008; Jones & Komar 2008a; Reichert 2009; Chatellenaz *et al.* 2010; Palmer 2011; Bowling *et al.* 2012; Posso *et al.* 2012; Reichert *et al.* 2012; Román & Wiley 2012; Fortes & Denis 2013; Hernández-Vázquez *et al.* 2013; Bencke & Pereira 2014; Machado *et al.* 2015; Cattau *et al.* 2016.
Helicolestes hamatus	Greeney *et al.* 2004.
Harpagus bidentatus	Schulze *et al.* 2000; Walther 2003; Greeney *et al.* 2004; Carvalho-Filho *et al.* 2008; Greeney & Gelis 2008; Cintra & Naka 2012; Whitacre 2012.
Harpagus diodon	Naka & Rodrigues 2000; Azevedo *et al.* 2003; Cabanne 2005; Azevedo *et al.* 2006; Sigrist 2006; Cabanne & Roesler 2007; Carvalho-Filho *et al.* 2008; Canuto 2009; Bodrati *et al.* 2010; Lees & Martin 2014.

Species	Located references
Ictinia plumbea	Seavy *et al.* 1997; Sick 1997; Seavy *et al.* 1998; Reichle *et al.* 2003; Antas 2004; Cabanne 2005; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Angehr 2006; Carvalho & Bohórquez 2007; Pérez-León 2007; Carvalho-Filho *et al.* 2008; Gussoni & Guaraldo 2008; Salvador-Jr. & Silva 2009; Bodrati *et al.* 2010; Chatellenaz *et al.* 2010; Jacomassa 2011; Whitacre 2012; Kjeldsen 2013; Pinto-Ledezma & Justiniano 2013; Chatellenaz 2015; Maciel *et al.* 2016.
Circus cinereus	Saggese & de Lucca 1995; Donázar *et al.* 1996; Maurício & Dias 1996; Sick 1997; Arballo & Cravino 1999; Bó *et al.* 2000; Jaksic *et al.* 2002; Bó *et al.* 2004; de la Peña 2005; Baladrón *et al.* 2007; Camilotti *et al.* 2008; Capllonch *et al.* 2011; Alvarado *et al.* 2015.
Circus buffoni	Bó *et al.* 1996; Sick 1997; Arballo & Cravino 1999; Bó *et al.* 2004; Chatellenaz 2005; Carvalho-Filho *et al.* 2008; Kirwan & Shirihai 2008; Chatellenaz *et al.* 2010; Alvarado *et al.* 2015.
Accipiter poliogaster	de Vries & Melo 2000; 2002; Thorstrom 2002a; Bodrati *et al.* 2010; Lima & Ribeiro 2011; Boesing *et al.* 2012.
Accipiter superciliosus	Hennessey *et al.* 2003; Thiollay 2007; Carvalho-Filho *et al.* 2008; Bodrati *et al.* 2010.
Accipiter collaris	Cuervo *et al.* 2008.
Accipiter gundlachi	Rompré *et al.* 1999; Wallace *et al.* 1999; Peña *et al.* 2012; Ferrer-Sánchez & Rodríguez-Estrella 2014; Ferrer-Sánchez 2015; Ferrer-Sánchez & Rodríguez-Estrella 2016.
Accipiter bicolor	Pavez & González 1998; Thorstrom & Kiff 1999; Thorstrom & Quixchán 2000; Reid *et al.* 2002; Figueroa *et al.* 2004a; b; Mikich & Bérnils 2004; Ojeda *et al.* 2004; Carvalho-Filho *et al.* 2005; Figueroa *et al.* 2007; Marini *et al.* 2007; Azpiroz & Menéndez 2008; Carvalho-Filho *et al.* 2008; Canuto 2009; Bodrati *et al.* 2010; Zorzin 2011; Whitacre 2012; Hayes 2014; Alvarado *et al.* 2015; Medel-Hidalgo *et al.* 2015; Rivas-Fuenzalida 2015b; Rivas-Fuenzalida *et al.* 2015c.
Geranospiza caerulescens	Sick 1997; Arballo & Cravino 1999; Sutter *et al.* 2001; del Ángel 2002; Reichle *et al.* 2003; Chatellenaz 2005; Sigrist 2006; Carvalho-Filho *et al.* 2008; Canuto 2009; Whitacre 2012.
Buteogallus anthracinus	Barrantes 1998; Boal 2001; Barradas-García *et al.* 2004; Márquez *et al.* 2005; Barradas-García & Morales-Mávil 2007; Clark 2007b; Pérez-León 2007; Flesch 2008; Sadoti 2008; Troy & Stahlecker 2008; Flesch 2009; Ruvalcaba-Ortega & González-Rojas 2009; Alava *et al.* 2011; Sadoti 2012; Uribe-Hernández *et al.* 2012; Etzel *et al.* 2014; Smith & Finch 2014; Licence & McCarty 2015.
Buteogallus aequinoctialis	Mikich & Bérnils 2004.
Buteogallus meridionalis	Narozky & Martelli 1995; Best *et al.* 1996; Sick 1997; Andrade & Andrade 1998; Arballo & Cravino 1999; Reichle *et al.* 2003; Antas 2004; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Navarro *et al.* 2007; Carvalho-Filho *et al.* 2008; Strewe *et al.* 2009; Chatellenaz *et al.* 2010; Marini *et al.* 2012; Maurício *et al.* 2013; Camacho-Varela *et al.* 2015; Silva & Machado 2015.
Buteogallus lacernulatus	Carvalho-Filho *et al.* 2008; Canuto 2009.
Buteogallus urubitinga	Best *et al.* 1996; Seavy & Gerhardt 1998; Arballo & Cravino 1999; Di Giacomo 2000; Naveda-Rodríguez 2002; Reichle *et al.* 2003; Antas 2004; Naveda-Rodríguez 2004; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Carvalho-Filho *et al.* 2006; Carvalho-Filho *et al.* 2008; Canuto 2009; Chatellenaz *et al.* 2010; Whitacre 2012; Kjeldsen 2013.
Buteogallus solitarius	Mee *et al.* 2002; Strewe & Navarro 2003; Jones 2005; Clark 2007a; Seminario *et al.* 2011; Phillips 2012; Phillips & Martinez 2013; Phillips *et al.* 2014.

Species	**Located references**
Buteogallus coronatus	Sick 1997; Bellocq *et al.* 1998; Machado *et al.* 1998; Carvalho *et al.* 2002; Maceda *et al.* 2003; Mikich & Bérnils 2004; de la Peña 2005; Di Giacomo 2005; Albuquerque *et al.* 2006; Barcellos & Accordi 2006; Granzinolli *et al.* 2006; Torres *et al.* 2006; Bragagnolo *et al.* 2007; Lobos *et al.* 2007; Maceda 2007; Maceda *et al.* 2007; Carvalho-Filho *et al.* 2008; Tizianel 2008; Chiaravalloti *et al.* 2009; Sarasola *et al.* 2010; Banhos & Sanaiotti 2011; Lobos *et al.* 2011; Berkunsky *et al.* 2012; Fandiño & Pautasso 2013; Urios *et al.* 2014; Kilpp 2015; Montalvo *et al.* 2015; Barbar *et al.* 2016.
Morphnarchus princeps	Sánchez & Sánchez-M. 2002; Muela & Valdez 2003; Márquez *et al.* 2005; Greeney & Nunnery 2006; Gelis & Greeney 2007; Greeney *et al.* 2008.
Rupornis magnirostris	Best *et al.* 1996; Capllonch 1997; Maragliano & Montalti 1997; Arballo & Cravino 1999; Naka & Rodrigues 2000; Panasci & Whitacre 2000; Carvalho *et al.* 2001a; Höfling & Camargo 2002; Naka *et al.* 2002; Panasci & Whitacre 2002; Reichle *et al.* 2003; Antas 2004; Bó *et al.* 2004; Chatellenaz 2005; de la Peña 2005; Di Giacomo 2005; Marini *et al.* 2007; Navarro *et al.* 2007; Carvalho-Filho *et al.* 2008; Gussoni & Guaraldo 2008; Salvador-Jr. & Silva 2009; Santos & Rosado 2009; Santos *et al.* 2009; Verea *et al.* 2009; Bodrati *et al.* 2010; Chatellenaz *et al.* 2010; Cavicchia & García 2012; Cintra & Naka 2012; Mojica 2012; Panasci 2012; Panasci unpub. data *apud* GRIN 2012; Uribe-Hernández *et al.* 2012; Romano *et al.* 2015.
Parabuteo unicinctus	Blue 1996; Silva & Olmos 1997; Arballo & Cravino 1999; Gerstell & Bednarz 1999; Patten & Erickson 2000; Maceda & Kin 2001; Willis & Oniki 2003; de la Peña 2005; Márquez *et al.* 2005; Dwyer 2006; Figueroa & González-Acuña 2006; Jenner *et al.* 2007; Pérez-León 2007; Dwyer & Mannan 2009; Ellis *et al.* 2009; Cavicchia & García 2012; Furman & Bastías 2012; Alvarado *et al.* 2015.
Parabuteo leucorrhous	Freile & Chaves 2000; Mikich & Bérnils 2004; Greeney & Nunnery 2006; Tobias & Seddon 2007; Zilio & Mendonça-Lima 2012.
Geranoaetus albicaudatus	Sick 1997; Bellatti 2000; Granzinolli 2003; Reichle *et al.* 2003; Di Giacomo 2005; Granzinolli & Motta-Junior 2006; Granzinolli *et al.* 2006; Actkinson *et al.* 2007; Granzinolli & Motta-Junior 2007; Rappole *et al.* 2007; Carvalho-Filho *et al.* 2008; Haralson 2008; Actkinson *et al.* 2009; Brown & Glinski 2009; Salvador-Jr. & Silva 2009; Motta-Junior *et al.* 2010; Greeney *et al.* 2011; Maurício *et al.* 2013.
Geranoaetus polyosoma	Jiménez 1995; Donázar *et al.* 1996; Jaksic & Lazo 1999; Bó *et al.* 2004; de la Peña 2005; Alvarado & Figueroa 2006a; Cabot & de Vries 2009; Cabot *et al.* 2010a; b; Greeney *et al.* 2011; Hahn *et al.* 2011; Lüthi 2011; Alvarado *et al.* 2015; Shirihai *et al.* 2015.
Geranoaetus melanoleucus	de Lucca & Saggese 1995; Hiraldo *et al.* 1995; Narozky & Martelli 1995; Best *et al.* 1996; Donázar *et al.* 1996; Sick 1997; Arballo & Cravino 1999; Jaksic & Lazo 1999; Sousa 1999; Bellatti 2000; Pavez 2001; Saggese & de Lucca 2001; Bencke *et al.* 2003; de la Peña 2005; Trejo *et al.* 2006b; Zorzin *et al.* 2007; Salvador-Jr. *et al.* 2008; Chatellenaz *et al.* 2010; Arriagada *et al.* 2011; Lüthi 2011; de Lucca & Saggese 2012; Alvarado *et al.* 2015; Ignazi 2015; Pérez 2015; Raimilla *et al.* 2015; Lemos 2016.
Pseudastur polionotus	Willis & Oniki 2002; Bencke *et al.* 2003; Corrêa *et al.* 2008; Canuto 2009.
Pseudastur albicollis	Draheim 1995; Cisneros-Heredia 2006; Cintra & Naka 2012; Whitacre 2012.
Pseudastur occidentalis	Vargas 1995; Best *et al.* 1996.
Leucopternis semiplumbeus	Ferguson-Lees & Christie 2001.
Leucopternis melanops	Ferguson-Lees & Christie 2001; Cintra & Naka 2012.
Leucopternis kuhli	Kirwan 2009.
Buteo plagiatus	Bibles & Mannan 2004; Werner 2004; Patrikeev 2007; Rappole *et al.* 2007; Flesch 2008; Flesch & Saavedra 2008; Flesch 2009; Ruvalcaba-Ortega & González-Rojas 2009; Sandoval 2009; Vargas-Masís & Ramírez 2012.

Species	Located references
Buteo nitidus	Sick 1997; Reichle *et al.* 2003; Navarro *et al.* 2007; Sandoval 2009; Strewe *et al.* 2009; Cintra & Naka 2012.
Buteo ridgwayi	Thorstrom 2002b; Thorstrom *et al.* 2005; 2007; Woolaver 2011; Woolaver *et al.* 2013a, b, c, Woolaver *et al.* 2015.
Buteo albigula	Gelain *et al.* 2001; Trejo *et al.* 2001; Ojeda *et al.* 2003; Pavez *et al.* 2004; Trejo *et al.* 2004; Trejo *et al.* 2006a; Silva-Rodríguez *et al.* 2008; Henry & Aznar 2009; Rivas-Fuenzalida *et al.* 2013; Alvarado *et al.* 2015; Rivas-Fuenzalida *et al.* 2015b.
Buteo brachyurus	Naka & Rodrigues 2000; Carvalho *et al.* 2001a; Jones 2002; Wheeler 2003; Meyer 2004, 2005; Meyer & Zimmerman 2007; Rappole *et al.* 2007; Williams-III *et al.* 2007; Brush 2008; Carvalho-Filho *et al.* 2008; Flesch 2008; Rizkalla *et al.* 2009; Salvador-Jr. & Silva 2009; Howell 2010; Snyder *et al.* 2010; Monsalvo 2012; Enge *et al.* 2014; Straube *et al.* 2014; Oliveira *et al.* 2015; FWC [s.d.].
Buteo galapagoensis	Faaborg *et al.* 1995; DeLay *et al.* 1996; Bollmer *et al.* 2003; Whiteman & Parker 2004a; b; Bollmer *et al.* 2005; Jaramillo & Vargas 2010; Rivera *et al.* 2011; Muñoz 2012.
Buteo albonotatus	Kennedy *et al.* 1995; Sick 1997; Pérez-León 2007; Carvalho-Filho *et al.* 2008; Flesch 2008; Howell 2010; Olmos & Albano 2012.
Buteo ventralis	Figueroa *et al.* 2000; Imberti 2003; Rivas-Fuenzalida *et al.* 2009, 2011; Norambuena *et al.* 2012; Medel-Hidalgo *et al.* 2013; Norambuena *et al.* 2013; Raimilla *et al.* 2013; Rivas-Fuenzalida & Asciones-Contreras 2013; Figueroa unpub. data *apud* GRIN 2015; Rivas-Fuenzalida 2015a; Rivas-Fuenzalida & Asciones-Contreras 2015; Rivas-Fuenzalida *et al.* 2015a, 2016.

APPENDIX II

Complete list of references retrieved in this review and cited in Appendix I.

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APPENDIX III

Results of the search for literature breeding data of two species of Accipitriformes not presented on Bierregaard-Jr.'s (1995) review.

Sharp-shinned Hawk *Accipiter striatus* – the vast majority of breeding records of the so-called "Central and South American group" of subspecies (*sensu* Ferguson-Lees & Christie 2001) refer to *A. s. erythronemius*, whose breeding traits were classified as entirely unknown by Bierregaard-Jr. (1995; but see comments by Di Giacomo 2005). Different populations of this subspecies' range were studied in detail, but most other breeding reports are anecdotal. Central American *A. s. chionogaster* (also labeled as having unknown breeding biology by 1995) now at least had one of its populations studied in detail. Finally, the Andean form *A. s. ventralis* have no new breeding data; its nest remains undescribed, and knowledge on breeding behavior is based solely on older scattered information (Bierregaard-Jr. 1995).

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Cuban Black Hawk *Buteogallus gundlachii* – apparently there is still little breeding data, as we located very few reports, and just two of these studies provide more detailed descriptions of breeding events.

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APPENDIX V

Results of the search for photographic breeding records of Neotropical Accipitriformes on the WikiAves database.

Species	Records' reference numbers
Elanus leucurus	WA1251178; WA1253853; WA1263279; WA1272398; WA1272409; WA1279861; WA1281964; WA1288071; WA1290781; WA1293418; WA1300395; WA1376684; WA1499798; WA1720428; WA1721934; WA1770437; WA1835635; WA1835637; WA1837761; WA1841067; WA1904171; WA2037143; WA2071064; WA2090188; WA21325; WA21537; WA2271383; WA250965; WA466357; WA661980; WA698506; WA719423; WA729366; WA732823; WA915133; WA915840; WA915852; WA936035.
Chondrohierax uncinatus	WA1160532; WA1688095; WA1937776; WA1968066; WA1981003.
Leptodon cayanensis	WA723947; WA723948.
Leptodon forbesi	WA938449.
Spizaetus melanoleucus	WA1140737; WA1140739; WA1370302; WA1378059; WA1438023; WA195643; WA2206395; WA2242350; WA2249207; WA2322423.
Rostrhamus sociabilis	WA1214147; WA1218422; WA1280372; WA147627; WA1493450; WA1588325; WA1771055; WA2021254; WA2021256; WA2108507; WA226747; WA24193; WA36753; WA474247; WA484024; WA64884; WA696195; WA696196; WA81214; WA819399.
Helicolestes hamatus	WA1589021; WA1966794; WA953944.
Harpagus bidentatus	WA2198552; WA2240795; WA668871.
Harpagus diodon	WA1156861; WA1200479; WA1228366; WA123732; WA1237599; WA14961; WA14962; WA1966820; WA1966889; WA206624; WA209513; WA219297; WA219978; WA222095; WA222762; WA244381; WA250110; WA251551; WA252886; WA255778; WA255779; WA255914; WA257012; WA275906; WA280598; WA507006; WA73820; WA76435; WA76436; WA76815; WA785304; WA819506; WA82627; WA860802; WA861618; WA884512; WA887671; WA887710; WA889684; WA897892; WA900167; WA98349.
Accipiter poliogaster	WA1920902; WA1985763; WA1989199; WA1992309; WA1994808; WA2005934; WA2034929; WA2047459; WA2132296; WA2319849; WA779787.
Accipiter bicolor	WA106136; WA1744297; WA89938.
Geranospiza caerulescens	WA140630; WA141005; WA1444043; WA1565980; WA1649149.
Buteogallus anthracinus	WA950092.
Buteogallus aequinoctialis	WA1503515.
Pseudastur polionotus	WA1570081; WA1570097; WA1581106.
Pseudastur albicollis	WA215803; WA722126.
Buteo nitidus	WA1184610; WA1392108; WA2187978; WA2187993; WA388429; WA476978; WA506191.
Buteo brachyurus	WA1116480; WA1356894; WA1356902; WA176090; WA176091; WA2033914; WA225567; WA33877; WA513759; WA513770; WA513777; WA513781; WA513790; WA513819; WA513828; WA819112; WA819113.

APPENDIX VI

Proposed corrections to four misidentified museum egg sets of Neotropical Accipitriformes. Arguments referring to geographical distribution are not presented since all species involved are sympatric at these collection localities (del Hoyo *et al.* 2016).

Set WFVZ 15561 - formerly assigned to Lined Forest-Falcon *Micrastur gilvicollis.* Seemingly, no information exists on Lined Forest-Falcon's eggs (Bierregaard-Jr. 1995, GRIN 2009, del Hoyo *et al.* 2016). This one-egg set was obtained by G. D. Smooker, whose identifications have already been questioned (Thorstrom & Kiff 1999). More importantly, the egg is much larger than those of another similar-sized, closely-related *Micrastur* falcon (Whitacre 2012). Thus, we doubt it could be properly atributed to Lined Forest-Falcon.
Measurements, clutch-size and overall appearance are suitable with known clutches of the Gray-headed Kite measured by us and to other data presented by Whitacre (2012). Thus, it almost certainly belongs to this species.
We recommend the treatment of this set as cfr. *Leptodon cayanensis*.

Set WFVZ 15951 - previously assigned to Black-collared Hawk *Busarellus nigricollis.* Also from Smooker's collection. Measurements of theses two eggs are much smaller than Black-collared Hawk's eggs (GRIN 2010), but consistent with those of Zone-tailed Hawk *Buteo albonotatus* (del Hoyo *et al.* 2016), as suggested by L. Kiff on the data slip of this set. Yet, contrary to the previous and next cases, these species overall appearances and "field jizzes" are quite different (J.A.B.M., pers. obs.) to justify such a misidentification by the collector. Also, dimensions, clutch-size and general appearance of the eggs did not allow a rigorous identification. We do not discard that the clutch refers to Zone-tailed Hawk, but evidence is not conclusive as they may refer to other hawks as well.
We recommend that this set should not be treated as *Busarellus nigricollis*, and tentatively identify as cfr. *Buteo albonotatus*.

Sets WFVZ 16312 and 16313 - both formerly assigned to Hook-billed Kite *Chondrohierax uncinatus.*
These three eggs are very distinct from, and much larger than, Hook-billed Kite's (J.A.B.M., pers. obs., Di Giácomo 2000, Whitacre 2012). Both dimensions, clutch-sizes and overall appearance fits with Gray-headed Kite's clutches. Albeit measurements of the two-egg clutch (WFVZ 16312) are slightly smaller than most Gray-headed Kite's, they fit with those of another two egg-clutch of this species, provided by Carvalho-Filho *et al.* (2005).
We assign these sets to *Leptodon cayanensis*.

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