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Capa: Indivíduo macho de tuim *Forpus xanthopterygius*, espécie politípica com ampla distribuição na América do Sul e que tem nesse volume sua taxonomia revisada por Bocalini & Silveira. Foto: Edson Endrigo.

Cover: Male Blue-winged Parrotlet *Forpus xanthopterygius*, a polytypic and widely distributed species in South America and whose taxonomy is revised in this volume by Bocalini & Silveira. Photo: Edson Endrigo.

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How to capture breeding Southern Lapwing *Vanellus chilensis*

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ABSTRACT: The Southern Lapwing (*Vanellus chilesnis*) is a common bird in Southern America and commonly found in any large open areas, including agriculture and urban. The lapwing is a facultative cooperative breeder and aggressively defends its breeding territory. Thus, the breeding system and their consequences for reproductive success are interesting for evolutionary biology. Capture of the lapwing, however, is difficult. Most studies to date have not captured or individually marked birds even though identifying individuals to examine their roles in the breeding units is essential for understanding group evolution and interactions. Here we describe ways to efficiently capture the Southern Lapwing during the breeding season using mist-nets at night and by taking advantage of their defensive behaviors. Before hatching, nets were placed inside the breeding territories and by strategically walking towards the birds they were guided towards the nets, in which they fell when taking flight. After hatching, we captured the young birds and held them near the nets in which the adults fell when defending them. By using these methods, we captured 78 birds during the 2012 and 2013 breeding seasons. We observed no nest nor territory abandonment after captures. We suggest that our methods are useful in most situations with lapwings and better capture and marking will contribute to developing long-term population monitoring.

KEYWORDS: Charadriidae, methods, mist-net, parental defense, shorebird.

INTRODUCTION

Understanding population dynamics, breeding behaviors and many other aspects of biology in many animals and especially birds requires their capture to uniquely mark each individual. Capturing, marking and recapturing some species of birds are relatively easy, and extremely difficult for others (Martin 1969, Braga *et al.* 2014). Some birds also remember conditions of their captures and avoid them in the future (Marzluff *et al.* 2010). The Southern Lapwing *Vanellus chilensis* (Molina, 1782) (Charadriiformes: Charadriidae) is very widespread in South America and much less common elsewhere (Martin 1997, Sánchez *et al.* 1998, Abrego 2012). Capturing this shorebird is extremely difficult. As birds of open areas, they apparently see and avoid nets. They are very defensive and, if they recognize a person as a threat, often attack the person (Costa 2002, *pers. obs.*). Finally, when one bird vocalizes it gathers the attention of other birds nearby and can alert them to potential captures and they seem to remember, often for extended periods of time, their capturer (*pers. obs.*).

The Southern Lapwing lives and nests on the ground in open areas and has become accustomed to urban areas (Sick 1997). Breeders can often use the same breeding territory in consecutive breeding seasons (Saracura 2003, *pers. obs.*). Lapwings are cooperative breeders with a flexible reproductive system, the details of which are still poorly known but may include pairs or cooperative breeding groups with three or four individuals (Walters & Walters 1980, Walters 1982, Saracura *et al.* 2008, Santos & Macedo 2011). Thus, understanding dynamics of lapwing breeding groups can provide information for understanding breeding system evolution (Costa 2002, Macedo 2008, Maruyama *et al.* 2010). Additionally, their study can inform wildlife management strategies (lapwings often use airports and may interfere with flights; Nascimento *et al.* 2005, Guedes *et al.* 2010).

Previous studies of behavioral and reproductive ecology of this common species relied on simple observations, without capturing and marking (Walters & Walters 1980, Walters 1982, Gallegos Luque 1984, Costa 2002, Maruyama *et al.* 2010). Only one study described capturing birds by using fall traps and nylon nooses near the nest (Saracura *et al.* 2008). However, they were unable to capture all birds in any family group and only captured a fraction of the total number of birds under study. Here, we describe how we captured all members of breeding units of the Southern Lapwing during the breeding season by using mist-nets at night.

METHODS

Study site

As part of a reproductive behavioral study underway, we captured the Southern Lapwing in the city of Curitiba (49°14' W, 25°27' S), state of Paraná, southern Brazil. During the 2012 breeding season (August – December) we captured on a campus of the Federal University of Paraná, and during 2013 breeding season (November 2013 – January 2014) on a campus of the Federation of Industries of Paraná (FIEP). The study site includes buildings, grassy lawns (including sports fields that are used for nesting), streets lined with trees and small patches of native forest.

Directed capture before hatching

During the breeding season and upon recognizing a breeding territory, prior to approaching birds, we setup 2 - 4 mist nets (mesh size 5 x 5 cm, 15 m length, 3 m height) at night. Nets were placed inside breeding territories but not too close from nests (> 10 m). Once nets were open and ready, we then walked away from the nets and to the opposite side of the nest and then slowly walked towards the nest until birds recognized us as intruders. Upon recognition, birds began their defensive display, in which they squatted and emitted alarm calls and walked away from the nests. We continued slowly walking towards the birds such that their walking away from us took them closer to the nets (3 to 5 m), at which time we suddenly ran in their direction forcing them to fly away, thereby flying into the net (Figure 1A). We immediately and quickly removed the bird or birds, banded them, released them and closed and removed the nets and left the area.

Baited capture with young birds

Young birds soon after hatching and when adults sound an alarm call (or when startled) immediately lie down and hide motionless. Thus, to avoid stepping on young birds, after they hatched we changed the capture technique. At this time, adults are more alert and more quickly call and fly away rather than defensively displaying at a nesting site. We then used the young as bait (Picman 1979, Picman *et al.* 2002). Young were at least two weeks old as a precaution against possible problems due to temperature regulation; adults brood young for several days after hatching (Walters 1982).

First, from a distance that did not cause an alarm response from the adult birds we were interested in capturing, we located the young shortly before sunset using binoculars or a spotting scope. Once all young were located, we quickly entered the area and captured them by hand. Then we quickly set up two mist-nets in a "V" formation (Martin 1969). At this time it was twilight or dark and we released the young inside the two arms of the "V" (Figure 1B). We retreated from the area, waited 10 min and then checked the nets. Sometimes, under campus lighting, we continuously observed birds and nets. If the birds were captured, we quickly processed them as described above and left the breeding area. If not, when an adult bird was near the "V" we ran (as described above) or walked briskly towards the birds to drive them into the nets.

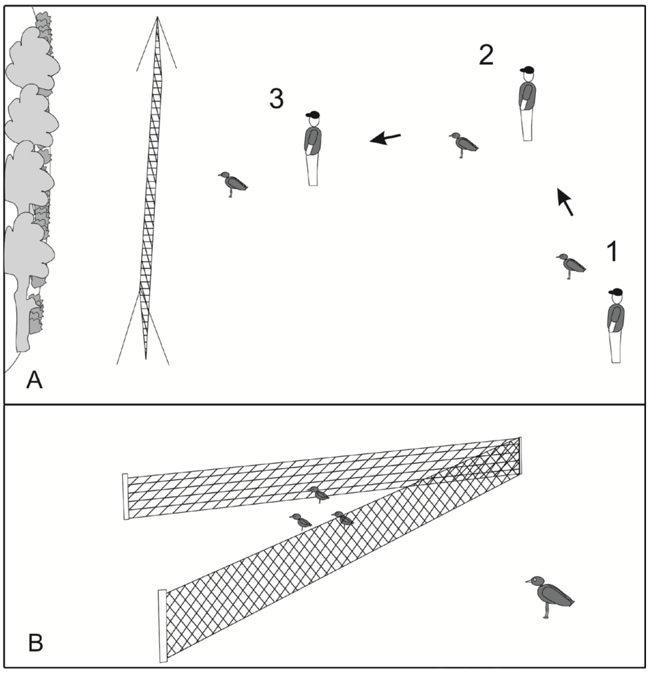

FIGURE 1. Schematic diagrams of the (A) directed capture and (B) young as bait methods to capture the Southern Lapwing (*Vanellus chilensis*) at night and in the breeding season. Scenarios are shown in (A), where a researcher directs a target individual to a mist-net during the night (arrows and numbers indicate the sequence), and in (B), where the mist-nets are set up in a "V" shape with the young within the "V" that draws the birds to the young, and thereby fall into the net.

RESULTS

We captured 52 lapwings during 26 nights in 2012 breeding season, and 26 during five nights in 2013 breeding season. Captured birds included all individuals that hatched eggs in the study site (n = 61), comprising nine breeding pairs and seven breeding groups (three or four individuals) in 2012, and all individuals in four pairs and four groups in 2013. Also, we captured additional birds that did not reproduce in the study site (12 in 2012, and five in 2013). Most birds were captured before hatching (81%, n = 42 in 2012 and n = 16 in 2013, Table 1). No abandonment of nests, young birds or breeding territories occurred after adults were captured.

TABLE 1. Number of adult individuals of the Southern Lapwing (*Vanellus chilensis*) captured by reproductive stage and method.

Reproductive Stage	Method	n
2012 breeding season		
Pre-laying	Directed	24
Laying/Incubation	Directed	18
Post-hatching	Young as bait	10
2013 breeding season		
Laying/Incubation	Directed	14
Post-hatching	Young as bait	12

DISCUSSION

We captured all nesting birds we wished to capture in both breeding seasons (n = 61), using the methods we described here. Other studies had no individuals captured or seldom more than one individual marked in any breeding unit (Walters & Walters 1980, Walters 1982, Gallegos Luque 1984, Saracura *et al.* 2008). Thus, by efficient use of these methods, we were able to capture at night and then observe behaviors during the day of uniquely marked individuals, which was essential for our study of mating systems, which otherwise would have been impossible.

In our preliminary attempts to capture the lapwing, aside from standard setting of mist-nets, we attempted to throw fish nets and mist-nets over birds at night, which worked reasonably well for Northern Lapwings *Vanellus vanellus* (Thompson *et al.* 1994). We also tried to launch nets using an air-pressure launcher. We built a drop-net system, but birds never entered the trap. We also attempted using nylon nooses and cages near nests (Berg *et al.* 2002, Saracura *et al.* 2008), all unsuccessfully. We captured one adult by hand while it was on the nest, reluctant to leave as we approached, but that nest was then abandoned. Once we began using the two methods we describe here, we soon discovered that these successful methods had no apparent negative effects on birds.

Lapwings are aggressive and may react differently to different intruders (Costa 2002) and there are behavioral differences between individuals (*pers. obs.*). Thus, observing target birds prior to capture aids in determining where to put nets, what path to walk to force birds towards the nets and so on. Even at night, lapwings sometimes see mist-nets, especially when cloudy and in areas with artificial lights. In some occasions, we used structures as trees, buildings, or simply elevations in the terrain as backgrounds for the nets to avoid detection by the lapwings. In darker areas without urban lights, captures should be even easier. Also, wind causes nets to move around and then they are easier to see (Martin 1969) so we recommend capturing when wind is not an issue. Additionally, if nets are placed too close to nests, birds can easily perceive the nets. Thus it is important to have nets ready to quickly deploy and at distances greater than around 10 m from the nests. Flashlights should be avoided because birds often immediately flee the area once illuminated (but see Thompson *et al.* 1994 for different results with the Northern Lapwing). Even when birds are difficult to see, they may continue to vocalize and can be followed by sound.

Because birds in the study site are more or less accustomed to people, in our first tries (prior to egg laying) at directed captures, we easily walked to within 10 m (or less) of the birds. However, once eggs were laid and incubation began, stronger defensive behaviors occurred. Most individuals walked away, stopped and squatted while giving alarm calls (Costa 2002). Birds that behaved that way were usually easily captured. However, some birds flew away more quickly and were somewhat harder to capture. In this case, we found out that it was better to simply come back later, after hatching, to use the young as bait.

As we practiced, our own capture success increased. Thus, captures were quicker and more efficient during the second year. Because most breeding pairs and groups reproduce in the same breeding territory in subsequent years, recapturing is unnecessary as identifying them by their bands is equivalent to capture for longevity studies. Thus, capture effort for long-term studies can be concentrated in the first year of study and as necessary in subsequent years. During the second breeding season monitoring the Southern Lapwing in the campus of the Federal University of Paraná we only needed to capture a few individuals (seven birds) to again have all individuals marked.

By capturing breeding units, a more efficient, more detailed population study became possible. By capturing birds at night, they are less likely to recognize the people involved and so subsequent observations do not cause attacks by the birds. We found that birds sometimes remember, and attack, the researcher when walking through the breeding area without stopping to observed birds, and up to a year after original capture or after capturing their young. Finally, no negative effects were detected in captured birds and abandonment never occurred, in contrast to a previous study (Saracura *et al.* 2008). Thus, these methods are useful for the Southern Lapwing and may be adaptable to a variety of situations, such as studies in natural environments. Using these techniques we are beginning to unravel the complexity of the Lapwing breeding system.

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First description of a nest of the Rufous-tailed Antthrush *Chamaeza ruficauda*

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ABSTRACT: I report a nest of Rufous-tailed Antthrush discovered on 9 December 1998 in the Serra dos Órgãos National Park, Rio de Janeiro, Brazil at the altitude of 1950 m. The nest was located in a natural tree cavity with vertically-elliptical entrance hole ca. 5 m above the ground. It was a thick pad of piled bamboo leaves, leathery tree leaves, fungal rhizomorphs, grass, and a piece of cellophane. The nest contained two nearly fully-grown nestlings, which were fed by both parents. The architecture of the nest and parental behavior are compared to those of other antthrushes.

KEY-WORDS: Formicariidae, Atlantic Forest, *Chusquea*, bamboo, snake skin.

The Neotropical family Formicariidae was thought to include both the antthrushes, characterized by cavity nests and unmarked white eggs, and the antpittas, with open cup nests and often marked eggs (Ridgely & Tudor 1994, Krabbe & Schulenberg 2003). However, recent studies based on genetic markers have recovered these two groups as non-sister clades and, as a result, the formicariid family was restricted to the antthrush genera *Chamaeza* and *Formicarius* (Rice 2005, Ohlson *et al.* 2013, Remsen *et al.* 2014). The antpitta genera *Grallaria*, *Hylopezus*, and *Myrmothera* were reclassified as Grallariidae, and *Pittasoma* antpittas were transferred to Conopophagidae.

Nesting biology of the antthrushes remains poorly known and nests have been described for only two of the six currently recognized species of *Chamaeza* and four of the six *Formicarius* (Krabbe & Schulenberg 2003). In *Chamaeza*, nest descriptions are based on a few (*C. campanisona*) or merely a single nest (*C. nobilis*). Among the species lacking any information on nest architecture is the Rufous-tailed Antthrush (*Chamaeza ruficauda*) and its two purportedly sister taxa with which this species has been confused in the past, the Cryptic (*C. meruloides*) and Schwartz's (*C. turdina*) antthrushes (see Raposo & Teixeira 1992, Willis 1992).

The Rufous-tailed Antthrush is a restricted-range species endemic to the Atlantic Forest region of South America. It inhabits humid forests and secondary woodlands with dense understory of bamboo. It prefers mountainous terrain as high as 2200 m a.s.l. in the Serra do Mar of south-eastern Brazil, but as low as 500 m in Rio Grande do Sul and 320 m in Misiones, Argentina (Ridgely & Tudor 1994, Bencke & Kindel 1999, Krabbe & Schulenberg 2003, Bodrati & Cockle 2006). In areas of sympatry with *C. meruloides* and *C. campanisona*, *C. ruficauda* tends to inhabit higher elevations (Willis 1992, Krabbe & Schulenberg 2003). All three species co-occur in the Organ Hills (Serra dos Órgãos) subrange of Serra do Mar where *C. ruficauda* is uncommon above 800 m (Mallet-Rodrigues *et al.* 2007; see also sound archives data of the Cornell University Macaulay Library and www.xeno-canto.org). Here I describe a nest of *C. ruficauda* found in this area.

The nest was discovered along the Bell Rock Trail (Trilha da Pedra do Sino) at 1950 m a.s.l. in the Serra dos Órgãos National Park, Rio de Janeiro (approximate coordinates 22°27'25" S, 43°01'10" W). The habitat was upper montane rain forest with 10-15 m tall canopy, and a dense understory of *Chusquea* and *Merostachys* bamboo. On 10 December 1998 I was able to locate a nest by following the adults carrying food to the nestlings. The birds were not particularly shy and could be easily observed from a distance of ca. 30 m through a 10 x 42 Zeiss binoculars.

The nest was located in a natural cavity in a tree growing at the bottom of a narrow, steep-sided ravine with a small creek running through it (Figure 1A). The lip of the nest hole was ca. 5 m up from the base of the tree but only 2 m above the level of a nearby trail. The nest tree was a broken-top stump with a smooth, light-colored bark and was 42 cm in diameter at the level of cavity entrance. The entrance hole was facing down slope (SSW, 220°), opened upwards, and was constricted to 10 cm in diameter at the level of the lip (Figure 1B). The cavity was not visible from the ground because of a thick layer of *Chusquea* bamboo just below it, but was not concealed by vegetation from above.

The actual nest was 45 cm below the lip of the entrance and was a shallow cup ca. 12 cm in diameter. It was a thick accumulation of piled and only loosely compacted plant material (Figure 2). I was able to examine only the top 5 cm layer of the nest. The bulk of it consisted of dry leaves and fragmented nodal sheaths of bamboo (mainly *Chusquea leptophylla*, with a few broader leaves of *Chusquea aff. anelytroides*). Mixed with the bamboo leaves were some black rhizomorphs of marasmioid fungus and a few grass blades, and the top layer also included a few leathery evergreen tree leaves and a 4 x 3 cm piece of cellophane. The nest cup and the lip of the cavity were not soiled with fecal material.

FIGURE 1. The Rufous-tailed Antthrush nest site, with nest entrance hole indicated with an arrow (A), and nest cavity seen from above (B).

FIGURE 2. A sample of plant material from the top layer of the nest of Rufous-tailed Antthrush.

The nest contained two completely feathered nestlings one of which was removed briefly for examination. It had fully open eyes and bill (exposed culmen) ca. 13 mm long. In coloration it was similar to the attending adults but more ochraceous ventrally. The rectrices were about half-grown and without distal darkening or pale terminal fringe characteristic of the lower-elevation congeners, *C. meruloides* and *C. campanisona*. The attending adults also had uniform rufous-brown tails, concolor with the back, and were more uniformly rufescent dorsally than the parapatric *C. meruloides*, which tend to be more olivaceous brown with a contrasting rufous brown forecrown. During ca. 1.5 h of observation in mid-morning, the nestlings were fed only four times. The food items brought for them were too mangled to be identifiable through binoculars. Both adults were involved in nestling provisioning. At one instance, both of them arrived at the nest with food at the same time. Instead of flying to it directly, the parents accessed the nest by climbing a system of interconnected, diagonally oriented bamboo stems, lianas, and fallen branches suspended in a dense matrix of *Chusquea* bamboo just below the nest. In contrast, they left the nest by flying out directly. On one occasion, the exiting bird appeared to have been carrying a white fecal sac. Occasionally the adults uttered short, guttural "krrr", either contact or alarm call.

This first nest of *C. ruficauda* is similar in its placement to the few known nests of other *Chamaeza* species. The selection by *C. ruficauda* of a natural tree cavity with vertically-elliptical entrance hole is shared with *C. nobilis* in Colombia (Cadena *et al.* 2000) and *C. campanisona* in Argentina and Brazil (Maders & Matuchaka 2011, Franz 2013; see also A. Studer photographs in Krabbe & Schulenberg 2003 and a presumed nest in Bencke 1998). *C. campanisona* are also said to nest in crevices in earthen banks (Canevari *et al.* 1991, Krabbe & Schulenberg 2003). The height above the ground of the *C. ruficauda* nest (*ca.* 5 m) falls at the upper limit of the range reported for *Chamaeza* in the literature (1-5.13 m), and the cavity depth (45 cm) on the lower end of the reported range (21-100 cm).

The composition of the nest described herein agrees well with that of previously reported nests of *C. campanisona*, but not *C. nobilis*. Nests of the former tend to be simple cups or platforms of plant material, typically leathery evergreen tree leaves (Bertoni 1901, Maders & Matuchaka 2011, Franz 2013). In contrast, the only known nest of *C. nobilis* consisted merely of a few feathers at the bottom of the cavity (Cadena *et al.* 2000). My nest was rather bulky and composed of a wider range of plant materials.

The presence of a piece of cellophane in the nest of *C. ruficauda* may indicate a preference for reptilian shed skin in this species. The use of squamate exuviae in nest construction is known in several families of passerine birds and the cellophane appears to be a look-alike substitute for this shiny, semi-transparent material (Zyskowski & Prum 1999, Hansell 2000). Although the use of such material has not been documented previously in *Chamaeza*, ventral scutes of a large snake have been reported in a nest of one of the *Formicarius* antthrushes (Skutch 1945, 1969).

The presence of nearly fully-grown nestlings in early December indicates a nesting season during austral spring in *C. ruficauda*. This timing is typical of other passerine birds in southeastern Brazil and agrees with the previous report of potential breeding activity (enlarged gonads) in this species (Belton 1985). Biparental provisioning of nestlings I observed is the norm in the formicariid clade. On the other hand, my observation of a parent bird which may have been carrying a fecal sac is noteworthy as nest sanitation remains undescribed in *Chamaeza* and because *Formicarius* antthrushes are thought to consume fecal material produced by the nestlings (Skutch 1969, Krabbe & Schulenberg 2003).

Our understanding of nest architecture and nesting behavior of the antthrushes remains far from complete and detailed descriptions of additional nests are needed to test the validity of preliminary generalizations presented here.

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A bird assemblage mobs an adult pitviper in southeastern Brazil

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ABSTRACT: Birds mostly mob avian or mammalian predators, but harass snakes as well. The mobbed snakes are potential or actual bird predators, but records of birds mobbing vipers are rare. I report herein on an avian assemblage mobbing an adult Jararaca Lancehead (*Bothrops jararaca*) in the Atlantic Forest of southeastern Brazil. The bird assemblage was composed of 8 species and 11 individuals. The most insistent mobber was a Golden-crowned Warbler. Two bird species dived at close range of the moving pitviper: the Sayaca Tanager and the Short-crested Flycatcher, which dived at the snake 2 and 1 times respectively. The snake seemed undisturbed by the harassing birds, but stopped moving after each of the dives. The Jararaca Lancehead occasionally forage at daytime, climb on vegetation, and prey on birds. Thus, it may actually pose a predation risk to the mobbing birds when they are nesting in the vicinity or when they are much distracted while harassing.

KEY-WORDS: Anti-predator behaviour, snake-mobbing, Atlantic Forest birds.

Mobbing is a type of anti-predator behaviour displayed by potential prey animals, vertebrates from fish to birds and mammals (Curio 1978, Ostreiher 2003). While mobbing, birds and mammals utter alarm calls and approaches (sometimes charging or diving) or follow the predator from close range (Owings & Owings 1979, Ostreiher 2003). Mobbing individuals may be in danger while displaying this behaviour and several instances of actual preying on these individuals are recorded (Sordahl 1990, Corrêa & Coutinho 1997, Motta-Junior. 2007, Foerster 2008).

Mobbing by birds is directed mostly at avian raptors such as hawks, falcons, and owls [e.g. Altmann 1956, Sordahl 1990, Motta-Junior. 2007 (review for Brazil in Cunha & Fontenelle 2014)]. Records of bird mobbing snakes are scarcer than those of mobbing birds of prey, and involve snakes that are potential or actual bird predators (Blem 1979, Francis *et al*. 1989, Matheus *et al*.1996, Mercado *et al*. 2002, Sazima & Marques 2007). I found only four records of birds mobbing vipers (Mounts 1927, Buskirk 1981, Bussière & Underhill 2012, Bussière 2013), all of which prey on birds even if occasionally (*e.g.* Garton & Dimmick 1969, Mehrtens 1987). Herein I report on what seems to be the first record of birds mobbing a South American viper.

A bird assemblage was recorded while mobbing an adult Jararaca Lancehead (*Bothrops jararaca*) near an abandoned building (22°26'20" S, 44°36'28" W, 1073 m above sea level) at the edge of the montane Atlantic forest in the Itatiaia range in southeastern Brazil, on 28 March 2014 at midday. Throughout the observation I used the "*ad libitum*" sampling method, which is adequate to record rare events (Altmann 1974). Ten digital photos of the mobbed snake and three mobber bird species are housed as vouchers in the Museu de Zoologia, Universidade Estadual de Campinas (ZUEC).

Following the insistent and noisy birdcalls broadcasted from a small group of treelets up to 3 m tall I found a mobbed Jararaca Lancehead, an adult male about 1 m total length. The snake was slowly ascending one of the treelets (Figure 1a) and attracted a varied bird assemblage composed of 8 species and 11 individuals. The most insistent mobber was a Golden-crowned Warbler (*Basileuterus culicivorus*), which closely followed the snake from a distance of about 15-20 cm (Figure 1a) hopping from one branch to another. A Ruby-crowned Tanager (*Tachyphonus coronatus*) male (Figure 1b) was the noisiest bird within the assemblage, calling persistently. The other birds mobbing the pitviper were two Sayaca Tanagers (*Tangara sayaca*), two Pallid Spinetails (*Cranioleuca pallida*), one Short-crested Flycatcher (*Myiarchus ferox*), two Bananaquits (*Coereba flaveola*), a Violet-capped Woodnymph (*Thalurania glaucopis*) male, and a White-barred Piculet (*Picumnus cirratus*) male, an apparently uncommon bird in mobbing assemblages (Figure 1c).

Only two bird species dived at close range (20-30 cm) of the moving pitviper: the Sayaca Tanager and the Short-crested Flycatcher, which dived at the snake 2 and 1 times respectively. The remaining birds followed the snake and uttered alarm calls or stayed silent and watched the snake's progress on the branches. The pitviper seemed undisturbed by the mobbing bird group, although it stopped tongue flicking and moving after each of the three dives. The assembled birds dispersed after the viper moved to an adjacent treelet and from there came down and became out of sight within a bush. As the mobbing was already in course when I arrived at the scene, the total duration of the mobbing behaviour remains unknown. Eight minutes elapsed from my noticing the noisy bird assemblage to their dispersing (12:08-12:16 h). I searched the treelet where the snake was mobbed for any bird nest but found none. However, I found an occupied nest of the Sayaca Tanager on a palm about 4 m tall in the vicinity (7 m apart) of the treelets where the bird group mobbed the snake.

FIGURE 1. Birds mobbing an adult Jararaca Lancehead (*Bothrops jararaca*) male. A Golden-crowned Warbler (*Basileuterus culicivorus*) close to the head of the ascending snake (a); the noisiest mobber, a Ruby-crowned Tanager (*Tachyphonus coronatus*) male (b); a White-barred Piculet (*Picumnus cirratus*) male (c), a seemingly uncommon mobber. Photos: Ivan Sazima

The Golden-crowned Warbler and the Bananaquit, as well as several species of tanagers, tyrant-flycatchers, and hummingbirds are already recorded mobbing snakes in other Neotropical areas (Buskirk 1981, Matheus *et al.* 1996, Mercado *et al.* 2002, Sazima & Marques 2007). Indeed, Bananaquits were consistently recorded mobbing the Puerto Rican Boa (*Epicrates portoricensis*) by Mercado *et al.* (2002). Birds that forage in groups and explore varied vegetation strata, such as tanagers and Bananaquits usually do, would find and mob arboreal snakes with frequency (Buskirk 1981, Matheus *et al.* 1996, Mercado *et al.* 2002, Sazima & Marques 2007). On the other hand, only two species of woodpeckers, the Puerto Rican Woodpecker (*Melanerpes portoricensis*) and the White-barred Piculet are recorded mobbing a snake (Mercado *et al.* 2002, this paper). Apparently, woodpeckers play only occasionally the role of a snake mobber.

The Jararaca Lancehead is mostly terrestrial and nocturnal, and forages on rodents by ambush, but may forage actively at daytime, climb on vegetation, and prey occasionally on birds (Sazima 1992). Thus, the mobbed pitviper might actually pose a predation risk to the assembled birds when they are nesting in the vicinity or when they are much distracted by mobbing (Sordahl 1990, Matheus *et al.* 1996).

Field biologists and ornithologists in particular are generally aware of snakebite risks while working in the field. As all the four viper species mobbed by birds (Mounts 1927, Buskirk 1981, Bussière & Underhill 2012, Bussière 2013, this paper) are common and involved in snakebites (Greene 2007), I suggest here that paying attention to unusual movements and/or alarm calls of birds at a given site may lessen the risk of this accident type.

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Lightning predator: the Ferruginous Pygmy Owl snatches flower-visiting hummingbirds in southwestern Brazil

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ABSTRACT: Pygmy owls of the genus *Glaucidium* prey on large insect and small vertebrates, mostly birds. Among the birds preyed on by pygmy owls are hummingbirds, caught mostly while mobbing these owlets or when still at nestling stage. I report here on the Ferruginous Pygmy Owl (*Glaucidium brasilianum*) snatching flower-visiting hummingbirds in an orchard at a farm in southwestern Brazil. I recorded one White-tailed Goldenthroat (*Polytmus guainumbi*) and three Gilded Hummingbirds (*Hylocharis chrysura*) preyed on by this owlet on three consecutive days. The large concentration of flowers and, consequently, of hummingbirds in the orchard likely contributed to the hunting success of the owlet on such fleeting and quickly moving prey. The role this pygmy owl plays on predation of adult hummingbirds in the Neotropics merits closer consideration.

KEY-WORDS: Preying behaviour, hummingbirds as prey, *Glaucidium brasilianum*, *Hylocharis chrysura*, *Polytmus guainumbi*, Cerrado vegetation.

Pygmy owls of the genus *Glaucidium* prey on large insects and small vertebrates, mostly birds (König *et al.* 1999, Marks *et al.* 1999). Among the birds preyed on by pygmy owls are hummingbirds, caught mostly while mobbing these owlets or when still at nestling stage (Jiménez & Jaksic 1989, Rashid 1999, pers. obs.). I am unaware of records of pygmy owls hunting hummingbirds on the wing, except for a brief mention in Scholtz (2001). Hence, I report here on the Ferruginous Pygmy Owl (*Glaucidium brasilianum*) snatching flower-visiting hummingbirds at a farm in South-western Brazil.

I recorded predation by this pygmy owl on hummingbirds in an orchard (21°27'41" S, 56°26'22" W, 310 m a.s.l) at a touristic farm in Jardim, Mato Grosso do Sul, southwestern Brazil, from 4 to 6 May 2011 at late afternoon (16:45-17:45 h). The vegetation type adjacent to the farm was the Cerrado (Eiten 1992). A plenty of flowering ornamental plants, including *Odontonema* sp. (Figure 1d), *Grevillea banksii*, and *Malvaviscus arboreus* grew in the orchard and its surrounding, a circumstance that attracted hummingbirds to the orchard. Throughout the observations totalling about 7 h, I used the "*ad libitum*" sampling method, which is adequate to record rare or sporadic events (Altmann 1974). Digital photos of the owl, the hummingbirds, and the predation events are housed as vouchers in the Museu de Zoologia, Universidade Estadual de Campinas (ZUEC). In the absence of an apparent natural mark I suppose that the recorded owlet was the same individual, as these birds are territorial and may even dive towards a whistling or play backing human imitator (König *et al.* 1999).

The commonest hummingbird in the orchard was the Gilded Hummingbird (*Hylocharis chrysura*), whereas the White-tailed Goldenthroat (*Polytmus guainumbi*) and the Glittering-bellied Emerald (*Chlorostilbon lucidus*) were less common. The hummingbirds actively visited the flowers for nectar, and the Gilded Hummingbirds frequently chased one another during the visits.

The first hummingbird I recorded preyed on by the owlet was a White-tailed Goldenthroat female on 4 May at 17:37 h. Her wing feathers were plucked out (Figure 1a) before the owlet pulled its prey to pieces. The owlet had a few favourite hunting perches, from which it scanned the surroundings for a potential prey (Figure 1b). On occasions, the Gilded Hummingbirds engaged in fierce contests on the ground (Figure 1c) that lasted for up to 2 min. Although the owlet was fully aware of these fights near its hunting perch, I recorded no predation attempts under these circumstances. Instead, on 6 May at 17:34 h the owlet waited for the hummingbirds to separate and resume their flower visiting, to snatch one of them on the wing. In two instances, on 5 May at 17:31 h and 6 May at 17:36 h, I recorded the owlet seizing a hummingbird together with a portion of the plant the bird was visiting (Figure 1d).

Pygmy owls are renowned for their ability to pursue birds (Marks *et al.* 1999), although the manoeuvrable and swift flight of hummingbirds makes them able to occasionally evade even the quick strikes of arboreal pitvipers (Schuchmann 1999) and the attacks of a forest hawk apparently specialised in preying on these fast birds (Stiles 1978). The large concentration of flowers and, consequently, of hummingbirds in the farm conceivably contributed to the hunting success of the Ferruginous Pygmy Owl on such fleeting and quickly moving prey. Although four small birds in three days may be regarded as successful hunting, the owlet possibly caught additional prey throughout its activity period. Pygmy owls are renowned for their ability to prey on large birds, even if these latter are not consumed entirely (Sick 1997, Marks *et al*. 1999, König *et al.* 1999).

Pygmy owls habitually employ a hunting perch and the sit-and-wait tactic to secure their prey (Marks *et al.* 1999, König *et al.* 1999). Aside from the flower-visiting hummingbirds preyed on by the Ferruginous Pygmy Owl (this paper), the only other successful preying attempt I ever observed was near a hummingbird feeder in a hotel (22°25'55" S, 44°36'54" W, 1120 m a.s.l) near Maromba at the Itatiaia range, Rio de Janeiro, on 25 April 2008 at about 17:00 h. A Brazilian Ruby (*Clytolaema rubricauda*) male mobbed too closely an apparently oblivious owlet perched by the feeder and was snatched in mid-air by a sudden movement of the predator. Hummingbirds are readily attracted to a perched Ferruginous Pygmy Owl or to the playback of its vocalisation (Sick 1997, Motta-Junior 2007, Amaral & Ragusa-Netto 2008, Cunha & Vasconcelos 2009). Thus, it is possible that part of successful hunting on hummingbirds by pygmy owls results from mobbing episodes (see Sick 1997). As pointed out by some authors (Curio & Regelmann 1986, Sordahl 1990, Motta-Junior 2007), mobbing a predator implies in real risk for the mobber (see the Brazilian Ruby above).

In North America, hummingbirds are preyed on by a variety of non-passerine and passerine birds (Miller & Gass 1985), but these authors conclude that predation is not an important mortality factor for adult hummingbirds. However, they caution that in the Neotropics predators may impose significant mortalities to hummingbirds

FIGURE 1. The Ferruginous Pygmy-Owl (*Glaucidium brasilianum*) and its hummingbird prey at an orchard in southwestern Brazil. On a feeding perch, the owlet plucks the wing feathers of a White-tailed Goldenthroat (*Polytmus guainumbi*) female (a); on a hunting perch, the owlet scans the surroundings for potential prey (b); unaware of the watching owlet, two Gilded Hummingbirds (*Hylocharis chrysura*) fight on the ground (c); immediately after the winner resumed its flower visiting, the owlet dived and snatched it on the wing together with a portion of the visited plant (d). Photos: Ivan Sazima.

(Miller & Gass 1985). I guess that pygmy owls are among the important predators of adult hummingbirds, and suggest that field ornithologists could increase our scanty knowledge on this subject by paying attention to some particular circumstances under which the owls may have opportunity to prey on these swift birds (*e.g.*, at feeders, while mobbing, and visiting flowers). The role the widespread Ferruginous Pygmy Owl plays on predation of adult hummingbirds in the Neotropics merits closer consideration, and natural history-oriented studies are helpful in this respect.

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Snake predation by the Whistling Heron *Syrigma sibilatrix* in the Venezuelan Llanos

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ABSTRACT: We describe a predation event on the snake *Mastigodryas boddaerty* (Colubridae) by the Whistling Heron *Syrigma sibilatrix* (Ardeidae) in the Venezuelan llanos. The Whistling Heron seems to include snakes occasionally in its diet as indicated by our observation, which also provide the second species of snake recorded in the diet of this heron.

KEY-WORDS: Ardeidae, Colubridae, diet, *Mastigodryas boddaerty*, ophiophagy.

Herons and egrets (Pelecaniiformes: Ardeidae) are birds whose diet is principally constituted by fishes and crabs, which are captured after a quick movement of the head and neck, being least important other items such as earthworms, insects, frogs and other small vertebrates (Kushlan 2004). Twenty-eight species of herons are found in South America, including the Whistling Heron *Syrigma sibilatrix* (Remsen *et al.* 2014). This species of heron is endemic to South America where it occurs in two disjunct populations. One population is found throughout the grasslands of the Bolivian Pantanal south to Paraguay, southeastern Brazil, Uruguay and northeastern Argentina, whereas the second population inhabits in the Colombian and Venezuelan llanos, which lies north of the Orinoco River (Dean 2012).

In Venezuelan llanos, the Whistling Heron is commonly found in tall dry grass pastures and less frequently in flooded fields until 500 m (Hilty 2003). This species is considered one of the least aquatic herons, mostly seen alone or as pairs walking very slowly or standing erect for several minutes, eating eels, frogs, earthworms and several types of insects (Kushlan *et al.* 1982). As for other species of tropical herons, there are few published accounts about the diet and preys of the Whistling Heron (Franz et al. 2007; Aoki & Filho 2013). In this paper we described the successful capture and consumption of a Boddaert Tropical Racer (*Mastigodryas boddaerty*) by a Whistling Heron in the Venezuelan llanos.

Our observation was carried out in the Hato Santa Luisa (coordinates: 7°40'N, 67°32'W, 60 m), Apure State, Venezuela. Hato Santa Luisa is located in the low llanos region which is characterized by a climate markedly seasonal with a rainy season comprised between May to October and a dry season during November and April. Rainfall is near 1500 mm and annual mean temperature averages 25°C. Vegetation corresponded principally to flooded savanna, seasonal flooded gallery forest and aquatic plant communities dominated by *Eichhornia* and *Paspalum* species (Castroviejo & López 1985).

At 12:06 h on the 16 August 2014 a solitary Whistling heron was observed and photographed for five minutes while walking through a flooded pasture of *Paspalum* and *Eichhornia* until it stopped before catching from the ground a long yellow snake. The heron handled shortly the snake by the head before it was completely swallowed (Figure 1). The snake size was estimated between 40 to 50 cm and it was identified as belonging to the genus *Mastygodryas* (G. Montigelli pers. com.) and to species level as the Boddaert`s Tropical Racer *Mastigodryas boddaerti* (Colubridae) (C. Molina pers. com.) based on its slender and slightly compressed body, well defined head, long tail, brown-olive coloration with a pair of beige dorsolateral stripes extending from neck to tail (Motingelli 2009). *Mastigodryas boddaerti* is a diurnal species of snake widely distributed in South America, occurring from eastern Venezuela to northern Bolivia including the Amazon region of Colombia, Peru and Brazil (Montingelli 2009).

Previous accounts by Kushlan *et al.* (1982) about the diet of Whistling Heron in the Venezuelan llanos have described their generalist and opportunistic feeding habits, and marked preference for invertebrates, especially insects such as grasshoppers and dragonfly

FIGURE 1. Predation and swallowing of a Boddaert's Tropical Racer (*Mastygodryas boddaerty*) by the Whistling Heron *Syrigma sibilatrix* in Apure, Venezuela (Photo by G. Buitrón-Jurado).

larvae. These account, however, also noted the capture of a small snake although it was not swallowed. However, in southern Brazil the effective predation of water snake, *Helicops infrataeniatus* (Serpentes, Colubridae), by the Whistling Heron has been documented previously (Franz *et al.* 2007). Our observation on the predation of *Mastygodryas boddaerty* was similar in foraging method to those provided by Franz *et al.* (2007) corroborating the occasional predation of snakes by Whistling herons in Neotropical floodplain savannas.

Inclusion of snakes in the diet of Neotropical herons seems rare, with most studies on heron's diets indicating preference for fishes, crabs, earthworms and insects to a lesser degree (Kushlan *et al.* 1982; Smith 1997). Other species of Neotropical herons recorded feeding on snakes include the Great Egret (*Ardea alba*), the Great Blue Heron (*Ardea herodias*), and the Pinnate Bittern (*Botaurus pinnatus*) (Smith 1997; Franz *et al.* 2007). Nevertheless, the only snakes identified to species level consumed by herons to date have been *Helicops infrataeniatus* (Franz *et al.* 2007) and *Seminatryx pygaea* (Smith 1997). Therefore, *Mastygodryas boddaerty* is the third species of snake recorded in the diet of a Neotropical heron.

Our observation and those of Brazil confirm the inclusion of non-venomous snakes in the diet of the Whistling Heron, although more detailed studies are needed to determine the importance of different species of snakes in the diet of Neotropical herons.

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Sex determination by morphometry of adult White-crested Elaenia (*Elaenia albiceps chilensis*)

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ABSTRACT: White-crested Elaenia (*Elaenia albiceps chilensis*) is a Neotropical austral migrant that is sexually monomorphic in plumage. We first determined whether the brood patch and cloacal protuberance are good indicators of an individual's sex by comparing these characters with individuals sexed using molecular techniques. Second, at several localities encompassing a 1500 km latitudinal gradient across the breeding range, we evaluated whether morphological measurements can be used for sex determination, using discriminant analysis and molecular sexing as dependent variables. Finally, the effectiveness of the discriminant analysis was assessed by a Jackknifed validation, and by a cross-validation process through the classification of a new sample. Sexing using genetic techniques and by cloacal protuberance size and presence of the brood patch produced the same results. We did not find differences in body measurements among study sites. In all localities, males were significantly larger than females in wing and tail lengths, whereas other variables did not exhibit differences between sexes. The best classification of sex by discriminant functions was obtained by including wing and tail length as discriminatory variables. The discriminant function correctly determined the sex of 86 % of all samples, with correct identification of 90 % of males and 75 % of females. The Jackknifed validation and cross-validation of a new sample resulted in similar sex classifications as those produced using the discriminant function. Discriminant analysis thus represented a simple and cost-efficient way to determine the sex of White-crested Elaenias for field ornithologists.

KEY-WORDS: Discriminat analysis, latitudinal gradients, Neotropical austral migrant, sexual size dimorphism.

INTRODUCTION

Sex determination of birds is key to understanding various aspects of the demography of a population as it may influence survival, dispersal, recruitment and other life history parameters (Gowaty 1993, Newton 1998), but sex differentiation is difficult in species with sexually monomorphic plumage, even for captured individuals. During the breeding season, the sex of most individuals of many species can be determined either by the presence or extent of a brood patch in females or the cloacal protuberance in males (Ralph *et al.* 1993). In some species, however, the male can develop an incubation patch, but it does not typically develop as extensively as in females (Skutch 1957, Pyle 1997). Furthermore, during the non-breeding season these characters are not useful, although sexing birds in the non-breeding season is desirable (e.g., sex-specific migration phenologies, migration routes, and wintering habitat use).

Morgan (2005) discussed the possibility of analyzing multi-modal distributions of morphological characters to differentiate sexes. This approach was used by Catry *et al.* (2005), who separated male and female Chiffchaffs (*Phylloscopus collybita*) based on the bi-modal distribution of wing length. However, although this method is based on sound assumptions, there is no independent verification of its reliability. Relatively unproblematic and reliable is taking a blood or tissue sample for later molecular sex determination in the laboratory (Griffiths *et al.* 1998). Many recent authors have identified useful morphological measurements for sex determination using molecular methods on a sub-sample of the species under study (Hipkiss 2007, Ottvall & Gunnarsson 2007). The sex is treated as a dependent variable in either a discriminant analysis or a logistic regression with a number of morphological measurements as explanatory variables. In recent years, these methods have been used to investigate morphological variables useful for sexing a number of non-passerine and passerine bird species (e.g., Campos *et al.* 2005, Svagelj & Quintana 2007, Cardoni *et al.* 2009).

Although these methods can lead to reliable sex determination of the population under study, their general application has some caveats (Ellrich *et al.* 2010). For example, statistical models are selected to fit a particular sample, and will therefore fit the particular sample better than they would fit the entire population from which the sample was drawn, or a sample from another population. Also, there are intra-specific differences in morphology, such as wing length, due to different migration distances (e.g., Lindström *et al.* 1996, Fiedler 2005).

White-crested Elaenia (*Elaenia albiceps chilensis*) is a Neotropical austral migrant and is abundant in *Nothofagus* forests of Patagonia between October and March (Grigera *et al.* 1994). This species is a small tyrant flycatcher (Tyrannidae) sexually monomorphic in plumage (Fitzpatrick 2004). There is little research about the White-crested Elaenia demography, which is hampered by the lack of data enabling researchers to determine sex in the field. Our aim was to evaluate sex determination of White-crested Elaenia using molecular techniques and morphometric measurements. First, we analyzed whether the presence of a brood patch or cloacal protuberance are good indicators of an individual's sex in known-sex individuals as determined through molecular techniques. Second, at several localities encompassing a 1500 km latitudinal gradient of the breeding range of White-crested Elaenia, we evaluated whether morphological measurements can be used for sex determination, using discriminant analysis and molecular sexing as dependent variables. Third, we assessed the effectiveness of the discriminant analysis in terms of the proportions of individuals of known sex that were classified correctly by a Jackknifed validation, and by cross-validation through the classification of a new sample.

METHODS

Study sites

Between October and March, White-crested Elaenias mainly inhabit *Nothofagus* forest within a narrow strip approximately 2000 km long, extending from the southern tip of South America to northern Patagonia. Along this latitudinal gradient, we selected four study sites in National Parks of Argentina: Parque Nacional (PN) Tierra del Fuego (54°49' S, 68°28' W), Province of Tierra del Fuego; PN Los Glaciares (49°14' S, 72°54' W), Province of Santa Cruz; PN Perito Moreno (47°57' S, 72°07' W), Province of Santa Cruz; and PN Los Alerces (42°36' S, 71°38' W), Province of Chubut (Figure 1). For cross-validation classification of a new sample, we selected a site near Esquel (42°55' S, 71°21' W), Province of Chubut (Figure 1). Vegetation corresponds to the Subantartic Biogeographical Province (Cabrera & Willink 1980). In the northern part of this latitudinal gradient, the climate is characterized by cold and wet winters and mild but dry summers. Most precipitation falls as rain and snow during autumn and winter. South of 55° S, precipitation is more evenly distributed throughout the year (Garibaldi *et al.* 2011).

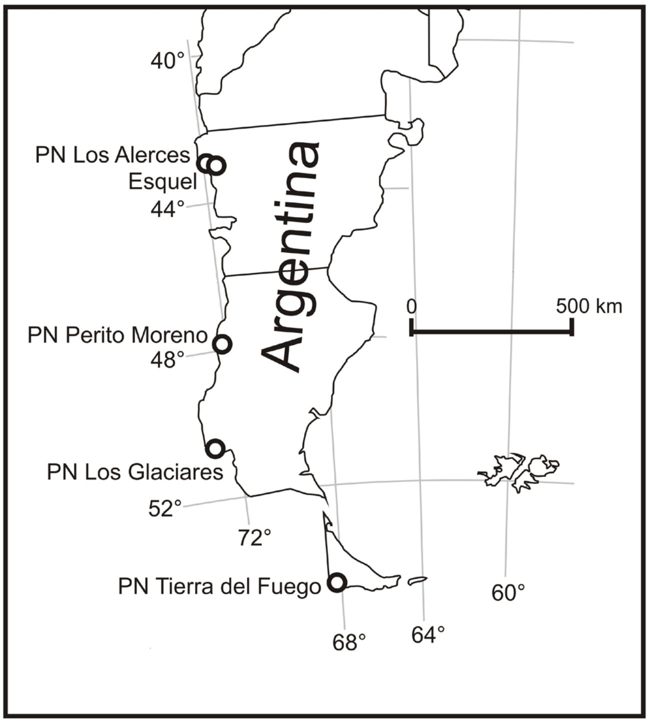

FIGURE 1. Geographical locations where White-crested Elaenias (*Elaenia albiceps chilensis*) were sampled in Patagonia, Argentina.

Sampling birds

Scientific nomenclature and common name follow the recommendation by the South American Checklist Committee (www.museum.lsu.edu/~Remsen/SACCBaseline.html, accessed on 20 May 2014). We only sampled breeding individuals to avoid the possibility of capturing individuals during migration. We sampled at the four National Park study sites from 1 January to 3 February 2012, and sampled at Esquel site from 10 December 2013 to 15 January 2014. Birds exhibiting territorial displays were captured by placing a White-crested Elaenia model coupled with conspecific songs and calls delivered through a portable speaker within 2 m of a mist net (12 x 3 m, 38-mm mesh size). At Esquel site, we passively captured birds using 10 mist nets (12 x 3 m, 38 mm mesh size) placed 70-100 m apart during four occasions for two consecutive days. Nets were opened during the first four to five hours after sunrise when weather conditions were not adverse (rainy or windy).

At all sites, captured birds were banded with numbered aluminum bands. For each captured individual, we recorded the size of the cloacal protuberance and stage of development of the brood patch. Cloacal protuberances were categorized as: none (0), small (1), medium (2), and large (3) and brood patch development was categorized as follows: not present (0), smooth skin (1), vascularized (2), wrinkled (3), and molting (4) (Ralph *et al.* 1993). We also took five morphological measurements from each adult bird: bill length (from the anterior end of the nostril to the bill tip), tarsus length (from the intertarsal joint to the distal end of the last leg scale before the toes emerge), tail length (from the base of the feathers to the end of the longest feather), wing chord (from the carpal joint to tip of the longest primary), and body mass. We used a digital caliper (± 0.01 mm) for bill and tarsus measurements, a wing ruler (± 1 mm) for tail and wing measurements, and a digital scale (± 0.1 g) to record weight.

Molecular analysis

For molecular sexing, we collected blood samples by piercing the brachial vein with a sterile needle and sampled blood using a 0.5-ml heparinized capillary tube. Blood samples were stored in absolute ethanol at room temperature. DNA from approximately 1 mm^3 of blood was purified, according to the protocols presented in Ivanova *et al.* 2006.

For molecular sex determination, we amplified a fragment of the Chromobox-Helicase-DNA-Binding (CHD) gene by utilizing PCR with primers P2 and P8 (Griffiths *et al.* 1998). The PCR procedure used approximately 40 ng of DNA and a primer concentration of 0.5 μM. PCR reactions used an initial denaturing step of 2 min at 94°C, followed by 35 cycles of 30 s at 94°C, 45 s at 49°C, and 45 s at 72°C and a final step for 10 min at 72°C. PCR products were scored by electrophoresis in 3 % agarose gels stained with Ethidium Bromide. Amplification of the CHD gene in males produced a single band and two bands in females. All PCR product lengths were about 350 to 400 bp, which is the expected weight (Griffiths *et al.* 1998). All studied samples (n=34) were analyzed in two independent PCR assays that included male, female and negative controls.

Data analysis

For statistical analysis, we used the subset of individuals that were sexed by molecular techniques (23 males and 11 females). Two-way ANOVAs were used to evaluate if external morphology varied with sex and study site. We used the type III method to compute the sum of squares given our unbalanced design and we checked for normality and homogeneity of variance (Shaw & Mitchell-Olds 1993).

We applied a Discriminant Function Analysis (DFA) to morphological measurements taken from White-crested Elaenias of known sex. We did not use stepwise techniques to identify the set of variables included in the DFA, and instead included only variables that showed differences among sexes (see Table 1; Dechaume-Moncharmont *et al.* 2011). The performance of each variable and its combinations were evaluated with the Wilk's Lambda statistic.

The effectiveness of the discriminant analyses was assessed, first in terms of the proportion of birds of known sex that were classified correctly, second by a Jackknifed validation, and finally by a cross-validation process through the classification of a new sample (Tabachnick and Fidell 1996). The Jackknifed validation process classifies each individual case using a function obtained from the total sample, excluding the individual case to be classified (Tabachnick and Fidell 1996). The cross-validated process was used with a new set of individuals obtained during sampling at Esquel site. However, for this group, sex determination was not verified by molecular sexing. Individuals were classified by the presence of cloacal protuberance (males) or incubation patch (females).

RESULTS

All DNA samples showed one of the typical PCR band patterns that differentiate males (one band) from females (two bands). The sex of all 34 White-crested Elaenias that were assessed by size of the cloacal protuberance (males) or development of the brood patch (females) were also genetically verified.

We did not find any differences in the five body measurements among study sites (Table 1). At all sites, wing and tail lengths were significantly larger in males than in females, whereas the other variables did not show differences between sexes (Table 1, Figure 2).

The classification of sex using DFA for wing, tail and the combination of these two body measurements were in the Table 2. The best classification was obtained when including wing and tail length as discriminatory variables (Table 2). The resulting function (D_1, with an associated cut-off value of -0.385) was:

D_1 = (0.62 x wing length) + (0.07 x tail length) - 55.51

Individuals with discriminant function scores greater than the cut-off were classified as male and those with lower scores as female. This function correctly determined the sex of 86% of all samples, with correct identifications of 90% of males and 75% of females (Table 2). Individuals with a wing length of 76 mm and a tail length of 63 mm are males, and individuals with a wing and tail of 73 mm and 60 mm, respectively, are females (Figure 3). The Jackknifed classification correctly determined the sex of 65% of all samples, with the correct identification of 75% of males and 63% of females. The cross-validation provided similar classifications to those produced by discriminant functions. The function derived from the cross-validation analysis correctly determined the sex of 76% of all samples, with the correct identification of 65% of males and 90% of females.

TABLE 1. Male and female body measurements (mean ± SD), of adult White-crested Elaenias (*Elaenia albiceps chilensis*) from four National Parks in Patagonia, Argentina. All measurements are given in mm except body mass in g. Factors of a Two-way Anova were Sex (S), Origin (O) and the interaction (SxO). Only indicated the results that were statistically significant at Type I error lest that 0.05.

	MALES			FEMALES			
Body Measurement	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Two-way Anova**
Wing Length							
PN Tierra del Fuego	6	75.8	2.6	4	72.8	2.2	$F_{S; 1, 26} = 5.5$, $P = 0.027$ $F_{O; 3, 26} = 1.1$ $F_{SxO; 3, 26} = 0.4$
PN Los Glaciares	4	74.5	2.4	3	73.3	2.1	
PN Perito Moreno	4	76.8	1.7	2	74.5	0.7	
PN Los Alerces	9	76.1	1.7	2	75.0	2.8	
ALL	23	75.9	2.1	11	73.6	2.0	
Tail Length							
PN Tierra del Fuego	5	62.6	2.1	2	60.0	1.4	$F_{S; 1, 23} = 6.9$, $P = 0.015$ $F_{O; 3, 23} = 0.3$ $F_{SxO; 3, 23} = 0.5$
PN Los Glaciares	4	61.0	0.8	3	60.3	2.5	
PN Perito Moreno	4	63.5	2.1	2	60.0	1.4	
PN Los Alerces	9	62.4	2.7	2	60.5	0.7	
ALL	22	62.4	2.1	9	60.2	1.5	
PN Tierra del Fuego	6	7.5	0.3	4	7.1	0.5	$F_{S; 1, 26} = 1.3$ $F_{O; 3, 26} = 0.8$ $F_{SxO; 3, 26} = 0.9$
PN Los Glaciares	4	7.4	0.6	3	7.6	0.4	
PN Perito Moreno	4	7.3	0.3	2	7.2	0.3	
PN Los Alerces	9	7.4	0.3	2	7.1	0.6	
ALL	23	7.4	0.3	11	7.3	0.4	
Tarsus Length							
PN Tierra del Fuego	5	20.9	1.2	2	20.3	0.3	$F_{S; 1, 21} = 0.6$ $F_{O; 3, 21} = 0.2$ $F_{SxO; 3, 21} = 0.6$
PN Los Glaciares	4	21.2	1.0	3	21.7	0.6	
PN Perito Moreno	4	21.8	0.7	2	21.3	0.1	
PN Los Alerces	8	21.6	0.5	2	21.7	1.8	
ALL	21	21.4	0.9	9	21.2	0.7	
Body Mass							
PN Tierra del Fuego	6	15.7	0.7	3	15.6	1.3	$F_{S; 1, 25} = 0.1$ $F_{O; 3, 25} = 1.3$ $F_{SxO; 3, 25} = 1.3$
PN Los Glaciares	4	15.4	1.3	3	16.8	1.9	
PN Perito Moreno	4	15.2	0.6	2	15.1	0.7	
PN Los Alerces	9	15.5	0.8	2	14.8	0.4	
ALL	23	15.5	0.8	10	15.7	1.4	

TABLE 2. Accuracy of sexing White-crested Elaenias (*Elaenia albiceps chilensis*) as percentages correctly classified using single measurements and a discriminant function D_1. All discriminant analyses were significant (P < 0.01).

			Accuracy (%)		
	Wilk´s lambda	**F-value**	**Males**	**Females**	**Total**
Tail Length	0.76	$F_{1, 26} = 8.23$	55	88	63
Wing Length	0.59	$F_{1, 26} = 18.40$	90	63	82
D_1	0.58	$F_{2, 25} = 8.98$	90	75	86

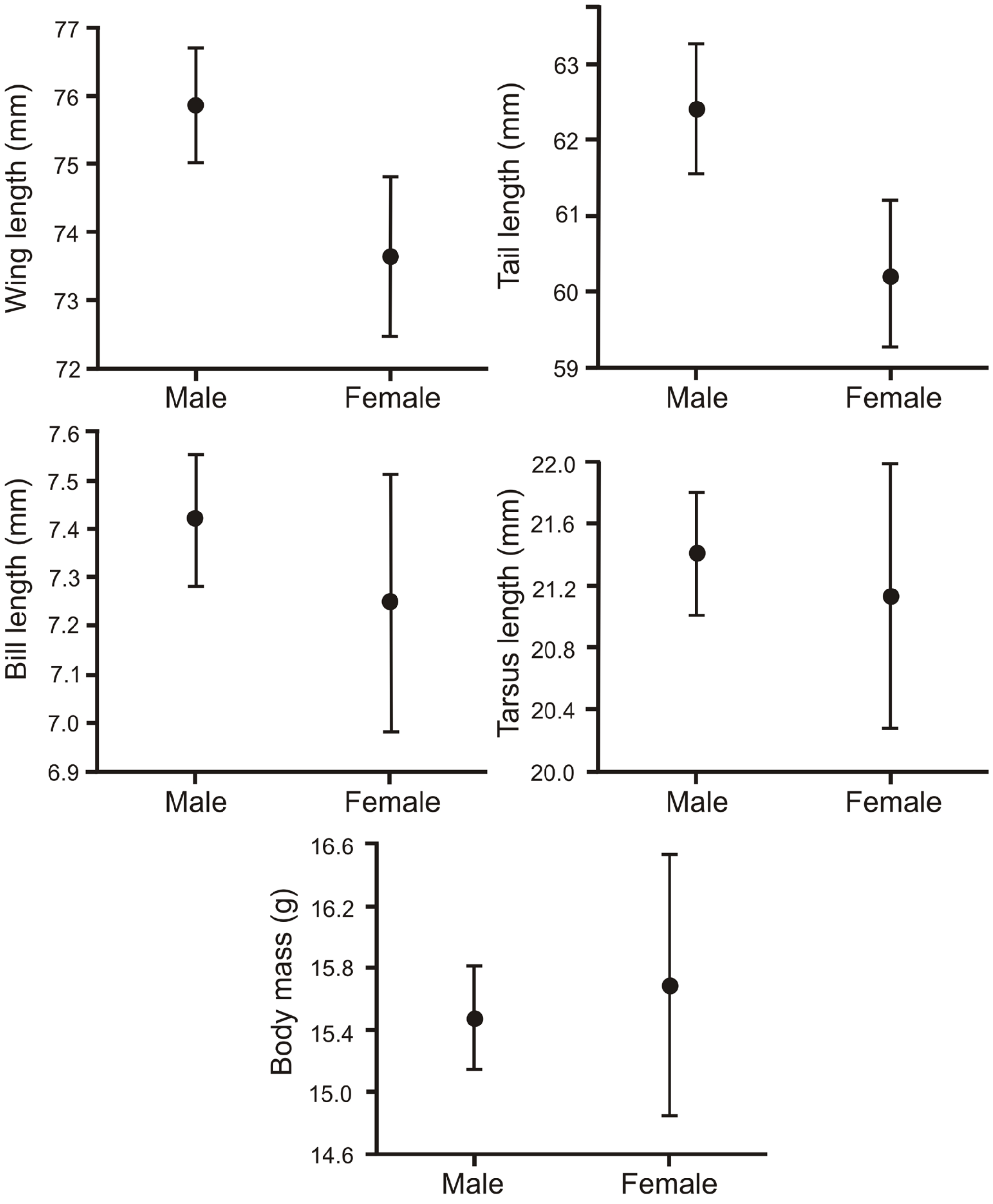

FIGURE 2. Male and female body measurements (mean ± 95% confidence interval) of adult White-crested Elaenias (*Elaenia albiceps chilensis*) of Patagonia, Argentina.

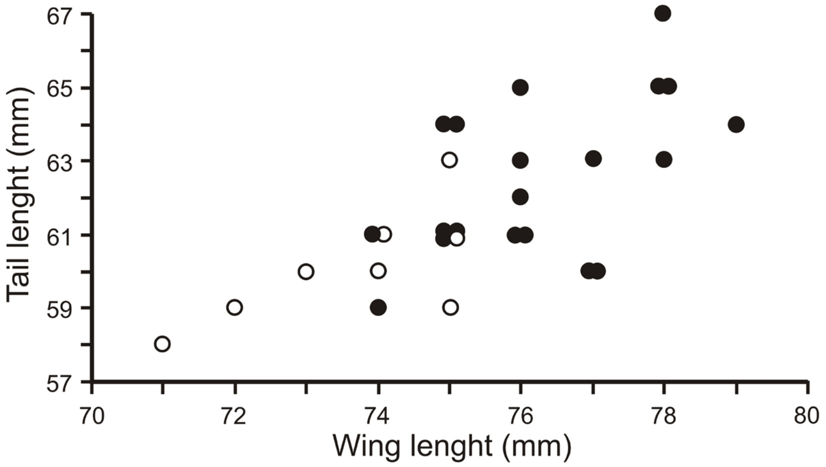

FIGURE 3. Relationship between wing length and tail length for males (black circles) and females (white circles) of adult White-crested Elaenias (*Elaenia albiceps chilensis*) of Patagonia, Argentina.

DISCUSSION

We found that White-crested Elaenias can be accurately sexed by the degree of development of the cloacal protuberance and by the presence of the incubation patch. The agreement between results of genetic sex determination and those from measurements taken from birds in the field clearly demonstrates that males do not develop a partial incubation patch. This is an important result because males in some species of flycatchers exhibit such character (e.g., in the genus *Myiarchus*, Pyle 1997). However, these features are only useful to identify the sex during the breeding season, and sexing birds in the non-breeding season is important for a proper assessment of the population dynamics of migrant birds throughout their annual cycle (Newton 2008).

Our results also show that at least two body measurements of White-crested Elaenias, wing and tail length, differ between sexes, with those of males being larger than females. Furthermore, using the discriminant function generated by the combination of these two measurements, we can differentiate the sexes with at least 90% and 75% confidence in males and females, respectively. These morphological measurements are commonly taken at banding stations and therefore the methods are highly standardized. In addition, obtaining these measurements does not require intensive handling of birds, thereby significantly reducing the stress on captured individuals.

A major criticism of the use of discriminant functions derived from body measurements to differentiate between sexes is that they are useful only for the populations from which the samples were obtained (Ellrich *et al.* 2010). In our study, we did not observe any geographic differences for the five morphological variables, even across a latitudinal gradient from 54° S (PN Tierra del Fuego) to 42° S (PN Los Alerces), i.e., separated by over 1300 km. We sampled during the active breeding period of White-crested Elaenia (corroborated by the capture of individuals in breeding condition at all sampling sites), so it is improbable that individuals captured at lower latitudes actually correspond to population that breed at higher latitudes and were migrating at the time of capture. However, we must note that for migratory birds, the wing functional features other than length *per se* could be responding to the latitudinal gradient. For example, wingtip shape is critical for speed and maneuverability in flight (Lockwood *et al.* 1998). Further studies, on the morphology and function of the wing are needed to establish whether these features in White-crested Elaenia may associate with the latitude and migration distance.

Our study shows that White-crested Elaenia males can be differentiated from females by body measurements, a common result obtained in passerines studies (e.g., Faria *et al.* 2007, Cardoni *et al.* 2009, Botero-Delgadillo 2010, Sandoval & Mennill 2013). Nevertheless, it would be important to assess other features that have been used to differentiate sexes and that can be measured during bird handling in banding stations, such as keel length. Murphy (2007) found that such a morphological measurement is very useful to differentiate the sex of individuals of Eastern Kingbirds (*Tyrannus tyrannus*). Other measurements may also be useful to differentiate the sexes in monomorphic species, for example the UV reflectance of plumage (Tubaro *et al.* 2005), although this is more difficult to obtain during fieldwork.

The results of our research are important for the analysis of geographical variation in this and other species of birds, because possible morphological differences among localities could be due to variations in the sex ratio of captured individuals in those sites. Also, these results are useful to assess whether males and females differ in their demographic characteristics and habitat selection during the non-breeding season, a period of the annual cycle poorly studied in Neotropical austral migrant birds.

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Rediscovery of the Crested Eagle *Morphnus guianensis* (Daudin, 1800) in the fragmented Atlantic Forest of Bahia, Brazil

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ABSTRACT: We here report the second documented record of Crested Eagle *Morphnus guianensis* from the Bahian Atlantic Forest, from a 2,300 ha patch of *Tabuleiro* forest in a pasture-matrix. The only previous documented record from Bahia is from the beginning of the 19th Century. This is the first record of this eagle from fragmented landscapes in the Atlantic Forest, in an isolated forest patch five times smaller than minimum expected home-range size. This observation suggests that *M. guianensis* may outlast the habitat fragmentation in Atlantic Forest landscapes, potentially relying upon multiple forest patches to hunt. The eagle was photographed after a failed predation attempt on a group of Golden-headed Lion Tamarins *Leontopithecus chrysomelas*. It is the first record of a potential prey species for Crested Eagles in the Atlantic Forest.

KEY-WORDS: Diet, habitat loss, *Leontopithecus chrysomelas*, predation, stepping stones.

The Crested Eagle (*Morphnus guianensis*) is a rare, patchily-distributed, forest-dwelling eagle occurring from southern Mexico (Chiapas) to Argentina (Misiones). It prefers lowland tropical and subtropical forests (GRIN 2014) but very little is known about its natural history. It is considered 'Near Threatened' globally, with declines inferred due to habitat loss and hunting (BirdLife International 2014) although confidence in these assessments is hampered by the natural rarity of this poorly studied species. The majority of recent Brazilian records are from Amazonia (*e.g.* WikiAves 2014, Gomes 2014). The few records from Atlantic Forest are mostly undocumented, very old (> 25 years), from the coast from Bahia (Wied-Neuwied 1820) to Rio Grande do Sul (Sick 1997). Owing to massive loss of the lowland Atlantic Forest, the Crested Eagle is Critically Endangered in São Paulo (Silveira *et al.* 2009), Minas Gerais (COPAM 2010) and Espírito Santo (Ipema 2005), and Possibly Extinct in Rio de Janeiro, Paraná and Rio Grande do Sul (Bergallo *et al.* 2000, Bencke *et al.* 2003, Mikich & Bérnils 2004). Recent records (< 25 years) in the Brazilian Atlantic Forest are anecdotal and lack documentation in the form of specimens, photos or voice-recordings. These reports come predominantly from protected areas such as the Serra do Caparaó National Park (Zorzin *et al.* 2006), Sooretama Biological Reserve (Parker & Goerck 1997), Morro do Diabo, Intervales and Jacupiranga State Parks (Galetti *et al.* 1997). The only recent record from an unprotected area is from Grão Pará, Santa Catarina, where a pair were reported soaring in thermal air currents over forest fragments in 2005 (Albuquerque *et al.* 2006). However, this is unusual behavior for this species, which apparently prefers the forest interior and it is rarely seen soaring or using thermal currents (LFS *pers. obs.*).

The only previous documented record from the state of Bahia concerns an adult male killed by locals at the Ilhéus River, near the city of Itororó (Bokermann 1957), reported by Wied-Neuwied in 16 January 1817 (1820, 1846). Almost two hundred years later, we report the second documented record of *Morphnus guianensis* in Bahia, which forms the northern limit for this species in the Atlantic Forest. On the afternoon of 5 December 2012 an adult bird was photographed (Figure 1) in a 2,300 ha *Tabuleiro* forest (15°59'S, 39°23'W; 197 m altitude) in the municipality of Belmonte, after a failed predation attempt on a reintroduced group of Golden-headed Lion Tamarins *Leontopithecus chrysomelas*. This *Tabuleiro* forest is in an advanced state of regeneration and harbors other endemic and threatened birds (*Amazona rhodocorytha*) and mammals, such as *Sapajus xanthosternos, Chaetomys subspinosus* and *Bradypus torquatus* (R. Costa-Araújo *pers. obs.*, Moura 2003). The forest fragment lies in a

FIGURE 1. a-b. *Morphnus guianensis* photographed in a 2,300 ha *Tabuleiro* Forest fragment on 5 December 2012 at Belmonte, Bahia, Brazil. Photos by R. Costa-Araújo.

landscape dominated by cattle pasture, in addition to *Eucalyptus* plantations, some cocoa agroforests and a few small degraded forest patches (Landau 2003, R. Costa-Araújo *pers. obs.*).

In addition to both documented records (Costa-Araújo *et al.* this paper, Wied-Neuwied 1820, 1846) there are two undocumented reports of Crested Eagles from Bahia: one heard only in 1974 at Porto Seguro (Willis & Oniki 2003) and an anonymous report from the municipality of Belmonte in 1995 (Anonymous 1995). Our record is unambiguous evidence for the persistence of *Morphnus guianensis* in the Southern Bahian *Tabuleiro* forests.

This is the first documented record of *M. guianensis* using a small forest fragment in the Atlantic Forest. Indeed, Crested Eagles were recorded breeding in a small patch of *Terra Firme* forest in Amazonia (Andretti 2010, Lees *et al.* 2013), which is similar in structure and floristic composition to the coastal *Tabuleiro* forest (Thomas 2003). According to the estimates of Thiollay (1989) from French Guiana, a Crested Eagle territory may include up to 100 km^2 of continuous habitat (see also Galetti *et al.* 1997). Nevertheless, we recorded this failed predation attempt in a patch five times smaller than this estimates, isolated by several kilometers from larger forest blocks (73 km^2 in Estação Veracel and Pau-Brasil private reserves, or 115 km^2 in Pau Brasil National Park). Our record suggests that Crested Eagles may persist in fragmented Atlantic Forest landscapes, potentially relying upon multiple patches to hunt. Further studies should address this hypothesis because persecution is a major threat for large raptors in fragmented landscapes (Trinca *et al.* 2008).

The feeding behavior of *Morphnus guianensis* remains poorly understood. Bierregaard (1984) reported on the prey-species brought to a fledging over three months in a nest near Manaus that included mostly snakes and small mammals. Vargas *et al.* (2006) reported a curious case of a young Harpy Eagle being fed by an adult Crested Eagle, in which snakes and mammals were the only prey delivered. A recent study found mammals highly represented in the Crested Eagle's diet and that primates accounted for 25% of mammal prey items (Gomes 2014). This observation is consistent with predation events by *M. guianensis* on eleven primate species from six different genera. The body mass of primates subject to successful or attempted predation events ranges between 0.3-3 kg (Table 1). The small-bodied species from genus *Leontopithecus* (Costa-Araújo *et al.* this paper), *Saguinus* (Vargas *et al.* 2006, Vasquez & Heymann 2001, Kessler 1995, Gomes 2014), *Saimiri* (Robinson 1994, Boinski *et al.* 2003), *Pithecia* (Gilbert 2000) and *Callicebus* (Gomes 2014) covers the majority of primate predation records and an young *Ateles paniscus* (Juliott 1994) completes the list. *Leontopithecus chrysomelas* are small tamarins, with a body-mass similar to most *Saguinus* spp. (≤0.7 kg) and may form part of the diet of Crested Eagles.

TABLE 1. Primate species attacked and/or preyed by *Morphnus guianensis*, with minimum and maximum adult weight (Emmons & Feer 1997) and body size class: small (≤ 3 kg) and medium (3-8 kg).

Specie	Weight (g)	Body size
Saguinus fuscicolis	338-436	Small
Saguinus geoffroy	453-520	Small
Saguinus labiatus	500-650	Small
Saguinus midas	415-665	Small
Saguinus mistax	536-700	Small
Leontopithecus chrysomelas	480-700	Small
Saimiri sciureus	480-1400	Small
Saimiri oerstedi	600-750	Small
Callicebus caligatus	860-1,400	Small
*Pithecia pithecia**	1,650-2,350	Small
*Ateles paniscus**	2,500-3,200†	Medium

*Attack on a younger individual.
†Estimated biomass of the young individual preyed (Julliot 1994).

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A second documented record of Spectacled Petrel *Procellaria conspicillata* in Argentine waters

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ABSTRACT: The Spectacled Petrel *Procellaria conspicillata* is endemic to Inaccessible Island, in the Tristan da Cunha group (central South Atlantic). The species is considered an occasional visitor to Argentina and there are few records of the species in national waters. On 13 February 2014, two birds were observed (and photographed) 89 nautical miles southeast off Buenos Aires Province at 38°55'S, 56°00'W. This record represents the second documented record of Spectacled Petrel for Argentina.

KEY-WORDS: Occurrence, Argentina, Buenos Aires Province, Continental shelf, Spectacled Petrel.

The Spectacled Petrel *Procellaria conspicillata* is a breeding endemic of Inaccessible Island, in the Tristan da Cunha group (Ryan 1998, Ryan & Moloney 2000, Ryan *et al.* 2006), and at sea is essentially confined to the South Atlantic Ocean north of the South Polar Front, chiefly between 24-41°S (Enticott & O'Connell 1985). The species disperses to southeast South America as far north as northern Brazil and the Benguela Current off Namibia and southwest South Africa (Camphuysen & van der Meer 2000, Lima *et al.* 2004). The Spectacled Petrel is considered to be a vagrant to the Indian Ocean, where it has been reported from Amsterdam Island and Australia (Onley & Scofield 2007, Shirihai 2008).

To date there are few records of Spectacled Petrels in Argentine Continental Shelf (<200 m depth) waters. The presence of the Spectacled Petrel in Argentine waters (<200 nm) was first recorded by Savigny (2002), who reported three birds attending commercial trawlers off the northeastern Islas Malvinas/Falkland Islands on 9 February 2000. White *et al.* (2002) reported a single bird from vessels whilst conducting at-sea seabird and marine mammal surveys northeast of Isla Soledad/East Falkland Island during March 2000. Imberti (2002) recorded a total of four birds from vessels close to the edge of Argentine territorial waters – along the shelf-break, east of Golfo San Jorge and Golfo San Matías (northern Patagonia) between 13 and 14 March 2000. A single bird was also recorded north of Islas Sebaldes/Jason Islands on 14 February 2004 (Black *et al.* 2005). It has to be stressed that these are all undocumented records. In recent years, Ginsburg & DeWitt (2013) photographically documented the species (a single bird) for the first time within Argentine waters off southeastern Buenos Aires Province on 3 February 2013.

On 13 February 2014 (16:00 local time, -3 GMT), two Spectacled Petrels were seen and photographed 89 nautical miles off southeastern Mar del Plata (Buenos Aires Province) at 38°55'S, 56°00'W. Water depth at this location was 84 m. The sighting was made opportunistically whilst onboard the *MV* Seabourn Quest during its voyage between Valparaiso, Chile, and Buenos Aires, Argentina, between 25 January and 15 February 2014, by way of Ushuaia, Argentina, the Antarctic Peninsula, and the Malvinas/Falkland Islands-Montevideo, Uruguay transect. The birds had distinctive white face markings (the spectacles) and white chins (Figure 1). The Spectacled Petrels were first noticed when crossing the wake of the vessel, about 50/70 m astern, and were observed flying in large circles behind the vessel, but did not come close to it during the observation. The Spectacled Petrels were seen along several Great Shearwaters *Puffinus gravis* and a few White-chinned *P. aequinoctialis* and Wilson's Storm-petrels *Oceanites oceanicus*, and an Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchos*. A few minutes prior to the observation, at least 50 Common Dolphins, *Delphinus delphis*, were sighted crossing the wake of the ship. The birds were observed for about 10 minutes.

To our knowledge, this represents the second photographically documented record of the Spectacled

FIGURE 1. Spectacled Petrel *Procellaria conspicillata* recorded at sea off southeastern Buenos Aires Province, Argentina. Photo: W. Stein, III.

Petrel in Argentine waters. This is novel information considering that the literature generally refers to the species as being found in the central South Atlantic Ocean close to Inaccessible Island during the breeding season (Enticott & O'Connell 1985). Moreover, tagged birds concentrated their foraging activity along the Mid-Atlantic Ridge, predominantly north and north-west of Inaccessible Island, with 50% of locations within 500 km of the islands whilst breeding (Reid *et al*. 2014). However, the satellite data reported by Reid et al. (2014) clearly provides additional records for Argentine waters and may suggest that the (northern) Patagonian Shelf is an important feeding ground for this species. The low encounter rate for the Spectacled Petrel in this region of the southwestern Atlantic during summer is probably due to (1) the low coverage of observers specifically trained in seabird identification on board research and commercial vessels operating in the vicinity of the Rio de la Plata Estuary and its neighboring waters and (2) local poorer oceanographic conditions in comparison with more northern latitudes (i.e. subtropical and tropical waters preferred by the birds are located north of 35°S), which contribute to the scarcity of published records.

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A Black Kite *Milvus migrans* on the Saint Peter and Saint Paul Archipelago, Brazil

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ABSTRACT: The Black Kite *Milvus migrans* is a widespread migratory raptor found over much of the Old World. Vagrants have been widely recorded far from its main migratory routes. Here, we report the occurrence of a Black Kite in the Brazilian Saint Peter and Saint Paul Archipelago (SPSPA) in April/May 2014. The bird remained for 32 days in the SPSPA, disappearing at the end of the rainy season. It looked healthy for most of this period and was once seen preying on a seabird chick. We speculate that the species was likely drifted off course by SW tradewinds, which may be responsible for the displacement of several other Old World bird species to the archipelagos of the west equatorial Atlantic, located in the Intertropical Convergence Zone. On the northwest African coast, trade winds are tangent to the western European-west African migratory flyway, which is used by *M. m. migrans* in its seasonal movements between Europe and Africa. We cannot, however, rule out ship-assistance for all or part of its journey to the archipelago. This is the first record of a Black Kite in Brazilian territory, although the species remains unknown on the American mainland.

KEY-WORDS: Occurrence, raptor, record, trade winds, vagrant.

The Black Kite (*Milvus migrans*) is a widespread generalist raptor found over most of the Old World and Australasia (Ferguson-Lees & Christie 2001). Depending on the taxonomic treatment, up to seven subspecies are recognized, some of which are sometimes treated as distinct species (Thiollay 1994, Ferguson-Lees & Christie 2001, 2005). The highly migratory subspecies *M. m. migrans* breeds in continental Europe, north-west Africa and west Asia, and winters primarily in Africa, south of the Sahara (Ferguson-Lees & Christie 2001). During migration, this race principally uses the Western European-West African Flyway, crossing the Strait of Gibraltar (Sergio *et al.* 2014), but substantial numbers migrate through the central and eastern Mediterranean corridors (via the Sicilian Channel and the Bosphorus, respectively); the Russian population moves down along the eastern coast of the Black Sea (Cramp & Simmons 1980, Panuccio *et al.* 2014).

Raptors show different migration strategies because of differences in body features such as aspect ratio and wing loading between different genera and species. Narrow wings associated with well-developed pectoral muscles, as found in *Circus* and *Falco*, favor longer sea and desert crossings through active flight. Large broad-winged raptors, on the other hand, rely mostly on soaring-gliding to migrate and avoid crossing open water as they cannot sustain active flight for long distances (Ferguson-Lees & Christie 2001). Black Kites are intermediate between these two types and thus tend to use soaring during migration but are also able to perform long powered flights over water (Panuccio *et al.* 2014).

Wind conditions may favor long sea crossings by species that usually avoid crossing water, but crosswinds may take raptors to places off their regular routes (Newton 2008). Vagrant Black Kites have been recorded, for example, in New Zealand (Gill *et al.* 2010), Micronesia (Mariana Islands and Wake Atoll; AOU 2000, Rauzon *et al.* 2008) and at Midway in the Hawaiian Islands in the mid-Pacific Ocean (AOU 2000).

These latter records referred to the subspecies

M. m. lineatus of the central and east Palearctic (AOU 2000, Wiles *et al.* 2004). Although the Hawaiian records led to the inclusion of the Black Kite in the *American Ornithologists' Union* list of North American birds (AOU 2000), the species is actually considered absent from the New World (Ferguson-Lees & Christie 2001). Herein we document the occurrence of the Black Kite in the Saint Peter and Saint Paul Archipelago (SPSPA), a group of oceanic islets under the Brazilian jurisdiction and well outside the species' normal distribution range.

The SPSPA is a small group of rocky islets (~1.7 ha) on the Mid Atlantic Ridge (0°55'N, 29°20'W) without perennial vegetation or natural freshwater sources. It is located 1,100 km from the Brazilian mainland, 650 km from the Fernando de Noronha archipelago and 1,970 km from the northwest African coast (Figure 1). Only three bird species nest at SPSPA: the Brown Booby *Sula leucogaster*; the Brown Noddy *Anous stolidus*; and the Black Noddy *A. minutus* (Both & Freitas 2004). The largest island, Belmonte, has a lighthouse and a research station, which permanently houses researchers through a long-term scientific research program (Viana *et al.* 2009).

From 16 April to 17 May 2014 LSH, BCLM and GTN photographed a Black Kite at Belmonte Is., SPSPA. The bird was identified as an adult by the absence of pale markings on the upper wing and the lack of a two-toned, cream-tipped under tail, which are typical features of juveniles (Ferguson-Lees & Christie 2001, 2005)

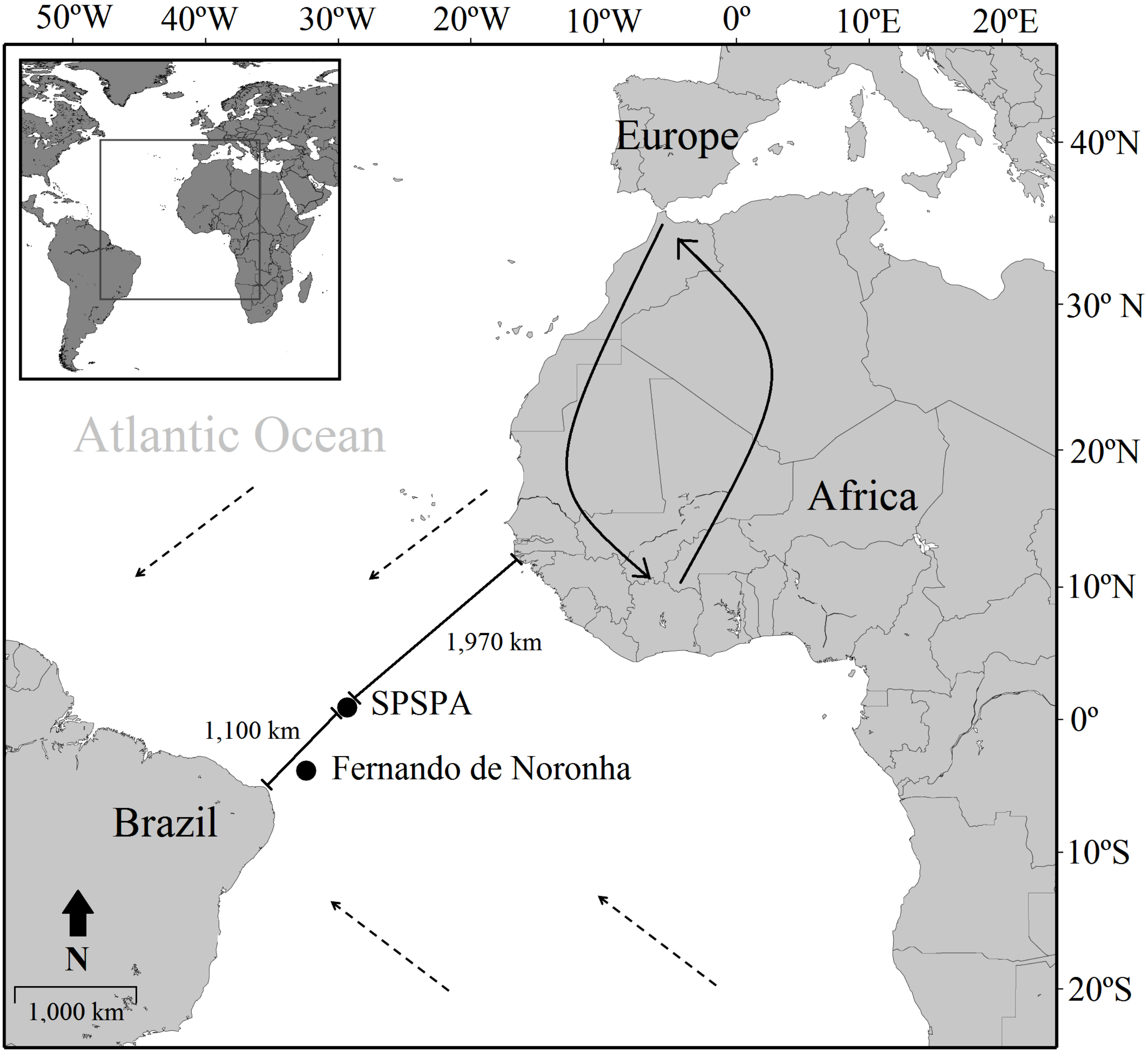

FIGURE 1. Map showing the Saint Peter and Saint Paul (SPSPA) and the Fernando de Noronha archipelagos between African and South American continents. Solid arrows schematically indicate the seasonal migrations of Black Kites *Milvus migrans* through the western European-west African migratory flyway: northward pre-breeding migration during northern spring; southward post-breeding migration during northern autumn. Dashed arrows indicate the easterly surface winds which are predominant between 30°S and 30°N.

(Figure 2a–d). The bird was a medium-sized hawk with a notched tail, grayish-white iris, yellow legs and mostly reddish-brown underparts. The brown, lightly barred tail (not rufous and distinctly forked), the lack of a whitish panel on the inner primaries on the underwing, and the presence of six primary "fingers" excluded the similar Red Kite *M. milvus* (Ferguson-Lees & Christie 2001). The predominantly whitish (as opposed to brown or rufous) crown identified it as belonging to the nominate subspecies and also ruled out *M. fasciicauda* (also referred to as *M. milvus fasciicauda*) from the Cape Verde Islands (Hille & Thiollay 2000, Ferguson-Lees & Christie 2001). The all-dark Northern Marsh Harrier (*Circus aeruginosus*) is another potential vagrant from the Old World, often confused with the Black Kite, but its tail is slightly rounded and unbarred (Ferguson-Lees & Christie 2001, 2005).

FIGURE 2. Black Kite *Milvus migrans* recorded in the Saint Peter and Saint Paul Archipelago, Brazil, from 16 April to 17 May 2014, (a) and (b) resting on Belmonte Is.; (c) and (d) in flight, showing diagnostic under and upper wing patterns (photographs: L. S. Hoffmann).

The bird appeared healthy when first detected and in the following two weeks. After two days of intense rain, it was found in a seemingly weakened condition and with the feathers soaked on Belmonte Is. on the 3rd May. Two days later, the kite apparently recovered its body condition and began to fly over the SPSPA, remaining mainly in the vicinity of seabird colonies. On one occasion, five days after recovering, it was seen capturing a nestling Brown Booby and carrying it away without difficulty. The kite disappeared 32 days after its arrival on the 18 May.

This record of a Black Kite on the SPSPA is the first for Brazilian territory and only the second for the combined area of coverage of the checklists of North and South American birds (AOU 1998 & supplements, Remsen *et al.* 2015). The species, however, remains unreported in the continental Americas (e.g., CBRO 2014, Remsen *et al.* 2015). The Black Kite may have reached the SPSPA with the assistance of trade winds originating in the northwest coast of Africa, which are tangent to the main flyway used by *M. m. migrans* in its movements between wintering areas in northwestern Africa and breeding areas in western Europe (Sergio *et al.* 2014). This region lies within the Subtropical High area, a high-pressure center in the Northern Hemisphere from which winds blow in a southwesterly direction. On the equator, these winds meet winds blowing from the Southern Hemisphere's Subtropical High area, which move northwestward from the southeast, forming the Intertropical Convergence Zone (Talley *et al.* 2011). The geographical position of this zone varies over the year, and from February to early June it is on the equator, where precipitation is highest (Riehl 1979).

The timing of the bird's arrival in the archipelago suggests that it strayed from its normal route and was perhaps drifted off its normal route during northbound migration. At the Strait of Gibraltar, the passage of migrating Black Kites towards the breeding grounds in spring peaks in the first half of March, while migration across the Mediterranean in more easterly routes occurs progressively later (Panuccio *et al.* 2014). Overall, the migratory season spans from late February through May (Ferguson-Lees & Christie 2001). The date on which the bird disappeared from SPSPA coincided with the end of the rainy season in the archipelago. Therefore, it may have survived for a month, due in part to the availability of freshwater provided by the frequent rains, and also by preying opportunistically on seabird nestlings.

The occurrence of other species of Old World birds in the SPSPA, such as the Little Egret *Egretta garzetta*, Eurasian Kestrel *Falco tinnunculus*, Lesser Moorhen *Gallinula angulata* (Bencke *et al.* 2005) and Western Reef-Heron *Egretta gularis* (Fedrizzi *et al.* 2007) is also likely to be associated with this particular configuration of easterly winds, although ship assistance cannot be ruled out in some cases. Records of Northern Pintail *Anas acuta*, Gray Heron *Ardea cinerea*, Squacco Heron *Ardeola ralloides*, Western Reef-Heron, Eurasian Whimbrel *Numenius phaeopus*, Bar-tailed Godwit *Limosa lapponica* (Silva & Olmos 2006), Eurasian Spoonbill *Platalea leucorodia*, Redshank *Tringa totanus* (Schulz-Neto 2004) and Corncrake *Crex crex* (Burgos & Olmos 2013) in Fernando de Noronha can be attributed to the same atmospheric phenomenon.

Under the appropriate conditions, archipelagos of the west equatorial Atlantic can serve not only as resting places for vagrant birds straying from the Western Palearctic and Ethiopian regions, but also as a gateway to the successful colonization of the New World, as was suggested for Western Reef-Heron (Fedrizzi *et al.* 2007) and Squacco Heron (Davis 2010). Although ship-assistance is theoretically possible for all or part of the journey for such birds, we consider that the occurrence of a Black Kite in the SPSPA is most likely a case of natural vagrancy. The species is physiologically capable of long over-water crossings; the SPSPA has no harbor and there is no regular shipping route that directly connects the archipelago to the Old World, although vessels pass close by; there is a system of trade winds that facilitate the westward dispersal of off-course migrants across the equatorial Atlantic Ocean; there are many other documented cases of Old World birds that arrived in islands of the west equatorial Atlantic in recent times and it is unlikely that most were ship-assisted, particularly shy birds that avoid landing on man-made structures such as vessels, as is the case with the Pintail, Corncrake, Eurasian Whimbrel, Eurasian Spoonbill, Redshank and Bar-tailed Godwit; and finally, the date on which the bird appeared in the archipelago coincided with a period of high migratory activity of the Black Kite in the west Palearctic. We suggest the use of the Portuguese name "Milhafre-preto" in Brazil, given its widespread usage in Portugal.

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A review of the distribution of the Crested Eagle, *Morphnus guianensis* (Daudin, 1800) (Accipitridae: Harpiinae), including range extensions

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ABSTRACT: Here we review the distribution of the Crested Eagle (*Morphnus guianensis*) in the Americas, and based on the Brazilian Harpy Eagle Conservation Program (PCGR) database, literature, online databases, zoos, wild and museum records, we provide an updated distribution map with 37 points outside the IUCN map; 16 were recorded close to the border of the map (up to 40 km), and do not expand or contribute to the distribution map. Far from the border (>40 km) we found 21 records, contributing to an expansion of the known range and habitat. At the northernmost extreme of distribution, the range was extended to southern Mexico; in Nicaragua, the range extension was farther south in the north, and two records extend the range to the southern border with Costa Rica. In Colombia, an old specimen is located between Darien Peninsula and the Perija Mountains. In Brazil a record from the ecotone between Cerrado and Gallery Forest, and another in an upland remnant of Atlantic Rainforest, expands the range towards central and southeastern Brazil, and to the Northeast, old records could expand the Atlantic Rainforest distribution towards the interior.

KEY-WORDS: Conservation, Falconiformes, Neotropics, Raptor.

Included in the order Accipitriformes, the Crested Eagle, *Morphnus guianensis*, and Harpy Eagle, *Harpia harpyja*, are the Neotropical representatives of the subfamily Harpiinae (CBRO 2014). The members of Harpiinae can be distinguished from other Accipitridae by large sizes and weight, length and wingspan, being traditional inhabitants of humid tropical forests (Ferguson-Lees & Christie 2001), preying on mid-sized mammals such as sloths, monkeys, and rodents (Ferguson-Lees & Christie 2001; Aguiar-Silva *et al.* 2014.

The species occurs in low density, and is deemed rare to very rare in all areas of distribution, mainly inhabiting Neotropical dense humid forest, mountain slopes, coastal forest, from sea level to 2200 m; it is considered resident (Brown & Amadon 1968; Hilty & Brown 1986; Bierregaard 1994; Howell & Webb 1995; Ridgely & Greenfield 2001; Ferguson-Lees & Christie 2001; Hilty 2003; Hennessey *et al.* 2003; Jones & Komar 2007). It can also occur in forest patches and has been recorded nesting in a Brazilian forest fragment, located in a mosaic between soybean fields and forest fragments (Lees *et al.* 2013), and also has been found in forest mosaics within the Gran Sabana, Venezuela (Crease & Tepedino, 2013).

In Brazil, the Crested Eagle is known as "Uiraçu-falso" or "Gavião-real-falso" [=False Harpy Eagle] (CBRO 2014). According to the literature, adults reach up to 89 cm in total length, wingspan up to 154 cm and weight up to 3 kg; females are larger and more robust (Bierregaard 1994; Ferguson-Lees & Christie 2001). The head is grayish with a crest tipped with a single larger medial black feather. In general the color pattern resembles that of Harpy Eagle, however the latter always has a black chest band (Sick 1997; Ferguson-Lees & Christie 2001). Adults most commonly are pale-morph, but may occur in two melanistic forms, dark-morph and extreme-dark-morph. During its 4-year sequence to attain adult plumage, birds become darker over time (Bierregaard 1994; Ferguson-Lees & Christie 2001).

Mauduyt (1782), described the *Aigle* (*petit*) *de La Guiane* in a systematic and comparative way, with specimens coming from Cayenne [=French Guiana]. Based on this work, in 1800 Daudin described *Falco guianensis* using Linnean nomenclature. Later, *Falco* was made a synonym of *Morphnus* by Dumont (1816), giving rise to the monotypic species *Morphnus guianensis*. In 1879, Gurney described *Morphnus taeniatus* as a full species, later synonymized because it was just a dark-morph (Lehmann 1943).

The Crested Eagle has a wide distribution over Central and South America (Ferguson-Lees & Christie 2001), however records are generally casual or by chance, being considered rarer than the Harpy Eagle in some regions where they coexist (Jones & Komar 2006).

More than 250 years after its description, few surveys include the species in their lists, and studies of its biology and ecology are rare, therefore understanding its distribution is the goal of this review. The Crested Eagle is a top predator, occurring in low densities, and is considered a Vulnerable (IBAMA 2014) and Near-threatened (IUCN 2014) species, due to habitat loss and hunting. The knowledge of its current distribution and ecological requirements could contribute as a basis for further conservation policies.

Currently, the most widely used distribution maps as a basis for conservation plans and determining the threat status of the vast majority of organisms are provided by the International Union for Conservation of Nature (IUCN 2014). However, recent records, very old ones, and those from gray literature or from birdwatchers, photographers or videographers are lacking consideration. Our goal is to review the distribution of the Crested Eagle, including new records, particularly for Brazil, which holds the largest continuous forests in the continent, and produce an updated map of its occurrence.

MATERIAL AND METHODS

The review follows the format of the database of the Global Raptor Information Network - GRIN (2013) for all countries. It is augmented with more details for the states of Brazil, old published records, information from the Brazilian Harpy Eagle Conservation Program (PCGR) database and online databases such as ORNIS, IBC and AVECOL, gray literature (such as Instituto Brasileiro de Meio Ambiente de Rescursos Naturais Renovaveis (IBAMA) [=Brazilian Environmental Agency] reports), birdwatcher reports, lodge lists, unpublished reports, photographs, and recently published studies. Those sources where the indication of the distribution of the species was very broad and poorly defined (for example, no specific localities mentioned) were not used in our final map.

The final map was created using the ArcGIS software at the "Laboratório de Agrimensura da Universidade Estadual do Amazonas". Records were subdivided into New (after 2000), Old (prior to 2000), Nests, and Rescued individuals by IBAMA overlaid with distribution limits provided in the IUCN map (IUCN 2014). For published records, whenever possible, we used the exact date, and when the article did not provide this information, we used the publication date. Not all records had accurate locations. When this information was available, the exact locality was included on the map, following the exact geographical coordinates. For those records with no exact geographic coordinates, we used coordinates associated with the geographical center of the municipality where they were obtained. Seven museum specimens without collecting dates were assumed as Old records on the map (prior to 2000). All records are presented in the Appendices, but some were not included on the map because they overlapped, or had little accuracy.

Collections and Museums

Since 2005, the "Programa de Conservação do Gavião-real" PCGR-INPA [=Brazilian Harpy Eagle Conservation Program; http://gaviaoreal.inpa.gov.br] visited collections researching specimens of Harpy Eagle, Crested Eagle, and Hawk-Eagles, to build a distributional database. Eight Brazilian collections housed specimens of Crested Eagle: Museu Paraense Emilio Goeldi (Belém, Pará – MPEG), Instituto Nacional de Pesquisas da Amazôonia – Coleção Ornitólogica (Manaus, Amazonas – INPA), Museu de Zoologia da Universidade de São Paulo (São Paulo, São Paulo – MZUSP), Museu de História Natural de Taubaté (Taubaté, São Paulo – MHNT), Universidade Federal de Santa Catarina – Coleção Ornitológica (Florianópolis, Santa Catarina – UFSC), Museu Frei Miguel (Luzerna, Santa Catarina), Museu de Biologia Prof. Mello Leitão (Santa Teresa, Espírito Santo – MBML), as well as small private collections as tourist exhibits, such as Museu do Índio (Florianópolis, Santa Catarina). Data from two collections, Museu Sete Quedas (Pato Bragado, Paraná) and Museu da Fauna (Rio de Janeiro, Rio de Janeiro, closed in 1983 and its collection tranferred to Museu Nacional in 1993), were taken only from literature describing their holdings. Twelve collections outside Brazil had Crested Eagle specimens, and data were accessed directly from the institution`s website or from websites that replicate information from different collections, such as ORNIS, where we accessed the collections of the Academy of Natural Sciences of Philadelphia (Philadelphia, Pennsylvania – ANSP); the United States National Musem (Washington, D. C. – USNM); Field Museum of Natural History (University of Chicago, Chicago, Illinois – FMNH); Louisiana State University Museum of Zoology (Baton Rouge, Louisiana – LSUMZ); Museum of Comparative Zoology (Harvard University, Cambridge, Massachusetts – MCZ); American Museum of Natural History (New York, New York – AMNH); Royal Ontario Museum (Toronto, Canada – ROM); Carnegie Museum of Natural History (Pittsburgh, Pennsylvania – CM); Los Angeles County Museum of Natural History (Los Angeles, California – LACM); Western Foundation of Vertebrate Zoology (Camarillo, California – WFVZ), and the Oklahoma Natural History Museum (Oklahoma City, Oklahoma – OMNH). Specimens with imprecise information about the collection site were not included on the map (Appendices 1 and 2).

Rescued and Captive Birds in Brazil

For the location of individuals rescued by wildlife authorities in Brazil (IBAMA), one point for the location of each bird's origin was plotted on the map, with the date of rescue included only in the text. For individuals at conservation centers and zoos, we inserted a point on the map only if they had information on the origin/capture. Current or past individuals of Crested Eagle were at: Zoológico de São Paulo – São Paulo; Zoológico do Centro de Instrução e Guerra na Selva – CIGS, Manaus, Amazonas; Zooparque de Itatiba – Itatiba, São Paulo; Zoológico Municipal Dois Irmãos – Recife, Pernambuco; and Criadouro Conservacionista – CRAX in Belo Horizonte, Minas Gerais (Appendix 1).

Online Databases

Open access online databases were also consulted. Photo and sound files and videos were obtained from the following websites providing both records and accession numbers: www.wikiaves.com.br (WA), www.xeno-canto.org (XC), and Macaulay Library (MAC) Cornell Lab. of Ornithology, Ithaca, New York (http://macaulaylibrary.org); or less scientific sites, such as the Internet Bird Collection (IBC), and stock photos at the Visual Resources for Ornithology (VIREO) at the Academy of Natural Sciences, Philadelphia (http://vireo.acnatsci.org). Some records came from private photo collections (Flickr); the authors were asked for permission to use the records and in some cases provided additional data. Despite the chance of mistaken indetifications between Crested and Harpy eagles, some unpublished sight records and sound recordings of Brazilian professional and amateaur ornithologists alike were included in the distribution map (Appendices 1 and 2).

RESULTS

A total of 269 Crested Eagle records were found from Mexico to Argentina. Listed by locality, 129 records were obtained for Brazil and 140 records for Mexico, Central America and other South American countries. From the total, 45 records did not meet criteria and were rejected from our map when they did not have known origin (zoo or museum specimens), were repetitive (different years at the same point), or the literature listed only "general occurrence" (Appendices 1 and 2).

Listed by source, 156 records are from published literature in articles and books, 45 are records from museums and collections (ORNIS database), and 17 are records from our PCGR Database. The remaining 51 records were obtained from online photo and sound websites and personal communications (Appendices 1 and 2).

Listed by date, the records spanned 1898–2014. One hundred and thirty records are Old (before 2000), 113 are New (after 2000), and 26 records have no precise date (Appendices 1 and 2). A total of 37 records were placed outside the IUCN map, and are highlighted in bold in the appendices (Appendices 1 and 2).

Review of the distribution of the Crested Eagle outside Brazil

Of the 140 records obtained for Crested Eagle in Mexico, Central and South America, excluding Brazil, 96 were sourced from published literature in books or articles, 27 came from records in museums and collections, and 17 were obtained from online databases, recordings of vocalizations and photos from personal archives. From those records, 30 are located outside the distribution map provided by IUCN (Figure 1), enlarging the area of occurrence to southern Mexico, to the north of Nicaragua and to its southern border, and in Colombia, to include the region between Darien Peninsula and the Perija Mountains, and all are highlighted in bold in Appendix 2.

North America

Mexico – The first visual record in the country (a soaring adult), occurred in 1992 in Campeche (J. Sutter and J. M. Diaz cited in Whitacre *et al.* 2012). However the first documented record was a photo from 2004, at the Biosphere Reserve of Montes Azules, in Chiapas (Grosselet & Gutierrez-Carbonel, 2007). Whitacre *et al.* (2012) mentioned the probable occurrence in Chiapas and Quintana Roo.

Central America

Crested Eagle can be considered rarer than the Harpy Eagle in regions where they coexist, according to Jones & Komar (2006).

Belize – The first record occurred in 1995, at Orange Walk (Hall 1995), and is rarely seen in Toledo and Orange Walk, Cayo (Jones *et al.* 2000). A probable record was

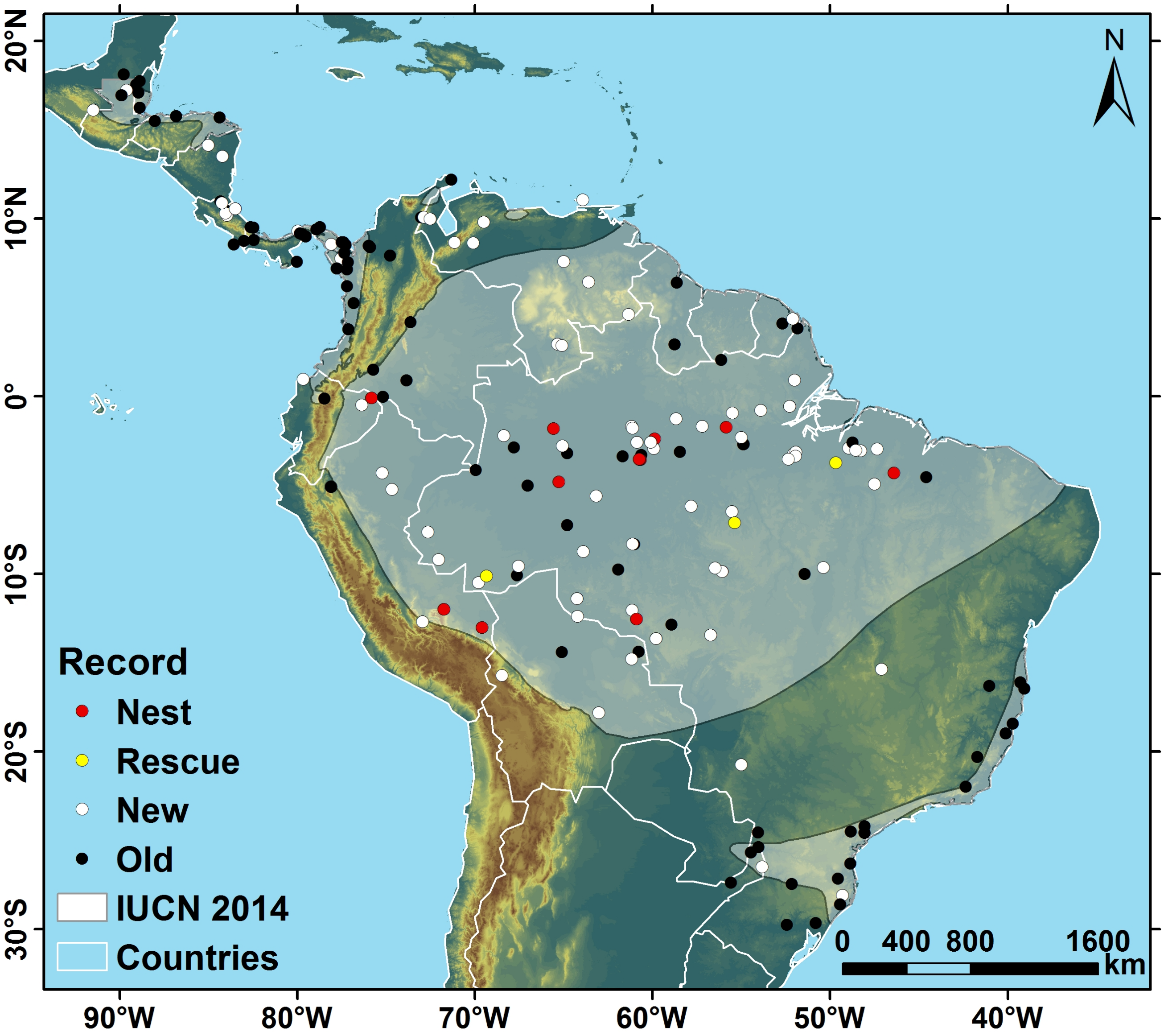

FIGURE 1. Localities where the Crested Eagle (*Morphnus guianensis*) has been recorded until 2014 (see Appendices 1 and 2). White circles represent recent records, after the year 2000; black circles represent records prior to 2000; red circles represent nests; yellow circles represent individuals rescued by IBAMA. The white water mark denotes the range contained in the IUCN (2014) map.

made in December 2006 in the southeast at Hickatee Lodge, Punta Gorda, Toledo (Jones & Komar 2007).

Guatemala – The first record occurred in 1978, reported by Ellis & Whaley (1981), in Flores (Petén). Between 1994 and 1995 an active nest was found in Tikal National Park, also Petén (Whitacre *et al.* 2012) and observations of a young bird were made in the same place, with a juvenile reported (Grijalva & Eisermann 2006). Eisermann & Avendaño (2007) considered the species resident and restricted to low-lying areas in the Atlantic region. The AMNH has a specimen collected in 1978 in Flores, Petén, and ROM has a specimen collected in 1966, in the same location.

Honduras – Bangs (1903) reported collection of a young male at La Ceiba, and Monroe (1968) of another individual in San Pedro Sula. A juvenile was photographed by Russell Thorstrom in flooded forest in Quebrada Kahkatingni, Patuca River, in June 1999 (GRIN 2013). Bonta & Anderson (2002) consider it a rare and resident species. The MCZ listed a skin from La Ceiba collected in 1902.

Nicaragua – An individual was seen in March 2001, near the community of Hormigero, Cerro Sasiaya, in the Bosawas Biosphere Reserve (GRIN 2013). Two other individuals were seen in May 1994 and May 1999 (Múnera-Roldán *et al.*, 2007) in the south, at Bartola Reserve; another individual was seen in 2001 in the "North Atlantic region" of the country, in the Alamikangban community, Prinzapolka, by Kjeldsen (2005).

Costa Rica – Birds were seen in the regions of Sarapiquí and Osa Peninsula (Stiles & Skutch 1989). There is a record of Carriker (1910) in Cuabre, near the Sacsola River (probably Sixaola). Slud (1964) recorded an individual at Cañas Gordas, near Panama. There were also records at Finca La Selva and Rara Avis Jungle Lodge, around Braulio Carrillo National Park (Jones 2004). An adult dark-morph was photographed in 29 April 2011, in Crucitas, Curtis de San Carlos, Alajuela (photo by R. Vargas; P. Camacho, pers. comm.) There is a photograph of a subadult pale-morph in 2005 from Tortuguero near the Nicaraguan border (Jones & Komar 2006), including a pale and a dark-morph pair photographed in 2005 (G. Ocklind, pers. file); besides there are two recent records, one from March 2013 (in the park, photo and record by R. Osborne and E. Miranda) and January 2014 (Caño Harold, photo by C. C. Obando), both from Tortuguero National Park (P. Camacho pers. comm., Fundacíon Rapaces de Costa Rica Database). The CM has a specimen collected in Cuabre, Límon, in 1904.

Panama – It is considered very rare, occuring in continuous forest and on the Caribbean slope, from southeast to east (Wetmore 1965; Ridgely & Gwynne 1989). There are occasional records from the southwestern Azuero Peninsula (Cerro Hoya region), in the provinces of Panama (eastern region) and Darién; those from Chiriquí and Coiba Island are unsubstantiated; there is a photographic record near Achiote Road in January 1975 (reported by W. Cornwell) (Ridgely & Gwynne 1989). Kiff *et al.* (1989) notes an egg obtained in the wild from a nest located on the Chiquita River, central Panama, and passed to the CEPEPE [=Center for Propagation of Endangered Panamanian Species]. Vargas *et al.* (2009) reported an adult Crested Eagle feeding a nestling Harpy Eagle in Quintin Darién. A young Crested Eagle was reported from San Lorenzo National Park, Colón, in March 2007 by Jones & Komar (2007). Two records were made in Darién National Park: an adult dark-morph was filmed at the Cana Camp in May 2010 (E. Groenewoud, IBC), and a female was sound-recorded by A. Spencer near her nest in March 2013, in Rancho Frio. The MAC has a sound recording made in 1981, of a dark-morph female perched in a tree, next to Pipeline Rd., northwest of Gamboa, in the Canal Zone (van den Berg 1981). The MCZ holds four old specimens from Panama: Changuinola (1928), Perme, in Darién (1929), Banana River (1928) and Puerto Obaldia (1930). The FMNH has a pair collected in San Blas, Puerto Obaldia, in 1935. The AMNH has one specimen from Barro Colorado Island from 1936, and two from Tapalisa, eastern Panama, from 1915.

South America

Colombia – Considered rare by Hilty & Brown (1986), these authors cite localities of Chocó, Baudó mountains, Achicayá and Sinu valleys, Córdoba and Perijá mountains, Guajíra (Carraipia), the eastern region of the Andes, and west of Meta (Villavivencio) and Caquetá. Márquez *et al.* (2005) provides records in museums, at least four specimens collected in Leticia, Caquetá and Chocó (Salaqui River and Juradó River). ANSP has a specimen listed from Morelia, Caquetá, undated. USNM maintains three complete specimens preserved in alcohol: one from Truandó, one from the Sinu River, in Rescues, Córdoba, 1949, and one from Uraba Gulf in Acandi, Chocó, 1949. FMNH maintains two specimens collected in Chocó in 1940, from Jampavado River and from Jurado River, plus one from Cuturu, Antioquia, in 1947.

Ecuador – Very rare, but has been recorded in the Pichincha region and at the base of the Andes (Ridgely & Greenfield 2001). Muñiz-Lópes *et al.* (2007) cite its occurrence in Esmeraldas Province. In 2007, a pale-morph individual was seen preying on a snake (*Spilotes pullatus*) in Cuyabeno, Sucumbios Province (L. Vaincenbacher, IBC, 2007). In the Wildlife Center of Napo, the species has been seen by birdwatchers and is listed for the region (http://www.napowildlifecenter.com), plus a photographic record of an individual dark-morph in 2008 (T. Cloudman http://www.hargrove.org/2008/images/2008crestedEagle-edited-jpg). In 2014 a nest was found in the Cuyabeno Reserve (R. Muniz-Lopes pers. comm.). In the Quito Zoo there is a female dark-morph of unknown origin (Montalvo & Montalvo 2012).

Bolivia – Pearman (1994 *In* GRIN 2013) records the species for the first time in Beni. Then it was seen in Noel Kempff National Park (Bates *et al.* 1998) and subsequently in La Paz and Santa Cruz de la Sierra (Hennessey *et al.* 2003). In 2005 it was seen in Caparú Biological Station (Vidoz *et al.* 2010).

Peru – Considered rare, it occurs in the eastern region of the Andes (Clements & Shany 2001). Kiff *et al.* (1989) cite the capture of a female from a nest in Amazonas Department in 1978 (this individual became part of the breeding stock at the Oklahoma City Zoo). It is listed from the Tambopata-Candamo Reserve (Parker *et al.* 1994), where they have recorded breeding activity since 2002 (Raine 2007). In 1977 and 2006, two different nests with nestlings were photographed in Madre de Dios, near Manu Lodge (R. Fabbri, pers. comm.). In 2001 it was seen preying on small primates, at the Quebrada Blanco Biological Station (Vasquez & Heymann 2001), and in June 2012, a young on the ground was seen and photographed (Flickr) in National Park Pacaya-Samiria, Loreto (A. Morales, personal file). The species is listed by Foss & Huanaquiri on a birdlist at a forest reserve in Loreto (Tahuayo River – http://thinkjungle.com/amazon-jungle-tours/tahuayo-lodge). The Centro de Reproducion Huayco, in Lima, owned by Jose Antonio Otero, housed six individuals with no record of origin. LSUMZ maintains two specimens collected from Amazonas Department, two specimens from Loreto Department, and a feather from the same location, all without exact dates.

Venezuela – Rarely sighted, occurs widely over lowland forests and mountains, with records from Northern Orinoco, Caura River, Maracaibo Basin, Perijá Mts., Zulia, Mérida, Lara, Amazonas, Bolívar, and Margarita Island (Hilty 2003). In 2006 it was recorded in Obispos, Barinas (Vargas *et al.* 2009), and in 2011, a nest was found and monitored in the Gran Sabana, Bolivar, with documenting photos by Crease & Tepedino (2013).

Guyana – Considered resident and scarce, occupying lowland forest environments (Braun *et al.* 2000). Pickles *et al.* (2011) recorded the species in the Chief Rewa Reserve, in Rupununí, in the south. Two specimens housed at ROM are from this same region, upper Takutu and upper Essequibos, Kwitara River, Rupununi, both from 1964. AMNH keeps a specimen from Kalacoon, undated.

French Guiana – It is widely distributed in forest areas, and is more common than Harpy Eagle in disturbed forests, however, it is not significantly more common in primary forest (Thiollay 2007). Julliot (1994) reports predation by the Crested Eagle on a young spider monkey (*Atteles paniscus*), at Nouragues Station, which took place in 1992. In August 2011, an extreme-dark-morph individual was photographed on the banks of the Approuague River (J. Tascon, pers. comm.). The Macouria Zoo in Guyana maintains a live specimen, dark-morph, possibly a male, with unknown origin (Maxcobigo, *In* IBC).

Suriname – Apparently a rare bird in primary forest, sometimes seen wandering into areas of the coast (Haverschmidt & Mees 1994). Possibly a resident, but no reproductive activity has been noted in the country. On the list of birds from Raleigh Falls-Voltzberg Nature Reserve, Sipaliwini District, where it was seen in a predation attempt on Guianan Cock-of-the-rock (*Rupicola rupicola*) (Trail 1987).

Argentina – Species considered to be resident (Mazar-Barnett & Pearman 2001). Pearman (2001) considers the species a casual visitor to Missiones, and reports the observation of an adult in El Piñalito Provincial Park. There are earlier records in Santa Ana (Bertoni 1913) and at Iguazú National Park, a pair displaying, recorded in September 1980 by Rumboll & Straneck (*In* Olrog 1985).

Paraguay – Del Castillo & Clay (2004) consider the species rare, but reproductively active in Alto Paraná. There are two visual records during a survey conducted in the San Rafael del Parana National Park, in Itapúa (Madroño-Nieto *et al.* 1997). The first confirmed record occured in 2002, at the same place, where a specimen was captured and donated to the Itaipu Binacional Zoo, which survived until 2002 (Del Castillo & Clay 2004, Museum of Natural History of Itaipu Binational). Another record also occurred near the Aurora Colony, in the same region of the San Rafael del Parana National Park, of an individual in flight in December 2003 (N. Lopes, *In* Del Castillo & Clay 2004).

Review of the distribution of the Crested Eagle in Brazil

Of the 130 records obtained for Crested Eagle from Brazil, 60 were sourced from published literature in books or articles, 18 came from records in museums and collections, and 34 were obtained from online databases, recordings of vocalizations and photos from personal archives, and 18 came from the PCGR Database. From these, seven records are located outside the distribution map provided by IUCN (Figure 1), enlarging the area of occurrence to the northeast, southeast and south, and are highlighted in bold in Appendix 1.

The majority of the records (70%) were outside conservation units, 27 records (21%) were from National Conservation Reserves and 12 (8%) were from County, Municipal or Private Reserves.

For each state we include the Brazilian region (South, Southeastern, Northeastern, Central and Northern Brazil) and abbreviations for the biome occupied (ARF-Atlantic Rainforest, AMZ-Amazonian Rainforest, and ECO – Ecotone Biome Cerrado/Gallery Forest).

Rio Grande do Sul (South-ARF) – There are only three historical records. The oldest comes from Ihering (1899), near the municipality of Taquara; its occurrence is also suggested at the Turvo River Reserve (Belton 1984). Bencke (1997) provides the last record from Santa Cruz do Sul in 1920. Considered very rare in the state by Sick (1997), it is currently classified as 'Probably Extinct' (Marques *et al.* 2002).

Santa Catarina (South-ARF) – There are five records of the species: in 1977 it was seen in Jordão Baixo (Siderópolis) by Albuquerque (1983); Rosário (1996) provides a record in Siderópolis; and another record in 2005, in Aiúre, in the municipality of Grão-Pará, in the foothills of Serra Geral (Albuquerque *et al.* 2006). Records from museums in Santa Catarina are unreliable, since they come from private collections, without scientific identification of locality. There is a specimen in Frei Miguel Museum, in Luzerna, from the locality of Joinville, prepared in 1926 (Favretto 2008). Recently a specimen at the Universidade de Santa Catarina (UFSC) was analyzed, which had been previously classified as a Harpy Eagle. We confirmed that it was a Crested Eagle. This specimen was collected between 1965-1970 in the municipality of Lontras, by G. Knolle, also for his private collection, and was subsequently donated to the Ornithological Collection of UFSC. There is an adult mounted specimen, pale-morph, sex undetermined, unknown origin, in the private collection of Museu do Índio, in Florianópolis.

Paraná (South-ARF) – The occurrence of the species was registered only at Marechal Cândido Rondon in 1964. This is a mounted specimen, housed in the Sete Quedas Museum, and similar to the previous cases, it was from a private collection (Straube & Urben-Filho 2010). The species possibly occurs at Iguaçu National Park, where well-preserved forest still remains (Forrester 1993).

São Paulo (Southeastern-ARF) – The first citation found was Ihering (1898), which dealt with the collecting a Harpy Eagle and likely (but not confirmed) occurrence of the Crested Eagle in the state. More recently, it was recorded in large reserves protected by the State government, known as State Parks (P. E.): twice in Jacupiranga P.E. (1990 and 1992), once in the Morro do Diabo P.E. (1992) and, once in Intervales P.E. (1995). In the first two records the birds were soaring, and in the last, landing (Galetti *et al.* 1997). In both cases only visual records were made. At the MZUSP Collection, there is a specimen from Apiaí, collected in 1900. MHNT has a mounted specimen displayed, however of unknown procedence. In the Itatiba Zooparque, there is a pale and dark-morph pair on display, both with unknown origin.

Rio de Janeiro (Southeastern-ARF) – There is only one historical record, from Pinto (1964) for the locality of Cantagalo, and from this same location, there is a skin in the collection of Johann Natterer (Hellmayr & Conover 1949). At the National Museum of Rio de Janeiro there are five specimens listed, however all are of unknown origin.

Espírito Santo (Southeastern-ARF) - There are two records: an observation at Sooretama Biological Reserve, Sooretama, by Parker & Goerck (1997) and another in Itaúnas State Park (Petroff 2001). At the Museu Biológico Mello Leitão, Santa Teresa (MBML) there is one mounted specimen of unknown origin and without registration number.

Minas Gerais (Southeastern-ARF) – There are two records. The first record is listed on the state list (Mattos *et al.* 1993), as having been seen in Mata Escura Biological Reserve, in Jequitinhonha (T. Mattos, pers. comm). The second record occurred in the Caparaó National Park, in Alto Caparaó, in 1997, in which two individuals were seen flying, which was probably a pair (Zorzin *et al.* 2006). CRAX maintains a live female dark-morph, previously paired with a male pale-morph borrowed from the São Paulo Zoo, but which died later (individual donated to Universidade Federal de Minas Gerais-UFMG, however it has not yet been taxidermized), both of unknown origin. Recently CRAX received another dark-morph female, from Pará (ICMBio).

Bahia (Northeastern-ARF) – There are two records: Willis & Oniki (2003) comment on an aural record in Porto Seguro, in 1974. There is also a visual record in the municipality of Barrolândia, municipality of Belmonte, 1995 (Galetti *et al.* 1997).

The remaining Brazilian Northeastern states generally do not have records of the species, whether historical or recent ones; however, Dois Irmãos Zoo in Recife, Pernambuco, exhibits an adult pale-morph, of unknown origin.

Mato Grosso do Sul (Central Brazil-ECO) - P. Scherer and C. Ribas report the species in April 2001, flying over a road near the Private Natural Reserve (RPPN) Buraco das Araras, in the municipality of Jardim (*In* Pivatto *et al.* 2006). This region is savanna (Cerrado) with Gallery Forest.

Mato Grosso (Central Brazil-AMZ) – There are nine records for the species. The oldest record comes from Chapada dos Parecis, in Juruena (Sick 1997). In 2005, an individual was photographed along the Cristalino River (A. Lees, pers. file), and in 2006, two individuals were seen and photographed on the CEPLAC Farm (Executive Board of the Cocoa Crop Plan), both in Alta Floresta (A. Lees, pers. comm.). In 2011 one individual was photographed at the Jardins da Amazonia Inn, in São José do Rio Claro (E. Endrigo, pers. comm.), and in 2012, a pair was recorded responding aggressively to playback, in the same locality, where possibly there was a nest (M. Pádua, pers. comm.); in October 2012 in the Cristalino RPPN, an adult was drying itself in the canopy, after a heavy rain (J. Silveira, pers. comm.). In addition to these, photographic records were also made in 2012 in the municipality of Comodoro, (D. Mota and V. Castro, pers. comm.). In September 2012, a nest with a nestling (4–5 months old) was located in the municipality of Paranaíta, at the Ouro Reunido Farm (P. Bernardo, pers. comm. and D. Oliveira, pers. comm.). At MZUSP, one specimen is listed from the Ipê Farm, in Vila Rica. CETAS-IBAMA pre-release facility in Guarantã do Norte is housing a live young female pale-morph from the municipality of Novo Progresso, PA, currently still being held.

Rondonia (North-AMZ) – There are nine records. Between 1987 and 1988, the Crested Eagle has been registered at the Cachoeira Nazaré, close to the Ji-Paraná River by Stotz *et al.* (1997). In 2003, Olmos *et al.* (2011) recorded three individuals in Serra Cutia, between the municipalities of Guajará-Mirim and Costa Marques, besides having verified the existence of native craftsmanship using feathers of the bird. In January 2010 an adult individual was seen in Chupinguaia (K. Okada, pers. com.); at the same locality, in September 2010, a nest was found close to the previous record, with an active pair and a nestling (M. Canuto, pers. file). The nest was visited in October by the PCGR Team, who found it on the ground, because the tree had fallen. In January 2012, at the same locality, an adult was seen during an avifauna inventory (R. Hippolito, pers. comm.), possibly one of the members of the resident pair. In 2011, next to the Ramal do Rio das Garças, in Porto Velho, an individual was photographed (F. Pereira). In March 2012, in Guaporé Biological Reserve, between São Francisco do Guaporé and Alta Floresta D'Oeste, an individual dark-morph was recorded calling next to a group of small primates (S. Alves, ICMBio/ReBio Guaporé, pers. comm. and file).

Acre (North-AMZ) – There are seven records. The first citation comes from Catuaba Experimental Farm – Universidade Federal do Acre-UFAC, near Rio Branco, between 1994 and 2004 (Rasmussen *et al.* 2005). The second record comes from the Alto Juruá Extractive Reserve, in Marechal Thaumaturgo (Whittaker *et al.* 2002). In 2008, DeLuca (2012) registers, through interviews with the locals, the presence of Harpy Eagle and Crested Eagle at the Chico Mendes Extractive Reserve and environs, comprising Assis Brazil, Brasiléia and Xapuri municipalities. In addition to this, and confirmed with a photograph, an adult dark-morph was seen in Rio Croa Community, municipality of Cruzeiro do Sul, in August 2012 (J. Filho), and Guilherme (2012) cites the species as resident for the whole State, using bamboo forests and rainforests with palm trees. In April 2013, a young pale-morph was seen flying in the municipality of Porto Acre (L. Rondini and T. Nascimento, pers. comm.). In 2009 a young specimen was rescued near Rio Branco, and forwarded to CETAS-IBAMA of Rio Branco, and later transferred to permanent capitivity, but we were not able to determine if it is still alive.

Amazonas (North-AMZ) – There are 16 recognized records/locations. The first record cites the occurrence of species in "Barra do Rio Negro" [=Manaus] and in Manaqueri [=Manaquiri] Lake (Manacapuru municipality) (Von Pelzeln, 1871), localities also replicated by Pinto (1964). In this same state one of the best-known papers about the species, Bierregaard (1984) described nesting of a pair, the male being pale-morph and the female, dark-morph, at the ZF-3 Reserve, 60 km north of Manaus (Gavião Camp-PDBFF Biological Dynamics of Forest Fragments Project) but the pair has not been registered subsequently. In 2004 an adult was observed at the Mamirauá Sustainable Development Reserve (RDS), in Tefé, Amazonas state, in a varzea forest (Cintra *et al.* 2007 and R. Cintra, pers. comm.). Olmos *et al.* (2006) also cite seeing two individuals resting and feeding, in the municipality of Alvarães. Cohn-Haft *et al.* (1997) cites its occurrence in large forest fragments of the PDBFF Project (Esteio, Dimona and Porto Alegre Farms) near Manaus. In the Adolpho Ducke Forest Reserve, Manaus, in 2005, an individual was spotted (J. Valsko, pers. comm.) and recorded vocalizing (W. Magnusson, pers. comm. and file at PCGR Database). There is also a record of the species in the Juami-Jupará Ecological Station, in 2006 (T.M.S. *In* Soares *et al.* 2008: 76). In July 2009 an adult pale-morph was photographed in the Anavilhanas National Park, perched on treetops in flooded forest (S. V. Wilson, pers. comm. and photo), and in June 2012, at the same location, a pair was seen carrying prey, probably for a nest (A. Whittaker, pers. comm.); however on a visit in 2013 the nest was not found (FBRG). On the banks of the Roosevelt River in Novo Aripuanã, on 2 July 2007, a pale-morph adult was seen in the canopy of a tree (B. Whitney, video IBC & pers. comm.), and on 12 September 2007 a pair and 17 September a subadult. Whittaker (in 2009) recorded an individual on the banks of the same river, and another around the lodging. In 2008, it was seen on the Urucu River, and also a nest (not studied by PCGR) (Whittaker *et al.* 2008). In 2011, an individual was photographed in Tapauá, in Nascentes do Lago Jari National Park (L. Condrati, pers. comm., ICMBio). In April 2013, a sub-adult pale-morph was seen on ZF-2 Road, 10 km from the Cuieiras Reserve nest known in the locality, interacting aggressively with a flock of Red-throated Caracaras (*Ibycter americanus*). Possibly this is a nestling from this nest, which has dispersed for two or three years (whitish general plumage, with wing coverts still grayish) (FBRG). In Amazonas, PCGR monitors four nests of this species, one in Manaus and three in the nearby town of Manacapuru. In Manaus, the nest is located in the Cuieiras Reserve (INPA), and was found by members of the TEAM Project – INPA in 2006, and has been monitored by PCGR since then (In Soares *et al.* 2008). The nests in Manacapuru, located on Cururu Lake, in a rural area of the municipality, were found and reported by local residents, and have been monitored since 2007. Recently a nest was discovered in August 2013, which is being monitored in Amanã RDS (Sustainable Development Reserve), under the auspices of the Mamirauá Sustainable Development Institute (IDSM). In addition to these *in vivo* records, the Instituto Nacional de Pesquisas da Amazônia INPA) - Ornithological Collection, holds a 1982 pale-morph female specimen, from the ZF-3 Reserve. Listed in MZUSP are a female, from October 1902, and a male, from January 1937, from the Juruá River (for our map assumed as near Carauarí), and another female from Manacapuru, dated October 1936. FMNH holds two skins of females: one from Lábrea, on the Purus River, 1935, and another from Lago do Baptista, in Itacoatiara, 1937. CM maintains a mounted specimen, collected in Tonantins, on the left bank of the Solimões River, in 1923. The CIGS Zoo (Manaus), kept a pale-morph male, however it died 17 July 2012 and was not preserved.

Roraima (North-AMZ) – The species was recorded at the Maracá Ecological Station by Moskovits *et al.* (1985). In 2004, an adult was photographed in the Viruá National Park, in Caracaraí (R. Czaban, IBAMA). In 2011, during a MZUSP expedition, an adult pale-morph was recorded, near the community of Caicubí, in the Jufari River, near Caracaraí (L. F. Silveira, pers. comm.).

Pará (North-AMZ) – There are 28 recognized localities/records for the species. The first reference is prior to the date of its description, Daudin (1800). In "Memórias de Dom Lourenço Álvares Roxo de Potflis", from 1752, translated and analyzed by Teixeira *et al.* (2010), the author makes a detailed description of the Harpy Eagle, and then describes the "ouyrà ouassù merì ou ouassù peua" a very similar bird to the Harpy Eagle, except for its more slender appearance (Teixeira *et al.* 2010). In the description, he is obviously describing the Crested Eagle however the "Memories" is not a scientific paper. In our most recent records, the species was seen in 2000, Taboca Island, Xingu River, and in 2008, in an Aquatic Bird Survey, Xingu River, both in forest (Henriques *et al.* 2008 and L. M. P. Henriques, pers. comm.); in September 2013, an adult pale-morph was photographed in Vitória do Xingu (V. Castro, pers. comm.). In February 2014 an adult pale-morph was observed on the left bank of the Xingu River, in Brasil Novo, near Altamira (TMS, PCGR Database). In Tapajós National Forest, by Henriques *et al.* (2003); in the Tapajós-Arapiuns Extractive Reserve, by Peres *et al.* (2003) and, in the municipality of Tailândia (Soares *et al.* 2008). Between 1998 and 2005, individuals were recorded in Tailândia, at the Agropalma Forest Reserve; between 2004 and 2006, in the municipality of Tomé-Açu, on the Cauaxi Farm; and between 2005 and 2007, also in Tailândia, on the Capim Farm (Portes *et al.* 2011). Throughout 2008, individuals were recorded in several forest reserves, Trombetas, Grão-Pará, Maicuru (female pale-morph collected) and in Faro State Forest (Aleixo *et al.* 2011). In Santana do Araguaia, at the Fartura Farm, the species was recorded between 2009 and 2010 (Somenzari *et al.* 2011). Between 2010 and 2011, the species was also recorded in Paragominas by Lees *et al.* (2012). In mid-2012 an adult was seen on the banks of the Tapajós River, in the municipality of Itaituba (G. Leite, pers. comm.); In mid-2012, a nestling female, dark-morph was rescued by IBAMA-Marabá, from the municipality of Tucuruí, and delivered to the Parque Zoo Botanico VALE in Parauapebas-Carajás, and from there transferred to recovery at the CRAX Conservation Center (F. Martins, pers. comm. ICMBio, PCGR). In the same year, a second nestling, also female from an unknown nest in the municipality of Novo Progresso, is still being held in the IBAMA-CETAS pre-release facility from Guarantã do Norte. In 2010 a nest was recorded in Belterra municipality. It was found during an inventory of birds in the region, and reported to PCGR, which we monitored for a few months, since the nestling was approximately four months old and out of the nest (C. Andretti, pers. comm.); the record was subsequently published with details by Lees *et al.* (2013). In 2011 there was a record in Jacareacanga, near the Teles Pires River (C. Borges, pers. comm.). In 2012, another nest of the species was located in the municipality of Oriximiná during mining activities of Mineração Rio Norte. This nest is located in an area of bauxite ore extraction within Porto Trombetas National Forest and following the recommendations of the PCGR and IBAMA-Oriximiná, the area will be maintained and protected. The Museu Paraense Emilio Goeldi holds a primary feather collected in 2000, from Altamira, Xingu River, and the skin of a female pale-morph adult from 2008, collected in Almeirim, in the Maicuru Biological Reserve, besides two skins of young males without provenance; and two specimens from the collection of the Museu Goeldi Zoo Botanical Park, one from 1916 and another from 1975. The FMNH keeps two skins of Piquiatuba in Belterra, collected in 1937: a female and a male with enlarged gonads, possibly being a pair in reproductive condition.

Amapá (North-AMZ) – There are four different records. The first two, in 1994 and 2000, individuals were alone, resting and feeding, in the municipality of Serra do Navio (Olmos *et al.* 2006). The other two records were provided by Schunck *et al.* (2011), one in 2008 and another in 2010. These are in the Carajaí Extractive Reserve, in the municipality of Laranjal do Jari, western Amapá. CM maintains a skin of a specimen collected in 1918, in the upper Arucaua River, a tributary of Uaca River, in Oiapoque.

Maranhão (North-AMZ) – The oldest record is that of a male from the mouth of the Flores River, Mearim River, municipality of Pedreiras, listed in the collection of birds of the Museu da Fauna (No. 1576), from 1956 (Aguirre & Aldrighi 1983, same specimen under Rio de Janeiro). A slightly more recent record is of a nest found and monitored for a few days in November 1997, in the municipality of Buriticupu (Martínez 2008). Recently, in 2009, during the movement of mobbing by a mixed bird species flock, after tape playback of Amazonian Pygmy-Owl (*Glaucidium hardyi*), a young Crested Eagle was attracted and registered in the municipality of Açailandia (F. Olmos and B. Lima, pers. comm.).

DISCUSSION

Up to 2006 *M. guianensis* was recorded at nine Brazilian National and State Reserves (ESEC, RESEX, FLONA, REBIO, PARNA, State Park) (Soares *et al.* 2008). Based on the compilation presented herein, the number of conservation areas of the same category as above harboring stocks of *M. guanensis* increased to 27, three times the previous study. Besides this increase, we also added 11 private reserve localities.

From 37 New records outside the IUCN map, 16 were recorded close to the border of the known range (up to 40 km); of those, 13 records were Old records and three were New, and do not expand or contribute to the distribution map, and could be an artefact of the border between our datapoints and the IUCN map, or were provided as only general occurrence in the literature, and therefore will not be discussed in detail.

Far from the border of the IUCN map (> 40 km), we found 21 records, contributing to an expansion of the known range; of these, 10 are New records and 11 are Old, and noted in bold face in the Appendices.

Mexico, at the northernmost extreme of distribution, the range was extended north to Southern Mexico, at Montes Azules, in 2004 with a photo (Grosselet & Gutierrez-Carbonel (2007), confirming the record (No. 132, Appendix 2).

Nicaragua, in 2001 a visual record in Prinzapolka (Kjeldsen 2005: 39) extended the range farther south than the IUCN map (No. 155, Appendix 2). In addition, there are currently two records at the southern border with Costa Rica, in 1994 and 1999 (Old records), published only in 2007 (Munera-Roldan 2007: 155), which extends the distribution of the Crested Eagle to Reserva Bartola, (Nos. 153 and 154, Appendix 2).

Costa Rica, an Old record not considered on the IUCN map was a visual record of Slud (1964) at Cañas Gordas (No. 159, Appendix 2), located between the Sirena Biological Station (Corcovado N. P.) on the Osa Peninsula (No. 157, Appendix 2) and the Caribbean lowland distribution.

Colombia, an Old record not considered on the IUCN map is a skin from Cuturu (FMNH 190728; No. 212, Appendix 2) from 1947, located between Darien Peninsula and Perija Mountains.

Brazil, there is a New overhead visual record at Buraco das Araras Private Natural Reserve, Mato Grosso do Sul (No. 63, Appendix 1) in Pivatto *et al.* (2006), an ecotone between Cerrado Biome and Gallery Forests, and could have been an individual dispersing, or transient, from Bodoquena Forest, where there are Harpy Eagles recorded, and which could possibly also support populations of Crested Eagle (PCGR Database). Bodoquena Forest is a upland remnant of Atlantic Rainforest on the ecotone with Semideciduous Forest, previously connected with Morro do Diabo, São Paulo (Galetti *et al.* 1997) (No. 125, Appendix 1), an Old record not included on the IUCN map. In Minas Gerais, there are two records far from the border of IUCN, but near the Atlantic Rainforest, and the IUCN distribution could incorporate these records, which are two visual records, in Mata Escura Reserve before 1993 (Mattos *et al.* 1993) (No. 65, Appendix 1), and Caparaó Park in 1997 (Zorzin *et al.* 2006) (No. 64, Appendix 1). In southern Brazil, in Rio Grande do Sul, there is a confirmed Old record, a specimen collected in 1920 from Santa Cruz do Sul, housed in a private collection (Bencke 1997) (No. 101, Appendix 1), and another collected in 1899 by Ihering (cited by Belton 1984 for Taquara, without details of the record).

Final Remarks

The most commonly cited publications for studying birds of prey, Ferguson-Lees & Christie (2001) and Amadon & Bull (1988), and more recently Whitacre *et al.* (2012), indicate the distribution of Crested Eagle in parts of North and Central America, and throughout South America, however the most commonly used tool for conservation strategies, the IUCN map, presents this distribution in a far more conservative form. Here it is possible to add the southernmost part of North America (Chiapas and Campeche), in southern Mexico to the range of the Crested Eagle, as well as three records in between the Amazon and Atlantic Rainforests, and one record in a forest patch within the Gran Sabana, Venezuela.

Our review suggests new data to be added in the compilation of the IUCN map, which from now on provides a database for the production of an updated species distribution map, extending known area of occurrence of the Crested Eagle. In southeastern Brazil, there are records previously not considered in the States of Minas Gerais and Bahia, in the central State of Mato Grosso do Sul and to the North, new habitat records in Roraima, Maranhão and Mato Grosso. Understanding the distribution of the Crested Eagle is indispensable for the efficient development of conservation strategies for the species and the ideal determination of the risk the species runs of extinction.

The Amazon is one of the current strongholds where large vertebrate populations find conditions to persist for ongoing generations (Reed *et al.* 2003). The prospect is of a future ideal for the conservation of large forest eagles (Crested Eagle, Harpy Eagle and Hawk-Eagle spp.). Predictive modelling scenarios for the next decades, according to current development policies, indicate an increase in the "arc of deforestation", the reduction of forest cover together with climate change (Laurance *et al.* 2001; Salazar *et al.* 2007), which could seriously reduce its distribution.

Brazilian law requires preservation of forest on private land (called Legal Forest Reserve) in the Amazon rainforest to be 80% of the propriety ("Lei N° 12.651, de 25 de maio de 2012"). Landowners who cut beyond the allowed percentage are supposed to replant with trees. The majority of Brazilian records come from private land, therefore a large effort should be carried out to maintain Legal Forest Reserves, areas which are not protected in conservation reserves. The Crested Eagle is listed as Near-Threatened (NT) by the IUCN (2014) and has already been proposed for the status of "Endangered" for the Brazilian List of Species threatened with Extinction, under review (PCGR and ICMBio), since the habitat that holds the largest populations is also under great risk, particularly in the future. Owing to the current scarcity of knowledge on the distribution and ecology of the Crested Eagle, it is possible that populations living in poorly sampled or little known areas could go extinct even before conservation programs or policies for the species's preservation are devised.

We believe that the greatest impact on populations of Crested Eagle is habitat loss and destruction, hunting pressure and consequently, pressure on their prey and nesting areas, mainly on the southern edges of the Amazon Rainforest and in the Southeast region of Brazil, in the remnants of Atlantic Rainforest.

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APPENDIX 1

Databases, museums and personal communications of Crested Eagle records from Brazil were cited using the following nomenclatures. **State**: (M. G. do Sul) – Mato Grosso do Sul; (R. G. do Sul) – Rio Grande do Sul. **Locality:** RESEX – Extractive Reserve; ESEC – Ecological Station; ARIE – Relevant Interest Ecological Area; PARNA – National Park; RDS – Sustainable Development Reserve; RPPN – Private Natural Reserve; REBIO – Biological Reserve; FLONA – National Forest; CEPLAC – Executive Board of the Cocoa Crop Plan; CIGS – Jungle Instruction Army Center; CETAS – Wildlife Center of Ibama – IBAMA – Brazilian Environment Agency; CRAX – Criadouro Conservacionista Center; PCGR – Harpy Eagle Conservation Program - Brazil. **Museums and Collections**: MZUSP – Zoology Museum of the University of São Paulo; MNRJ –National Museum of Rio de Janeiro; UFSC – Federal University of Santa Catarina; MHNT – Taubaté Natural History Museum; ORNIS – Online database of Ornithological Collections; CM – Carnegie Museum of Natural history; FMNH – Field Museum of Natural History; MPEG – Museu Paraense Emilio Goeldi; INPA – Intituto Nacional de Pesquisas da Amazônia Collections; WA – www.wikiaves.com data; IBC – The Internet Bird Collection. **Record Type**: Occu – general region of occurrence cited in literature, without specific records, number of sights, number or data on individuals, Ind. – one specimen record, 2ind – two specimen records. **Sex/ Age/Plumage:** n.a. – not available, Ppale – pale-morph plumage, Pdark – dark- morph plumage.

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
1	Acre	Rio Branco	Catuaba Farm	1999-2004	Rasmussem *et al.* 2013	Literature	occurence	n.a.
2	Acre	Marechal Thaumaturgo	Alto Juruá RESEX	2002	Whittaker *et al.* 2002	Literature	occurence	n.a.
3	Acre	Assis Brasil, Brasileia and Xapuri	Chico Mendes RESEX	2008	De Luca 2012	Literature	occurence	n.a.
4	Acre	Rio Branco		2009	IBAMA Report - Rio Branco, AC	PCGR Database	report	young
5	Acre	Porto Acre		2013	L. Rondini (photo); T. Nascimento (visual)	WA 959961	photo	young
6	Acre		Bamboo and Palm forest - occurrence in the state not on map	n.a.	Guilherme 2012	Literature	occurence	n.a.
7	Acre	Cruzeiro do Sul	Rio Croa Community	2012	João D. Filho pers. comm.	WA 722798	photo	adult/Pdark
8	Amapá	Oiapoque	Uaca River	1918	CM	CM P68846	skin	n.a.
9	Amapá	Serra do Navio		1994	Olmos *et. al.* 2006	Literature	visual	n.a.
10	Amapá	Serra do Navio		2000	Olmos *et. al.* 2007	Literature	visual	n.a.
11	Amapá	Laranjal do Jari	Rio Carají RESEX	2008	Schunck *et al.* 2011	Literature	occurence	n.a.
12	Amapá	Laranjal do Jari	Rio Carají RESEX	2010	Schunck *et al.* 2012	Literature	occurence	n.a.
13	Amazonas	Japurá	Juami-Jupará ESEC	2005	Soares *et al.* 2008, Sanaiotti per.obs.	PCGR Database	visual/ predation	adult
14	Amazonas		Cuieiras and Manacapuru - not on map	2006, 2007	Soares *et al.* 2008, Sanaiotti per.obs.	PCGR Database	nest	nest
15	Amazonas	Novo Aripuanã	Rio Roosevelt Lodge	1988	Whittaker 2009	Literature	occurence	pair

No.	**State**	**Municipality**	**Locality**	**Date**	**Record Source**	**No. Collection / Museum/Source**	**Record type**	**Sex / Age / Plumage/Nest**
16	Amazonas	Manacapuru		1936	MZUSP	MZUSP 16442	skin	
17	Amazonas	Lábrea	Purús River	1935	FMNH	FMNH 100819	skin	female
18	Amazonas	Itacoatiara	Baptista Lake	1937	FMNH	FMNH 101835	skin	female
19	Amazonas	Tonatins	Solimões River	1923	CM	CM P97629	mounted specimen	n.a.
20	Amazonas	Rio Preto da Eva	Reserve ZF3 - ARIE	1982	INPA	INPA 590	skin	n.a.
21	Amazonas	assumed near Carauari	Juruá River	1902	MZUSP	MZUSP 2593	skin	female
22	Amazonas	assumed near Carauari	Juruá River	1937	MZUSP	MZUSP 18113	skin	male
23	Amazonas	Novo Aripuanã	Roosevelt River	2007	Bret Whitney pers. comm.	IBC	Video	adult/Ppale
24	Amazonas	Coari	Urucu River	2008	Whittaker *et. al.* 2008	Literature	visual	pair/young/ nest
25	Amazonas	Alvarães		1993	Olmos *et al.* 2006	Literature	visual	2 individuals
26	Amazonas		Citation von Pelzeln - not on map	n.a.	Pinto, 1964	Literature	occurence	n.a.
27	Amazonas	Barra do rio Negro [= presently Manaus]	not on map	n.a.	Von Pelzeln 1871	Literature	occurence	n.a.
28	Amazonas	Manacapuru	Manaqueri [=Manaquiri] Lake - not on map	n.a.	Von Pelzeln 1872	Literature	occurence	n.a.
29	Amazonas	Rio Preto da Eva	ZF3 Reserve, Gavião camp - PDBFF Project - ARIE	1980	Bierregaard 1984	Literature	literature/ photo	pair/nest
30	Amazonas	Rio Preto da Eva	PDBFF Project Forest Fragments - ARIE	n.a.	Cohn-Haft *et al.* 1997	Literature	occurence	n.a.
31	Amazonas	Manaus	Reserva Florestal Adolpho Ducke - ARIE	2005	J. Valsko; W. Magnusson, PCGR	Database/pers. comm.	visual/call record	young
32	Amazonas	Novo Airão	Anavilhanas PARNA	11,22/6/2012	Whittaker 2012	WA 735004	photo	pair
33	Amazonas	Novo Airão	Anavilhanas PARNA	2009	S.Wilson, PCGR	Database	photo	1 adult
34	Amazonas	Manacapuru	Cururu Lake, Solimões River	2007	PCGR	Database	nest - Teixeirinha	nest - Teixeirinha
35	Amazonas	Manacapuru	Cururu Lake, Solimões River	2008	PCGR	Database	nest - Bracelo	nest - Bracelo
36	Amazonas	Manacapuru	Cururu Lake, Solimões River	2008	PCGR	Database	nest - Erivan	nest - Erivan
37	Amazonas	Manaus	Cuieiras Reserve - ARIE	2006	PCGR	Database	nest - Cuieiras	nest - Cuieiras
38	Amazonas	Tapaua	Nascentes do Lago Jari PARNA	2011	Luiz Henrique Condrati pers. comm.	WA 414010	photo	adult/Ppale
39	Amazonas	Manaus	Cuieiras Reserve, Km 9 - ARIE	2013	F. B. R. Gomes	WA 1025169	photo	subadult

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
40	Amazonas	Amanã	Amanã RDS	2013	A. Jaskulski pers. comm.	WA 1067156; 1067159; 1067157	photo	pair/young/nest
41	Amazonas		CIGS Army Zoo, unknown procedence	died 2012	F. B. R. Gomes	Pers. Archive	photo	male/Ppale
42	Amazonas	Alvarães, Uarini, Fonte Boa, Tonatins, Maraã and Japurá	Ressaca do Panelão - Mamirauá RDS	2004	Cintra *et al.* 2007	Lit. and pers. comm.	visual	n.a.
43	Bahia	Belmonte	Barrolândia	1995	Galetti *et al.* 1997	Literature	visual	adult
44	Bahia	Porto Seguro		1974	Willis & Oniki 2003	Literature	occurrence/call	n.a.
45	Espírito Santo	Sooretama, Linhares, Jaguaré and Vila Valério	Sooretama REBIO	1997	Parker III & Goerck 1997	Literature	occurence/visual	n.a.
46	Espírito Santo	Conceição da Barra	Itaúnas State Park	n.a.	Petroff 2001	Literature	occurence/visual	n.a.
47	Espírito Santo		Museu de Biologia Mello Leitão - unknown procedence	n.a.	PCGR visited 2006	Database	skin	Ppale
48	Maranhão	Pedreiras	Flores River	1956	Aguirre & Aldrighi 1983	Museu da Fauna N.1576	skin	male
49	Maranhão	Buriticupu	Southeastern Buriticupu	1997	Martinéz 1997	Literature	nest	adult/young/nest
50	Maranhão	Açailandia		2009	Fábio Olmos and Bruno Lima	Visual record and pers. comm	visual	young
51	Mato Grosso	Alta Floresta	Cristalino River	2005	Alexander Lees pers. arch.	Photo pers	photo	young
52	Mato Grosso	Juruena	Chapada dos Parecis	n.a.	Sick, 1997	Literature	occurence	n.a.
53	Mato Grosso	Alta Floresta	CEPLAC	2006	Alexander Lees	Visual record	visual	adult
54	Mato Grosso	Alta Floresta	CEPLAC	2006	Alexander Lees	WA 349411	photo	adult
55	Mato Grosso	São José do Rio Claro	Jardim da Amazônia Lodge	2011	Edson Endrigo	WA 368198	adult	adult
56	Mato Grosso	São José do Rio Claro	Jardim da Amazônia Lodge	2012	Marcelo Pádua	Call recorded	call recorded	pair/adult
57	Mato Grosso	Mundo Novo	Cristalino RPPN	2012	Júlio Silveira	WA 804572	photo	adult
58	Mato Grosso	Comodoro		2012	Vitor Castro	WA 581114	photo	1 adult
59	Mato Grosso	Comodoro		2012	Danilo Mota	WA 669576	photo	1 adult
60	Mato Grosso	Paranaíta		2012	Dalci Oliveira and P. Bernardo	WA 879011 and pers. comm.	photo	nest
61	Mato Grosso	Vila Rica	Ipê Farm	n.a.	MZUSP	MZUSP 78122	skin	n.a.

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
62	Mato Grosso							
63	M. G. do Sul	Jardim	Buraco das Araras RPPN	2001	Pivatto *et al.* 2006	Literature	visual	adult/Ppale/ flying
64	Minas Gerais	Caparaó	Caparaó PARNA	1997	Zorzin *et al.* 2006	Literature	visual	pair flying
65	Minas Gerais	Jequitinhonha	Mata Escura REBIO	n.a.	Mattos *et al.* 1993	Literature	occurence	n.a.
66	Minas Gerais		CRAX - Conservationist Center - unknown procedence	n.a.	CRAX	PCGR Database		female/Pdark
67	Parnambuco		Dois Irmãos Zoo - unknown procedence	n.a.	PCGR Database	PCGR Database		adult/Ppale
68	Pará	Vitória do Xingu	Ilha da Taboca “Area 2”, Xingu River	2000	Henriques *et al.* 2008	Lit. and pers. comm.	visual	adult
69	Pará	Vitória do Xingu	Transect 6, Area 2, Aquatic Survey, Xingu River	2008	Henriques *et al.* 2008	Lit. and pers. comm.	visual	adult
70	Pará	Belterra	Paraíso das Abelhas sem Ferrão	2010	Christian Andretti and Lees *et al.* 2013	WA 522322 and Literature	photo	nest/young
71	Pará	Vitória do Xingu		2013	Vitor Castro	WA 1091697	photo	n.a.
72	Pará	Itaituba	Right bank of Tapajos River	2012	Gabriel Leite	WA 1036295	photo	n.a.
73	Pará	Jacareacanga	Near Teles Pires River	2011	Christopher Borges	WA 844120	photo	adult
74	Pará	Faro	Faro State Park	15_28/1/2008	Aleixo *et al.* 2011	Literature	occurence	n.a.
75	Pará	Oriximiná	Trombetas State Park	16_28/4/2008	Aleixo *et al.* 2011	Literature	occurence	n.a.
76	Pará	Óbidos, Alenquer, Oriximiná and Monte Alegre	Grão-Pará ESEC	28/8_10/9/2008	Aleixo *et al.* 2011	Literature	occurence	n.a.
77	Pará	Oriximiná	Trombetas State Park	2012	IBAMA Report - Oriximiná, PA	PCGR Database		nest
78	Pará	Altamira	Ilha da Taboca - Xingu River	2000	MPEG	MPEG 55570	remige	n.a.
79	Pará	Almeirim	Maicuru REBIO	2/10_5/11/2008	Aleixo *et al.* 2011 and MPEG	MPEG 66390	skin	female/Ppale
80	Pará		Museu Paraense Emilio Goeldi - unknown procedence	1916	MPEG	MPEG 1287	skin	young/male
81	Pará		Museu Paraense Emilio Goeldi - unknown procedence	1975	MPEG	MPEG 30888	skin	young/male
82	Pará	Belterra	Piquiatuba	1937	FMNH	FMNH 101507	skin	male enlarged gonads

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
83	Pará	Belterra	Piquiatuba	1937	FMNH	FMNH 101506	skin	female enlarged gonads
84	Pará	Belterra	Tapajós FLONA	2003	Henriques *et al.* 2003	Literature	occurence	n.a.
85	Pará	Santarém	Tapajós Arapiuns RESEX	2003	Peres *et al.* 2003	Literature	occurence	n.a.
86	Pará	Tailândia		2008	Soares *et al.* 2008	Literature	occurence	n.a.
87	Pará	Novo Progresso		2012	CETAS IBAMA Guarantã do Norte, MT, without destination	PCGR Database	rescued	young/Pdark
88	Pará		Para State - not on map	historical	Teixeira *et al.* 2010	Literature	occurence	n.a.
89	Pará	Tomé Açu	Cauaxi Farm	2004, 2006	Portes *et al.* 2011	Literature	occurence	n.a.
90	Pará	Tailândia	Group Agropalma Reserve	1998, 2005	Portes *et al.* 2011	Literature	occurence	n.a.
91	Pará	Tailândia	Rio Capim Farm	2005, 2007	Portes *et al.* 2011	Literature	occurence	n.a.
92	Pará	Santana do Araguaia	Fartura Farm	2009-2010	Somenzari *et al.* 2007	Literature	occurence	n.a.
93	Pará	Tucuruí		2012	Frederico Martins - ICMBio; housed at CRAX	ICMBio - pers. comm.	rescued	young
94	Pará	Paragominas		2010-2011	Lees *et al.* 2012	Literature	occurence	n.a.
95	Pará	Brasil Novo	Xingu River left bank	2014	T. M. Sanaiotti, PCGR	Database	visual	adult/Ppale
96	Paraná	Marechal Cândido Rondon	Sete Quedas Museum	1964	Straube & Urben-Filho 2010	Literature	mounted specimen	n.a.
97	Rio de Janeiro	Cantagalo		n.a.	Pinto,1964: 82-83	Literature		n.a.
98	Rio de Janeiro	Cantagalo		n.a.	Hellmayr & Conover 1949	Literature	skin, Johann Natterer collection	n.a.
99	Rio de Janeiro		Rio de Janeiro Nacional Museum - without procedence	n.a.	MNRJ	MNRJ 889, 8552, 21645, 44312, 44313	5 specimens	n.a.
100	R. G. do Sul	Taquara		1899	Von Ihering 1899	Literature	occurence	n.a.
101	R. G. do Sul	Santa Cruz do Sul		1920	Bencke 1996	Literature	mounted specimen	Ppale
102	R. G. do Sul	Derrubadas - occurrence suggested	Rio Turvo State Park	1984	Belton 1984	Literature	occurence	n.a.
103	R. G. do Sul	Foz do Iguaçu	Iguaçu PARNA	1993	Forrester 1993	Literature	occurence	n.a.
104	R. G. do Sul	Very rare in the State		n.a.	Sick 1997	Literature		n.a.

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
105	R. G. do Sul	Probably Extinct in the State		n.a.	Marques *et al.* 2002	Literature		n.a.
106	Rondônia	Guajará Mirim and Costa Marques	Serra Cutia	2003	Olmos *et al.* 2011	Literature	visual	1 adult/Ppale
107	Rondônia	Guajará Mirim and Costa Marques	Serra Cutia	2003	Olmos *et al.* 2011	Literature	visual	2 adult/Ppale
108	Rondônia	Ji-Paraná	Cachoeira Nazaré, Ji-Paraná River	1987-1988	Stotz *et al.* 1997	Literature	occurence	n.a.
109	Rondônia	Chupinguáia	Boa Esperança Village	25/08/2011	S.O.S. Falconiformes	Pers. comm. and photos	photo	young
110	Rondônia	São Francisco do Guaporé and Alta Floresta D'Oeste	Guaporé REBIO	mar/12	Sandro Alves	Video pers. archive	video	adult/Pdark
111	Rondônia	Chupinguáia	Boa Esperança Village	2010	Kurazo Okada Aguiar	WA 10942	photo	1 adult
112	Rondônia	Chupinguáia	Boa Esperança Village	set/12	S.O.S. Falconiformes	Pers. comm. and photos	photo	pair/nest
113	Rondônia	Chupinguáia	Boa Esperança Village- not on map	2012	Raphael Hipólito	Pers. comm.	photo	1 adult/Ppale
114	Rondônia	Porto Velho	Ramal Rio das Garças	12/09/2011	F. Pereira	WA 674776	photo	1 adult/Ppale
115	Roraima	Caracaraí	Viruá PARNA	2004	Robson Czaban	WA 88548	photo	1 adult/Ppale
116	Roraima	Caracaraí	Jufari River, Caicubí Village	2011	L. F. Silveira	Pers. comm.	visual	adult
117	Roraima	Boas Vista	Maracá ESEC	1985	Moskovits *et al.* 1985	Literature	occurence	n.a.
118	Santa Catarina	Siderópolis	Jordão Baixo	1977	Albuquerque 1983	Literature	visual	adult
119	Santa Catarina	Grão Pará	Aiúre	2005	Albuquerque *et al.* 2006	Literature	visual	2 visual
120	Santa Catarina	Joinville	Frei Miguel Museum	1926	Favretto, 2008	Literature	mounted specimen	adult/Ppale
121	Santa Catarina	Lontras		1965/70	PCGR Database	UFSC 362	mounted specimen	adult/Ppale
122	Santa Catarina	Siderópolis		1997	Rosário 1997	Literature	occurence	n.a.
123	São Paulo	Jacupiranga, Barra do Turvo, Cananéia,Iporanga, Eldorada and Cajatí	Jacupiranga State Park	25/05/1990	Galetti *et al.* 1997	Literature	visual	1 adult

No.	State	Municipality	Locality	Date	Record Source	No. Collection / Museum/Source	Record type	Sex / Age / Plumage/Nest
124	São Paulo	Jacupiranga, Barra do Turvo, Cananéia,Iporanga, Eldorada and Cajatí	Jacupiranga State Park	14/12/1992	Galetti *et al.* 1997	Literature	visual	1 adult
125	São Paulo	Teodoro Sampaio	Morro do Diabo State Park	14/12/1992	Galetti *et al.* 1997	Literature	visual	1 adult
126	São Paulo	Ribeirão Grande, Guapiara, Sete Barras, Eldorado and Iporanga	Intervales State Park	24/02/1995	Galetti *et al.* 1997	Literature	visual	1 adult
127	São Paulo	Apiaí		1900	MZUSP	MZUSP 2417		n.a.
128	São Paulo	Occurrence in the State - not on map		1898	Ihering 1898	Literature	possible occurence	n.a.
129	São Paulo		Zooparque Itatiba at Itatiba, without procedence	n.a.	PCGR	PCGR		captive pair
130	São Paulo		Museu de Historia Natural de Taubaté - without procedence	n.a.	MHNT	n.a.	mounted specimen	adult/Ppale

APPENDIX 2

Databases, museums and personal communications of Crested Eagle records from outside Brazil used the following nomenclatures. Museums and Collections accessed with **ORNIS** – Online database of Ornithological Collections: (AMNH) American Museum of Natural History; (ROM) Royal Ontario Museum; (MCZ) Museum of Comparative Zoology; (CM) Carnegie Museum of Natural History; (FMNH) Field Museum of Natural History; (ANSP) Academy of Natural Sciences of Philadelphia; (USNM) United Sates National Musem; (LSUMZ) Louisiana State University Museum of Natural Science; (MHNIB) Museum of Natural History Itaipu Binacional; (XC) Xeno-canto Online Sound Collection; (MAC) Macaulay Library Collection; and (CEPEPE) Center for Propagation of Endangered Panamanian Species. **Record Type**: **Occurrence:** general region of occurrence cited in literature, without specific record details, number of sights, number or data on individuals; **Plumage:** Ppale – pale-morph, Pdark – dark-morph plumage, Pextdark – extreme dark-morph.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
131	Mexico	Campeche	Calakmul Ruins	1992	Sutter & Diaz *in* Whitacre *et al.* 2012	Literature	visual	adult soaring
132	Mexico	Chiapas	Montes Azules Biosphere Reserve	2004	Grosselet & Gutierrez-Carbonel 2007	Literature	photo	adult
133	Mexico	Chiapas	Chiapas	n.a.	Whitacre *et al.* 2012	Literature	occurence	n.a.
134	Mexico	Quintana Roo	Quintana Roo	n.a.	Whitacre *et al.* 2012	Literature	occurence	n.a.
135	Belize	Orange Walk	Chan Chich Lodge	1995	Hall 1995	Literature	occurence	n.a.
136	Belize	Toledo	Toledo	1995	Howell *et al.* 2000	Literature	occurence	n.a.
137	Belize	Cayo	Cayo	1995	Howell *et al.* 2001	Literature	occurence	n.a.
138	Belize	Orange Walk	Orange	1995	Howell *et al.* 2002	Literature	occurence	n.a.
139	Belize		Southeastern Region	2006	Jones & Komar 2006	Literature	occurence	n.a.
140	Guatemala	Petén	Flores	1981	Ellis & Whaley 1981	Literature	occurence	n.a.
141	Guatemala	Petén	Tikal National Park	1994	Whitacre *et al.* 2012	Literature		nest
142	Guatemala	Petén	Tikal National Park	1995	Whitacre *et al.* 2012	Literature		nest
143	Guatemala	Petén	Tikal National Park	2006	Grijalva & Eisermann 2006	Literature		young
144	Guatemala		Atlantic Region	2006	Eisermann & Avendaño 2007	Literature		n.a.
145	Guatemala	Petén	Flores	1978	ORNIS	AMNH812849	skin	n.a.
146	Guatemala	Petén	Flores	1966	ORNIS	ROM115862	complete sleleton + partial skin	n.a.
147	Honduras	La Ceiba	La Ceiba	1903	Bangs 1903	Literature	collected	young
148	Honduras	San Pedro Sula	San Pedro Sula	1968	Monroe 1968	Literature	occurence	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
149	Honduras		Quebrada Kahkatingni - near Patuca River	1999	Russell Thorstrom *in* GRIN 2013	Literature		young
150	Honduras		Occurrence in Honduras	2002	Bonta & Anderson 2002	Literature	occurence	n.a.
151	Honduras	La Ceiba	La Ceiba	1902	ORNIS	MCZ110535	skin	n.a.
152	Nicaragua	Jinotega	Hormigero Community, Cerro Sasiaya, at Bosawas Biosphere Reserve	2001	GRIN 2013	Literature	occurence	n.a.
153	Nicaragua	San Juan del Nicaragua	Bartola Reserve	1994	Múnera-Roldán *et al.* 2007	Literature		adult
154	Nicaragua	San Juan del Nicaragua	Bartola Reserve	1999	Múnera-Roldán *et al.* 2007	Literature		adult
155	Nicaragua	Prinzapolka, Zelaya	Alamikangban Community	2005	Kjeldsen 2005	Literature		adult
156	Costa Rica	Heredia	La Selva Biological Station, Sarapiquí region	1989	Stiles & Skutch 1989	Literature	occurence	n.a.
157	Costa Rica	Sirena	Sirena Biological Station, Corcovado National Park, Osa Peninsula	1989	Stiles & Skutch 1989	Literature	occurence	n.a.
158	Costa Rica	Límon	Cuabre - Sixaola River	1910	Carrier 1910	Literature	occurence	n.a.
159	Costa Rica	Puntarenas	Cerro Cañas Gordas	1964	Slud 1964	Literature	occurence	n.a.
160	Costa Rica	San Jose Limon	La Finca Selva - Braulio Carrillo National Park	2004	Jones 2004	Literature	occurence	n.a.
161	Costa Rica	San Jose Limon	Rara Avis Jungle Lodge -Braulio Carrillo National Park	2004	Jones 2004	Literature	occurence	n.a.
162	Costa Rica	Límon	Tortuguero	2006	Jones & Komar 2006	Literature	occurence	n.a.
163	Costa Rica	Límon	Tortuguero	2005	G. Ocklind	Pers. comm.	photo	pair
164	Costa Rica	Límon	Tortuguero National Park	2013	Carlos Calvo Obando photo/ Fundación Rapaces de Costa Rica, P Camacho Varella pers. comm.	PCGR Database	photo	adult/ Ppale
165	Costa Rica	Límon	Caño Harold - Tortuguero National Park	2014	Ron Osborne photo/ Fundación Rapaces de Costa Rica, P Camacho Varella pers. comm.	PCGR Database	photo	adult/ Ppale
166	Costa Rica	Alajuela	Crucitas - Cutris de San Carlos	2011	Rodolfo Vargas Leiton photo/ Fundación Rapaces de Costa Rica, P Camacho Varella pers. comm.	PCGR Database	photo	adult/ Pdark
167	Costa Rica	Límon	Cuabre	1904	ORNIS	CMP23989	skin	n.a.
168	Panama		Caribbean slopes, Southeast and East Panamá	1965	Wetmore 1965	Literature	occurence	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
169	Panama	Los Santos	Azuero Peninsula	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
170	Panama	Los Santos/Mariato	Cerro Hoya National Park	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
171	Panama	Panamá Province	region	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
172	Panama	Chiriqui Province	region	1989	Ridgely & Gwynne 1989	Literature	unsubstantiated occurence	n.a.
173	Panama	Veraguás	Coiba Island, Gulf of Chiriquí	1989	Ridgely & Gwynne 1989	Literature	unsubstantiated occurence	n.a.
174	Panama	Panamá Canal	Barro Colorado Island	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
175	Panama	Chiriquí	Boquete	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
176	Panama		Panamá Canal Zone	1989	Ridgely & Gwynne 1989	Literature	occurence	n.a.
177	Panama	Guna Yala	Chiquita River region, Central Panamá	1989	Kiff *et al.* 1989	Literature	egg laying by CEPEPE captive	n.a.
178	Panama	Dárien	Quintín Community	2006	Vargas *et al.* 2006	Literature	interspecific interation	n.a.
179	Panama	Cólon	San Lorenzo National Park	2007	Jones & Komar 2007	Literature		young
180	Panama	Dárien	Cana Camp - Darién National Park	2010	E. Groenewoud	IBC	photo	adult/Ppale
181	Panama	Dárien	Rancho Frio Camp - Darién National Park	2013	A. Spencer	XC127521	vocalization near nest	nest
182	Panama	Gamboa	Canal Zone	1981	Van den Berg, A. B.	Mac28459	vocalization	female/Pdark
183	Panama		Changuinola	1928	ORNIS	MCZ137642	skin	n.a.
184	Panama	Dárien	Perme	1929	ORNIS	MCZ155152	skin	female
185	Panama	N.i.	Banana River	1928	ORNIS	MCZ137127	skin	female
186	Panama	Kuna Yala	“Puerto” Obaldia	1930	ORNIS	MCZ156514	skin	male
187	Panama	Kuna Yala	San Blas - Port Obaldia	1935	ORNIS	FMNH100685	male of pair	male
188	Panama	Kuna Yala	San Blas - Port Obaldia	1935	ORNIS	FMNH100729	female of pair	female
189	Panama	Panamá Canal	Barro Colorado Island	1936	ORNIS	AMNH300600	skin	n.a.
190	Panama	Dárien	Tapalisa, eastern of Panamá - Tapalisa River	1915	ORNIS	AMNH135352	skin	n.a.
191	Panama	Dárien	Tapalisa, eastern of Panamá - Tapalisa River	1915	ORNIS	AMNH135353	skin	n.a.
192	Colombia	Chocó	Region	1986	Hilty & Brown 1986	Literature	occurence	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
193	Colombia	Chocó	Baudó Mountains	1986	Hilty & Brown 1986	Literature	occurence	n.a.
194	Colombia	Valle del Cauca	Achicaya River Valley (Anchicaya)	1986	Hilty & Brown 1986	Literature	occurence	n.a.
195	Colombia	Cordova	Sinú River Valley	1986	Hilty & Brown 1986	Literature	occurence	n.a.
196	Colombia	Cordova	Cordova	1986	Hilty & Brown 1986	Literature	occurence	n.a.
197	Colombia	Zúlia	Perijá Moutains	1986	Hilty & Brown 1986	Literature	occurence	n.a.
198	Colombia	La Guajira	Carraipa	1986	Hilty & Brown 1986	Literature	occurence	n.a.
199	Colombia		East of Andes region	1986	Hilty & Brown 1986	Literature	occurence	n.a.
200	Colombia	Meta	Vilavivencio region	1986	Hilty & Brown 1986	Literature	occurence	n.a.
201	Colombia	Caquetá	Caquetá	1986	Hilty & Brown 1986	Literature	occurence	n.a.
202	Colombia	Amazonas	Letícia	1972	Márquez *et al.* 2005	Literature	Museum, no data	n.a.
203	Colombia	Caquetá	Belén	1941	Márquez *et al.* 2005	Literature	Museum, no data	n.a.
204	Colombia	Chocó	Salaqui River	1940	Márquez *et al.* 2005	Literature	Museum, no data	n.a.
205	Colombia	Chocó	Juradó River	1940	Márquez *et al.* 2005	Literature	Museum, no data	n.a.
206	Colombia	Caquetá	Morélia region	n.a.	ORNIS	ANSP153087	skin	n.a.
207	Colombia	Chocó	Truandó River (Truanto)	n.a.	ORNIS	USNM17781	Complete specimen in alcohol	n.a.
208	Colombia	Cordova	Sinú River	1949	ORNIS	USNM410536	Complete specimen in alcohol	n.a.
209	Colombia	Chocó	Acandi, Gulf of Uraba	1949	ORNIS	USNM425433	Complete specimen in alcohol	n.a.
210	Colombia	Chocó	Jampavado River	1940	ORNIS	FMNH102242	skin	n.a.
211	Colombia	Chocó	Juradó River	1940	ORNIS	FMNH102243	skin	n.a.
212	Colombia	Antioquia	Cuturu	1947	ORNIS	FMNH190728	skin	female
213	Ecuador	Pichincha	Pichincha region	2001	Ridgely & Greenfield 2001	Literature	recorded	n.a.
214	Ecuador		Base of Andes region	2001	Ridgely & Greenfield 2001	Literature	occurence	n.a.
215	Ecuador	Esmeraldas	Esmeraldas	2007	Muniz-Lopes *et al.* 2007	Literature	occurence	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
216	Ecuador	Sucumbios	Cuyabeno Wildlife Reserve	2007	Libor Vaincenbacher	Photo IBC	snake predation	Ppale
217	Ecuador	Sucumbios	Cuyabeno Wildlife Reserve	2014	R. Muniz-Lopes - PCAHE	pers. comm	visual	adult/chick/ nest
218	Ecuador	Napo	Napo Wildlife Center	2008	T. Cloudman	list of species	adult	Pdark
219	Ecuador	Not reported	Quito Zoo at Guayllabamba	2011	Montalvo & Montalvo 2011	Literature	captive	adult female/ Ppale
220	Bolivia	Beni	Beni	1994	M. Pearman 1994 *in* GRIN 2013	Literature	occurence	n.a.
221	Bolivia	Beni	Noel Kempff National Park	1998	Bates *et al.* 1998	Literature	occurence	n.a.
222	Bolivia	La Paz	La Paz	2003	Hennessey *et al.* 2003	Literature	occurence	n.a.
223	Bolivia	Santa Cruz	Santa Cruz	2003	Hennessey *et al.* 2003	Literature	occurence	n.a.
224	Bolivia	Mérida	Caparú Biological Station	2005	Vidoz *et al.* 2010	Literature	occurence	n.a.
225	Peru		Gallery forest, Eastern region of Andes	n.a.	Clements & Shany 2001	Literature	occurence	n.a.
226	Peru	Amazonas Departmet	Donated to Oklahoma City Zoo	1978	Kiff *et al.* 1989	Literature	female collected	female/nest
227	Peru	Madre de Dios	Reserva Tambopata - Candamo	1994	Parker III *et al.* 1994	Literature	occurence	n.a.
228	Peru	Madre de Dios	Reserva Tambopata - Candamo	2007	Raine 2007	Literature		nest
229	Peru	Madre de Dios	Amazon Manu Lodge	1977	R. Fabbri, pers. arch.	Photo personal archive		adults/chick/ nest
230	Peru	Madre de Dios	Amazon Manu Lodge	2006	R. Fabbri, pers. arch.	Photo personal archive		adults/chick/ nest
231	Peru	Cuzco	Quebrada Blanco Biological Station	2001	Vazquez & Heymann 2001	Literature	predation on monkeys	n.a.
232	Peru	Uacayali	Pacaya municipally	2012	A. Morales	Photo personal archive		young
233	Peru	Not reported	Centro de Reproducion Huayco at Lima	2013	J. A. Otero	pers. comm.	captive	6 individuals
234	Peru	Iquitos	Peru Lodge, Tahuayo River	2013	Peru Lodge	list of species	occurence	n.a.
235	Peru	Amazonas	Departamento do Amazonas	n.a.	ORNIS	LSUMZ84285	skin	n.a.
236	Peru	Loreto	Departamento de Loreto	n.a.	ORNIS	LSUMZ114339	complete in alcohol	n.a.
237	Peru	Loreto	Departamento de Loreto	n.a.	ORNIS	LSUMZ114589	complete in alcohol	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
238	Peru	Loreto	Departamento de Loreto	n.a.	ORNIS	LSUMZ118952	feathers	n.a.
239	Venezuela		North of Orinoco River	2003	Hilty 2003	Literature	occurence	n.a.
240	Venezuela		Caura River	2003	Hilty 2003	Literature	occurence	n.a.
241	Venezuela		Maracaibo Basin	2003	Hilty 2003	Literature	occurence	n.a.
242	Venezuela		Sierra Perijá	2003	Hilty 2003	Literature	occurence	n.a.
243	Venezuela		Zulia	2003	Hilty 2003	Literature	occurence	n.a.
244	Venezuela	Merida	Andes	2003	Hilty 2003	Literature	occurence	n.a.
245	Venezuela		Lara	2003	Hilty 2003	Literature	occurence	n.a.
246	Venezuela	Amazonas	Amazonas Province	2003	Hilty 2003	Literature	occurence	n.a.
247	Venezuela		Bolivar	2003	Hilty 2003	Literature	occurence	n.a.
248	Venezuela	Margarita	Margarita Island	2003	Hilty 2003	Literature	occurence	n.a.
249	Venezuela	Barinas	Obispos municipality	2006	Uztcátagui *et al.* 2010	Literature	occurence	n.a.
250	Venezuela	Bolivar	Gran Sabana region	2011	Crease & Tepedino 2013	Literature	nest	n.a.
251	Guyana		Lowland forest environments	n.a.	Braun *et al.* 2000	Literature	occurence	n.a.
252	Guyana	Rupununi	Chief Rewa Reserve (head)	2011	Pickles *et al.* 2011	Literature	occurence	n.a.
253	Guyana	Rupununi	Upper Takatu - Upper Essequibos	1964	ORNIS	ROM94735	skin	n.a.
254	Guyana	Rupununi	Upper Takatu - Upper Essequibos	1964	ORNIS	ROM94725	skin	n.a.
255	Guyana	Bartica	Kalacoon (Kalakun)	n.a.	ORNIS	AMNH804578	skin	n.a.
256	French Guyana		Forest areas, General occurrence	n.a.	Thiollay 2007	Literature		n.a.
257	French Guyana	Cayenne	Nouragues Field Station	1992	Julliot 1994	Literature	predation on monkey	n.a.
258	French Guyana	Cayenne	Approuague River, Regina municipality	2011	Johann Tascon	Literature		adult/Pextdark
259	French Guyana	Non reported	Guyana Zoo, in Macouria	n.a.	Maxcobigo	IBC	photo	male/Pdark
260	Surinam		Forest areas, General occurrence	n.a.	Haverschimidt & Mees 1994	Literature	occurence	n.a.
261	Surinam	Sipaliwini District	Raleigh Falls-Voltz Bergue Nature Reserve	1987	Trail 1987	Literature	predation on *Rupicola rupicola*	n.a.

No.	Country	County	Locality	Year	Citation	Source/ Collection number	Record	Sex/Age/ Plumage/Nest
262	Argentina		Resident in the country, General occurrence	n.a.	Mazar-Barnett & Pearman 2001	Literature		n.a.
263	Argentina	Missiones	El Piñalito Provincial Park	2001	Pearman 2001	Literature		adult
264	Argentina	Santa Ana	Santa Ana	1913	Bertoni 1913	Literature	occurence	n.a.
265	Argentina	Missiones	Iguazú National Park	1980	Rumboll & Straneck (In Olrog,1985)	Literature	pair in display	n.a.
266	Paraguay		Alto Paraná region	2004	Del Castillo & Clay 2004	Literature	occurence	n.a.
267	Paraguay	Itapúa	San Rafael Nacional Park	1997	Madroño 1997	Literature	pair displaying	n.a.
268	Paraguay	Itapúa	San Rafael Nacional Park	1997	Madroño 1997	Literature		adult
269	Paraguay	Itapúa	San Rafael Nacional Park - collected and donated to Zoo	died 2002	Del Castillo & Clay 2004	MHNIB872	adult captured, housed in Museum	adult
270	Paraguay	Itapúa	Colônia Aurora, Region of San Rafael Nacional Park	2003	N. Lopes *in* Del Castillo & Clay 2004	Literature		adult flying

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Morphological variability and taxonomy of the Blue-winged Parrotlet *Forpus xanthopterygius* (Psittacidae)

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ABSTRACT: *Forpus xanthopterygius* is a polytypic species that ranges through most of South America. Currently, it comprises five subspecies: *F. x. xanthopterygius*, *F. x. crassirostris*, *F. x. spengeli*, *F. x. flavissimus*, and *F. x. flavescens*. Previous studies that have revised the taxonomy of this complex used a limited number of specimens, hence disagreements about allocation of specific or subspecific status, and even the validity of some taxa, continue. Here, we revise the taxonomy of the *Forpus xanthopterygius* complex based on morphological and morphometric characters. We analyzed 518 specimens from the entire species geographical distribution. Our results allowed us to propose the recognition of two valid taxa that we suggest to be treated as full species (*Forpus xanthopterygius* and *Forpus spengeli*). *Forpus xanthopterygius* shows great phenotypic variability, in which the plumage is brighter and yellowish in drier habitats and dull and darker in humid ones; nevertheless, this variation has no taxonomic significance.

KEY-WORDS: Bergmann's rule, geographic variation, Gloger's rule, morphology.

INTRODUCTION

The genus *Forpus* comprises seven recognized biological species widely distributed across the Neotropics (Forshaw & Cooper 1989). These species are distributed from Panama to Argentina, with isolated populations in Mexico and the Caribbean. They are small parrotlets (total length between 11 and 15 cm), with wedge-shaped tails, and large bills that are distinctly notched on the maxilla. There is sexual dimorphism in plumage: females have uniform green coloration while males have blue in some parts of the wings and rump (Forshaw & Cooper 1989, Forshaw 2010). The genus is most frequent in drier habitats and open areas, but some species occur in humid areas (Smith *et al.* 2013).

The Blue-winged Parrotlet, *Forpus xanthopterygius* (Spix 1824) is a polytypic species that ranges through most of South America, from the Amazon basin to northern Argentina, including a disjunct population in northern Colombia currently considered as a part of this complex (Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997, Forshaw 2010). The main features that distinguish *F. xanthopterygius* from other *Forpus* species are the blue pattern found in the males' rump and wings and the color pattern of the head (Sick 1997). It inhabits gallery forest, lowland rainforest edge and secondary growth; it also occurs in savanna, palm groves, semi-arid scrub, pastures and suburbs, up to 1.200 m. They feed mainly on fruits and seeds of plants in secondary vegetation (Collar 1997).

Currently, this species-complex comprises five accepted subspecies: *F. x. xanthopterygius*, *F. x. crassirostris*, *F. x. spengeli*, *F. x. flavissimus*, and *F. x. flavescens* (Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997, Forshaw 2010, Clements *et al.* 2014). Males of the nominate form have green color covering most of the body, with paler and more yellowish on underparts; the primaries, secondaries, under-wing coverts, lower back and rump are violet-blue. Descriptions of the other subspecies are based primarily on males' coloration patterns, especially regarding the blue regions on wings, rump and lower back and the color of the forehead, crown and face (Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997, Forshaw 2010).

Historically, *Forpus xanthopterygius* had long been considered as a subspecies within the *Forpus passerinus* complex (*e.g.*, Peters 1937, Pinto 1938). However, Gyldenstolpe (1945) treated it as a distinct species based on its sympatric distribution and differences in the rump color. *Forpus passerinus* males have green rump as opposed to blue in *F. xanthopterygius*. This proposal has been followed by the majority of the subsequent authors (e. g., Schauensee 1966, 1970, Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997) including all current works, except Dickinson & Remsen (2013) that places the race *spengeli* within the *F. passerinus* species complex.

Spix (1824) described *Forpus xanthopterygius* as *Psittaculus xanthopterygius,* and the applicability of this name has generated many discussions among authors (*e.g.*, Pinto 1945, 1978, Juniper & Parr 1998). The original description was based on two specimens from Minas Gerais (Brazil), none of them designated as a type. Salvadori (1891) and Hellmayr (1905) recognized that these two birds belonged to two different species, one being an immature *Brotogeris chiriri* and the other a female of *Psittacula passerina vivida* Ridgway 1888. Spix (1824) also described another species as *Psittaculus gregarius* from Minas Gerais, and Hellmayr (1905) suggested they might be juveniles of *Psittaculus xanthopterygius,* Rigdway (1888) subsequently separated these as *Psittacula passerina vivida.* After this, *F. xanthopterygius* was considered invalid and *Forpus crassirostris* (Taczanowski 1883) was used instead, until Gyldenstolpe (1945) reinstalled the name in his revision of the entire genus *Forpus*. Since then some authors (*e.g.*, Schauensee 1966, 1970, Forshaw & Cooper 1989) followed Gyldenstolpe (1945) and used *Forpus xanthopterygius*, while others (Stotz *et al.* 1996, Collar 1997, Juniper & Parr 1998) followed Pinto (1945, 1978) and used *Forpus crassirostris*. Whitney & Pacheco (1999) reviewed this nomenclature problem and concluded that *Forpus xanthopterygius* is a valid name, citing the *International Code of Zoological Nomenclature* (ICZN) to uphold that a name remains valid even if its description was based on more than one taxon, since the author designated no type.

The taxonomic history is not limited to nomenclatural issues; there are also disagreements concerning the allocation of the specific or subspecific status and some of these taxa are of disputed validity. Taczanowski (1883) described a darker taxon from Amazonian Peru, giving it a specific status (*Psittacula crassirostris*). From northern Colombia, *Psittacula spengeli* Hartlaub, 1885 was described based on a turquoise-blue rump and wings; however, the author did not directly relate this new taxon to any previously described taxa in this complex, stating only that it resembled *P. cyanopygia* Souancé 1856 from Mexico. Another distinct species, *Psittacula flavescens* Salvadori, 1891 from Bolivia, was described as much like the male of *P. passerina*, but paler and yellowish. Finally, two additional taxa have been described as subspecies: *flavissimus* (Hellmayr 1929), a yellow-faced form, and *olallae* (Gyldenstolpe 1945), a darker blue form, from northeastern Brazil and Codajás (Amazonas, Brazil), respectively.

Cory (1918) kept *F. crassirostris* and *F. spengeli* as distinct species and placed *flavescens* within *F. xanthopterygius*. Peters (1937) and Pinto (1938) placed all named taxa in *Forpus passerinus*. Gyldenstolpe (1945) made a partial revision of this complex, recognizing only *F. crassirostris*, *F. spengeli* and *F. flavescens*, as subspecies within *F. xanthopterygius*. Darrieu (1983) performed another review considering only five taxa (all except *F. spengeli*); he recognized *xanthopterygius*, *flavissimus*, *crassirostris* and *flavescens* as valid subspecies but felt that *olallae* could not be separated from *F. x. crassirostris*. This arrangement was followed by subsequent authors (*e.g.*, Forshaw & Cooper 1989, Collar 1997, Juniper & Parr 1998, Forshaw 2010). In addition, recent authors (Collar 1997, Juniper & Parr 1998) have suggested that *F. x. spengeli* is possibly related to *Forpus cyanopygius*, and it would be better classified as a subspecies within this complex, or as an independent species.

Smith *et al.* (2013) presented a phylogeny of *Forpus* based on both mitochondrial and nuclear DNA sequences. All named taxa of *F. xanthopterygius sensu latu* were included, with *spengeli* only being represented by mitochondrial DNA (mtDNA) data. In their analysis of mtDNA they found that the *F. xanthopterygius* complex was not monophyletic; their data suggested that *F. x. crassirostris* was sister to a clade comprising *F. coelestis*, *F. conspicillatus*, *F. xanthops, F. passerinus*, as well as the remaining *F. xanthopterygius* subspecies. In the multilocus species tree, the position of *F. x. crassirostris* was poorly resolved and its sister relationship to other *F. xanthopterygius* subspecies was weakly supported (Smith *et al.* 2013).

Given these results, a taxonomic reassessment of *Forpus xanthopterygius* is needed. Previous revisions made (Gyldensolpe 1945, Darrieu 1983) did not consider all taxa described and used limited geographic sampling of specimens. Here, we propose a more comprehensive taxonomic review of *Forpus xanthopterygius* species complex based on a large number of specimens from throughout the taxon's entire range to understand the morphological variation and to delimit valid taxa. The definition of valid taxa within polytypic species is essential to organize our knowledge and provide a framework for evolutionary studies as well as identifying basal units for conservation.

MATERIAL AND METHODS

We analyzed 518 specimens (308 males and 210 females) including available types of all taxa of the *Forpus xanthopterygius* complex. Studied specimens were housed in collections of the following institutions: Museu de Zoologia da Universidade de São Paulo (MZUSP, São Paulo, SP); Museu Paraense Emilio Goeldi (MPEG, Belem, Brazil), Museu de Biologia Professor Mello Leitão (MBML, Santa Teresa, Brazil); American Museum of Natural History (AMNH, New York, USA); Field Museum of Natural History (FMNH, Chicago, USA); Smithsonian Institution National

Museum of Natural History (USNH, Washington D. C., USA); Instituto Alexander Von Humbolt Colección de Ornitologia (IAVH, Bogota, Colombia); Museo Nacional de Colombia (MNC, Bogota, Colômbia), Muséum National d'Histoire Naturelle (MNHN, Paris, France); Zoologischen Staatssammlung München (ZSM, Munich, Germany); Museum für Naturkunde of the Humboldt-University (ZMB, Berlin, Germany); Royal Natural History Museum (NRM, Stockholm, Sweden); Academy of Natural Sciences of Drexel University (ANSP, Philadelphia, USA). The list of specimens examined is presented in the Appendix.

For the plumage coloration analysis, color discrimination was assessed in a standardized and comparative way; each color pattern was classified according to Munsell (1994; hereafter M) and Smithe (1975; hereafter S) color guides. Morphometric characters (exposed culmen, bill width and height, wing, tail and tarsus length) were measured using calipers (precision of 0.01 mm) and a ruler (precision of 0.5 mm) following Baldwin *et al.* (1931).

Morphometric data were analyzed by GraphPad Prism 5 (GraphPad Software, Inc.), SPSS 13.0 (Lead Technologies, Inc.) and BioEstat 5.0. To evaluate sexual dimorphism within the putative subspecies we used the Student's *t*-test. An analysis of variance (one-way ANOVA) was used to compare morphological measurements among subspecies. The Tukey HSD test was applied as a *post hoc* test to investigate for significant pairwise differences between taxa. We used Bonferroni correction to reduce the possibility of rejection of the null hypothesis by chance. To this end, we reduced the critical value of alpha (0.05); when many tests were carried out in the same experiment we divided 0.05 by the number of tests to get a new value of alpha. Since we have 10 possible tests (five putative subspecies) the new critical value of alpha adopted was 0.005. We also performed a principal component analysis (PCA) to assess possible differences that were not shown by univariate tests. When samples did not meet the assumptions of normal distribution and homogeneity of variance, we used non-parametric tests. For statistical analysis only adult males were used to prevent potential problems due to sexual dimorphism and birds identified as juveniles were excluded. Considering the *Forpus xanthopterygius* complex widespread distribution, we used a linear regression analysis to test for latitudinal trends in body size.

We created distribution maps using Quantum Gis 2.4.0, using the locations coordinates contained on specimens labels, and, when they were not available, these were obtained by consulting ornithological gazetteers (Stephens & Traylor 1983, Paynter 1989, Paynter & Traylor 1991, Paynter 1992, Vanzolini 1992, Paynter 1997, Paynter 1995) and geographic data websites (*e.g.*, http://www.fallingrain.com and http://www.bngb.ibge.gov.br/bngb.php).

In defining taxonomic levels and limits, the criterion adopted was the diagnosability of populations; specimens were grouped according to similar morphological characters that were consistently diagnosable from others. We adopted the null hypothesis as defined by Gill (2014) that distinct and reciprocally monophyletic sister populations of birds are reproductively isolated and would not interbreed freely if they were to occur in sympatry. When we found data to support the null hypothesis, divergent allotaxa were treated as species by default (Gill 2014); therefore, population clusters can be posteriorly designated as a valid species, and this is in agreement with the Phylogenetic Species Concept (PSC, Cracraft 1983, 1985, 1987) and the General Lineage Species Concept (GLSC, de Queiroz 1998).

RESULTS

Plumage

We were able to identify two populations as clearly diagnosable by plumage; each of them had consistent diagnosable features that allowed us to classify them as independent evolutionary units. These two units were based on male blue parts including: rump, back, primaries, secondaries and under-wing coverts.

The first population recognized is wide-ranging, occurring from the Amazon basin, Peru, Bolivia, south to Paraguay and Argentina, across several major South American biomes. Males of this population can be diagnosed by their back, rump and under-wing coverts being ultramarine blue (S 270-ultramarine), and primaries and secondaries being ultramarine-blue (S 270-ultramarine) with spectrum-blue (S 5.5. PB 4/14) (Figure 1). The blue plumage characters are consistent over the entire distribution of this population. In contrast, the green plumage presents considerable variation throughout the range. This variation is seen in the colors of the head, forehead, crown and ear coverts, which varies from parrot green (S 5GY 5.5/5.5) to light yellow (M 5Y 8/8) with many intermediate states. Based on geography, this suggests clinal variation and to measure this, the colors of the head in males were scored to quantify the amount of yellow in this region, as follows: **(0)** parrot green (S 5GY 5.5/5.5), **(1)** dark yellow (M 5Y 7/6) with parrot green (S 5GY 5.5/5.5), **(2)** light yellow (M 5Y 8/8) with parrot green (S 5GY 5.5/5.5), **(3)** dark yellow (M 5Y 7/6) with apple green (S 7.5 GY 7/8) , **(4)** light yellow (M 5Y 8/8) with apple green (S 7.5 GY 7/8) and **(5)** light yellow (M 5Y 8/8). Geographic variation of head color was mapped according to the score given to each individual (Figure 2).

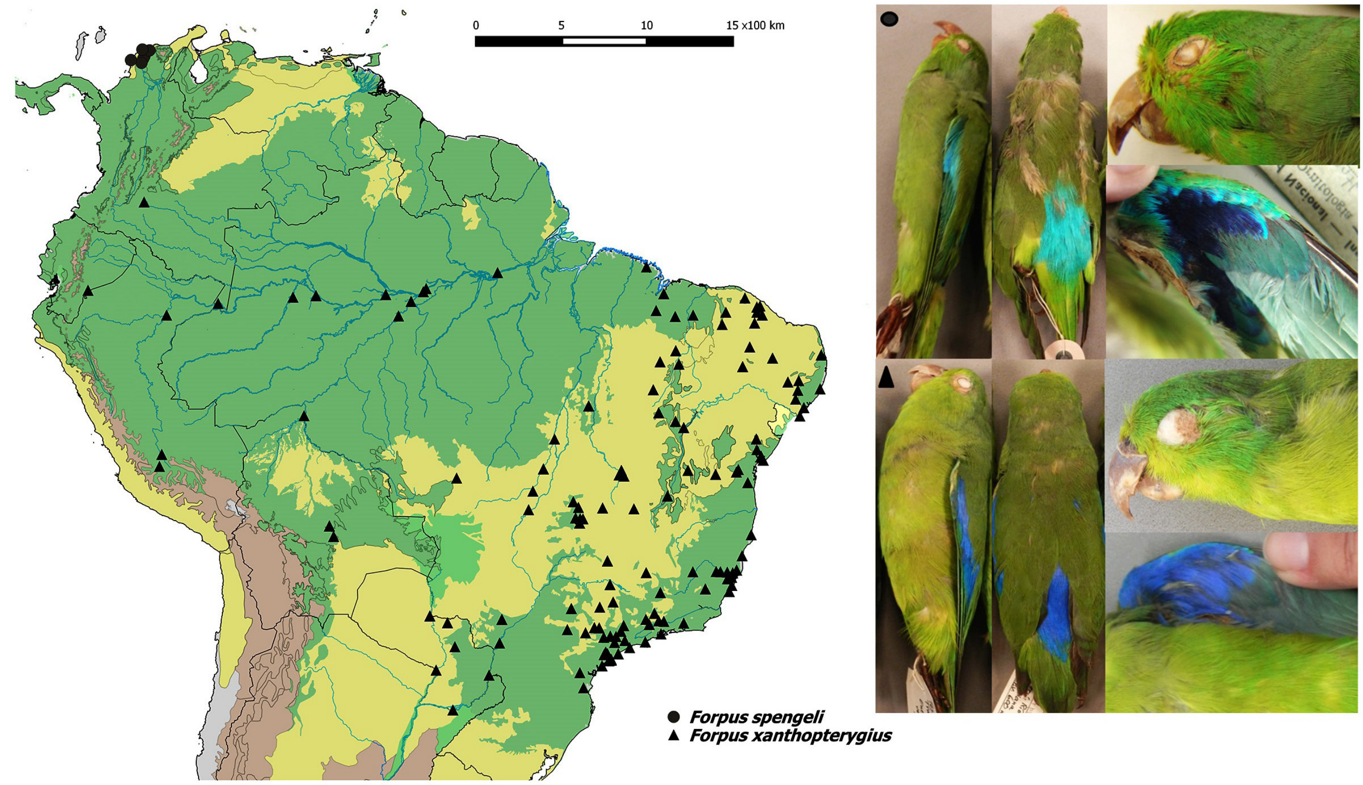

FIGURE 1. The specimen record map; each point represents a locality with a minimum of one specimen analyzed (see Appendix). *Forpus spengeli* (black dots) and *Forpus xanthopterygius* (black triangles). Inset: lateral, dorsal, head, and under wing coverts of *Forpus spengeli* (above), and *Forpus xanthopterygius* (below). Humid/forested biomes in green; open/dry forest in yellow.

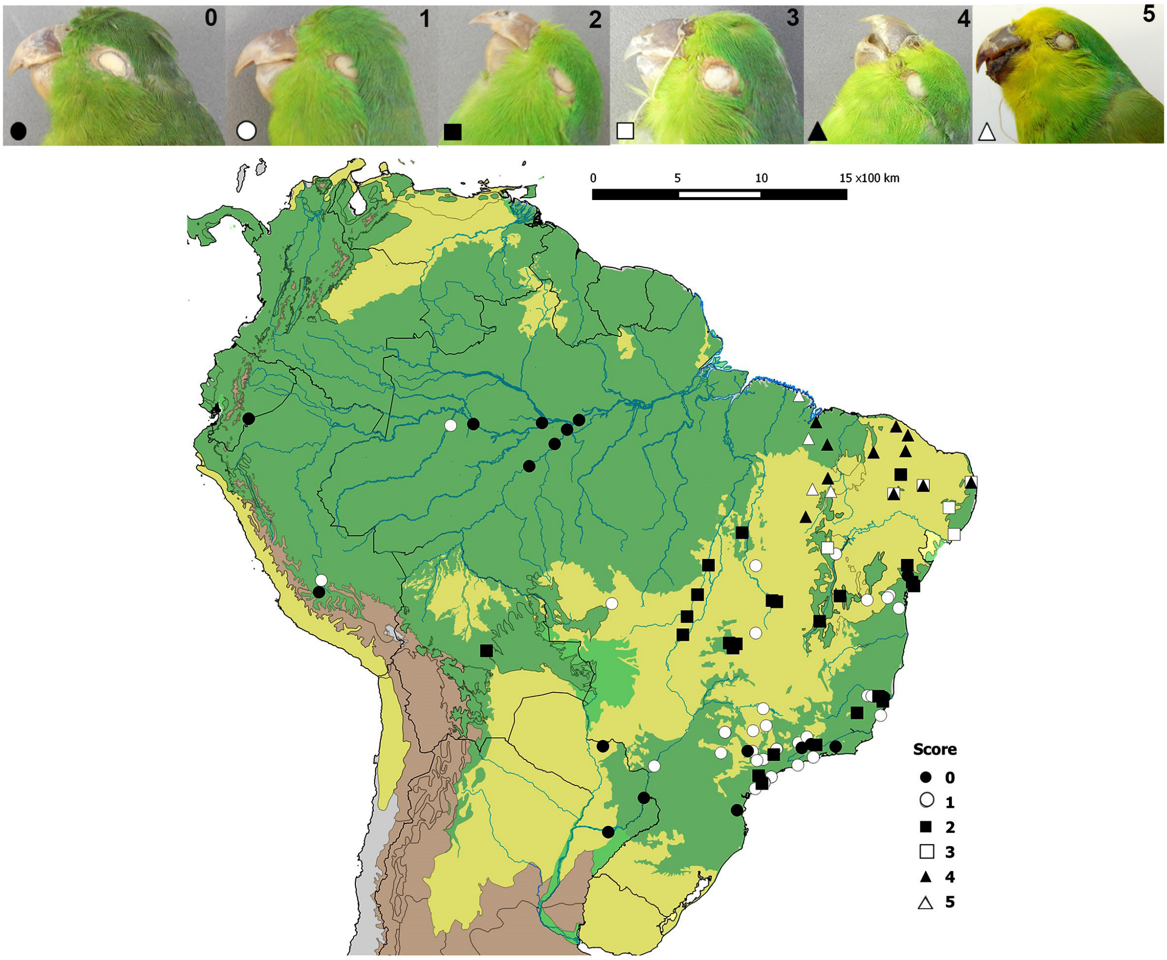

FIGURE 2. Geographic distribution of head color scores; the photos on top represent the phenotypic variation attributed to each score. See text for details.

Phenotypic variation in head color coincided roughly with boundaries of major biomes such as Amazonia, Atlantic forest, Cerrado and Caatinga (Figure 2). In most forested and humid regions (Amazonia and Atlantic forest) darker coloration patterns predominated (0, 1 and 2), while in open vegetation (Cerrado and Caatinga) lighter forms occurred (2, 3, 4, and 5). Amazonian specimens had the darkest coloration pattern (always 0 and 1) while for Atlantic forest specimens scores were mostly 1 with scattered scores 0 and 2. Specimens from Cerrado exhibited scores of 2-3, which were darker than specimens from Caatinga, where lighter and yellowish individuals were more prevalent (3, 4, and 5). Within the subset of specimens from northeastern Brazil, the head color pattern becomes progressively more yellowish from northern Bahia, where the most common scores were 2 and 3, to Maranhão, where scores were 4 and 5. Despite the tendency of head color scores to differ between biomes, no plumage score that was unique to a region. Thus, head color scores mix extensively across geography.

A disjunct population from northern Colombia has turquoise-blue (S 93- Robin's Egg blue) on back and rump, innermost primaries coverts spectrum-blue (S 5.5. PB 4/14), secondaries coverts spectrum-blue (S 5.5. PB 4/14) with base turquoise-blue (93- Robin's Egg blue) and under-wing coverts turquoise-blue outermost, followed by ultramarine-blue (S 270-ultramarine) feathers. The green parts on males were similar to all remaining populations of the *Forpus xanthopterygius* complex. The head is apple green (S 7.5 GY 7/8) with yellow (M 5Y 7/6); chest and belly are apple green (S 7.5 GY 7/8), upper back and green parts of wing and tail are parrot green (S 5GY 5.5/5.5) (Figure 1).

Morphometry

Table 1 presents the descriptive statistical analysis of the morphometric data of the studied taxa. The normality and homoscedasticity tests results were compatible with the use of parametric tests. Student's *t*-test demonstrated that there is no morphometric sexual dimorphism among Blue-winged parrotlet specimens. One-way ANOVA and the posterior Tukey HSD after Bonferroni's correction revealed some significant differences between pairs of taxa (Table 2), but the values overlap, making difficult the discrimination of any diagnosable unit by morphometry. The PCA analysis (Figure 3) generated a synthetic variable that explains 61.85% of the variance between all taxa, with tail and wing length accounting for most of the variation. The PCA graph revealed that taxa overlap widely in the morphometric space; the only noticeable pattern is that *crassirostris* specimens tend to cluster more frequently on the top whereas those of *xanthopterygius* group more commonly at the bottom of the graph.

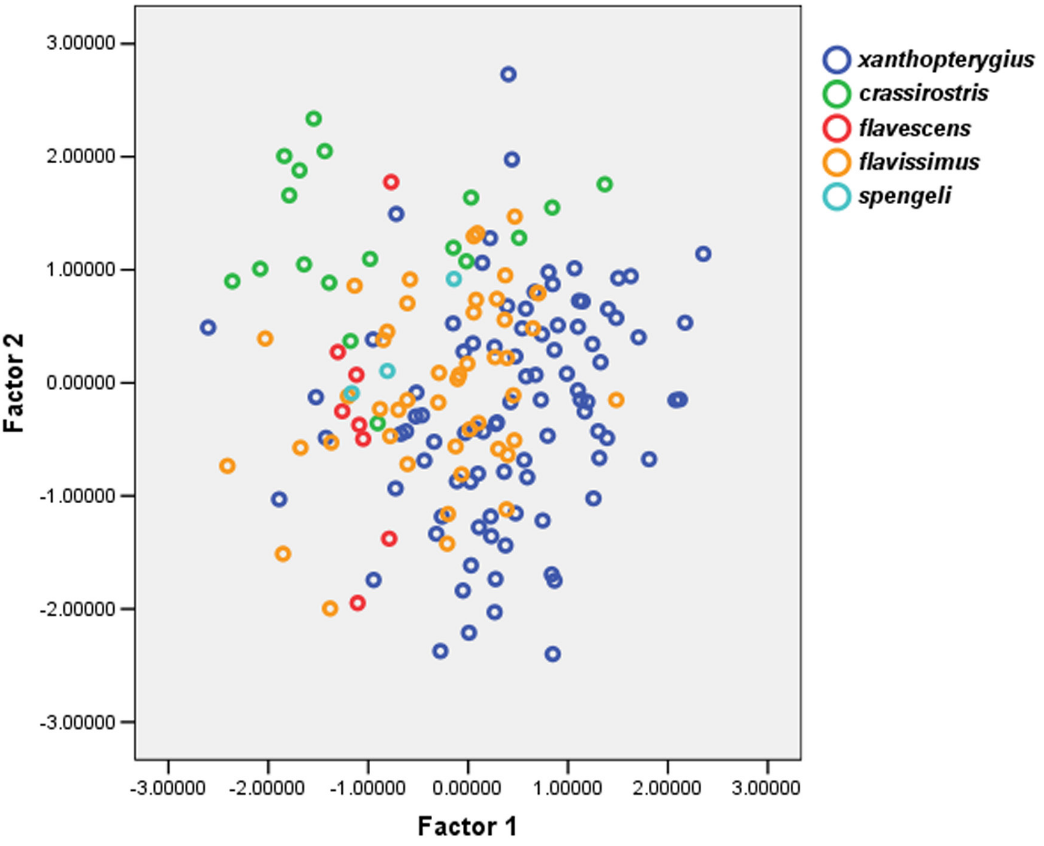

FIGURE 3. Principal Components Analysis showing the distribution in the morphometric space of five purported subspecies of the *Forpus xanthopterygius*, each represented by a different color (see legend). Factor 1 corresponds mostly to differences in wing, tail and tarsus length, whereas in factor 2 most of the variance is explained by exposed culmen length.

TABLE 1. Descriptive statistics of morphometric data. Measurements (mm) as mean and standard deviation are in the first row, and minimum as maximum values are in the second row.

Taxon	Culmen	Bill Width	Wing	Tail	Tarsus
spengeli	11.94 ± 0.86	8.52 ± 0.26	79.7 ± 4.4	40.68 ± 3.03	8.11 ± 0.73
	(10-13)	(8.29-8.84)	(73-87.67)	(36.5-46)	(7.49-9.14)
xanthopterygius	11.49 ± 0.63	8.62 ± 0.37	81.61 ± 3.19	45.58 ± 4.22	9.33 ± 0.88
	(10.76-11.5)	(7.2-9.1)	(71-88.5)	(34-54.5)	(7.21-11)
crassirostris	11.65 ± 0.4	8.76 ± 0.37	73.83 ± 3.42	39.36 ± 5.53	8.47 ± 1.11
	(10.76-12.5)	(7.84-9.21)	(68-80)	(31-50)	(6.4-10.5)
flavissimus	11.81 ± 0.61	8.27 ± 0.28	79.26 ± 3.19	43.8 ± 4.08	8.64 ± 0.84
	(10.34 -13)	(7.66-8.87)	(70-85)	(36-54)	(7.11-10.5)
flavescens	10.92 ± 0.54	8.65 ± 0.29	80.37 ± 3.37	38.5 ± 1.98	7.67 ± 0.49
	(9.9-11.61)	(8.39-9.32)	(76-85)	(36-40.5)	(7.16-8.57)

TABLE 2. Tukey HSD results for five morphometric parameters after Bonferroni's correction ($\alpha = 0.005$). The comparisons were performed between pairs of taxa. Ns = no significant difference; < 0.005* = significant difference.

Taxa	Culmen	Bill Width	Wing	Tail	Tarsus
xanthopterygius X spengeli	ns	ns	ns	ns	ns
xanthopterygius X crassirostris	ns	ns	< 0.005*	< 0.005*	< 0.005*
xanthopterygius X flavissimus	ns	< 0.005*	< 0.005*	ns	< 0.005*
xanthopterygius X flavescens	ns	ns	ns	< 0.005*	< 0.005*
spengeli X crassirostris	ns	ns	< 0.005*	ns	ns
spengeli X flavissimus	ns	ns	ns	ns	ns
spengeli X flavescens	ns	ns	ns	ns	ns
crassirostris X flavissimus	ns	< 0.005*	< 0.005*	< 0.005*	ns
crassirostris X flavescens	ns	ns	< 0.005*	ns	ns
flavissimus X flavescens	< 0.005*	ns	ns	ns	ns

A linear regression test demonstrated that wing length was the morphometric character more strongly correlated with latitude ($r^2 = 0.2769$, $F = 59.75$, $P < 0.0001$; Figure 3). Tail length ($r^2 = 0.1654$, $F = 30.72$, $P < 0.0001$; Figure 4), tarsus length ($r^2 = 0.113$, $F = 19.87$, $P < 0.0001$; Figure 4), bill width ($r^2 = 0.0766$, $F = 12.86$, $P = 0.0004$; Figure 4) and exposed culmen ($r^2 = 0.04712$, $F = 7.664$, $P = 0.0063$; Figure 4) also had positive correlation with latitude ($\alpha = 0.05$), although with lower values of r^2. These results strongly suggest the existence of a subtle latitudinal cline.

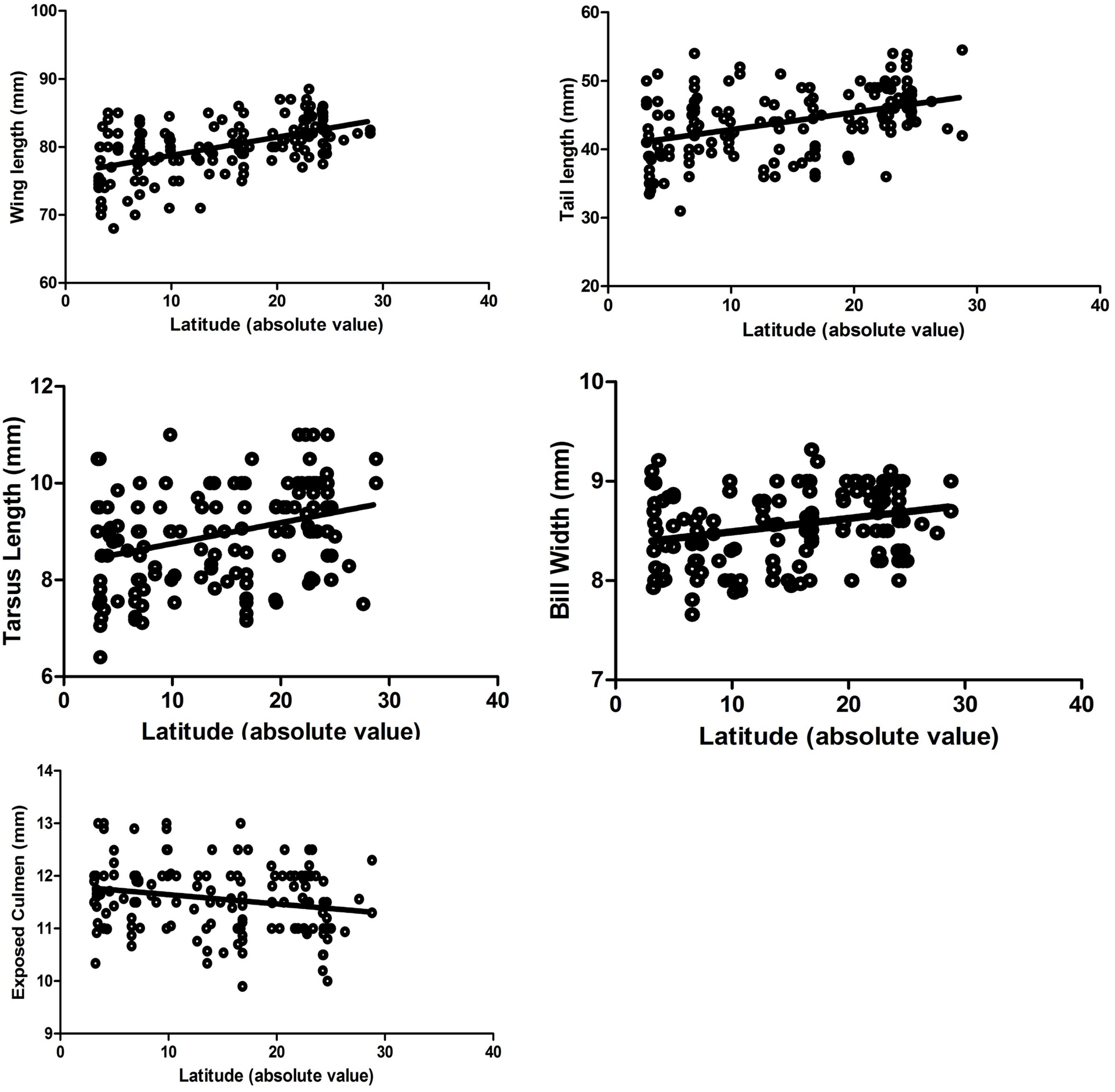

FIGURE 4. Linear regression tests showing the relationship between different body size measurements and latitude in measured specimens of *Forpus xanthopterygius.*

Taxonomy

The two populations we find to be clearly distinctive in terms of plumage characters have available names in the literature, and they may be recognized at the specific level as follows:

***Forpus spengeli* (Hartlaub 1885)**

English name: Turquoise-winged Parrotlet.

Type-locality: Barranquilla, Colombia.

Diagnosis: males can be distinguished from any other *Forpus* species by having back and rump turquoise-blue (S 93- Robin's Egg blue); primaries base spectrum-blue (S 5.5. PB 4/14); secondaries coverts spectrum-blue (S 5.5 PB 4/14) with base turquoise-blue (S 93- Robin's Egg blue) and outermost under-wing coverts turquoise-blue followed distally by ultramarine-blue (S 270-ultramarine) feathers, a pattern not found in any *Forpus* (Figure 1). In the female's plumage all blue is replaced by apple-green (S 7.5 GY 7/8), with the lower body and wings being parrot green; forehead and crown are more yellowish than in males.

Distribution: Restricted to northern Colombia, from the Caribbean coast (Cartagena) across the lower Magdalena Valley, south to northern Bolívar and east to the base of the Santa Marta Mountains and west to the foothills of the Perijá mountains (Figure 1)

***Forpus xanthopterygius* (Spix 1824)**

English name: Blue-winged Parrotlet.

Portuguese name: Tuim

Type-locality: Minas Gerais, Brazil

Diagnosis: males with back, rump and under-wing coverts ultramarine blue (S 270-ultramarine), primaries and secondaries coverts ultramarine-blue (270-ultramarine) with spectrum-blue (S 5.5. PB 4/14), considerably darker than that found in *Forpus spengeli*. Females are similar to those of *Forpus spengeli*, but forehead and crown color varies from uniform parrot green (S5GY 5.5/5.5) to totally light yellow (M 5Y 8/8), through intermediated states, similar to the patterns seen in males, but with females always more yellowish than males.

Distribution: From southern Colombia (Leticia and Putumayo) to northeastern Ecuador, eastern Peru and eastern Bolivia, in Beni and Santa Cruz; also in central Amazonia along the Amazon River and the lowermost part of its tributaries such as the Tapajós; eastern Brazil from Maranhão and Ceará to Santa Catarina, northeastern Argentina (Missiones and Corrientes) and Paraguay (Figure 1).

DISCUSSION

Forpus spengeli is an endemic species from northern Colombia. Hartlaub (1885) originally gave *spengeli* specific status and it is unclear why this species subsequently was considered as a subspecies for so long; the unique pattern of bicolored feathers found in the under-wing coverts (see Figure 1) suggests that this species may not even be related to *Forpus xanthopterygius* or *F. cyanopygius* as previously suggested. Range-wide sampling corroborated all diagnostic features described by Hartlaub (1885), and the specific status is supported both under the Phylogenetic Species Concept (Cracraft 1983, 1987, 1989) and the Biological Species Concept (Mayr *et al.* 1953), given the fact that this population is reproductively isolated from *F. xanthopterygius* population. The molecular results of Smith *et al.* (2013) also support this species designation, since in the mtDNA phylogeny *spengeli* is genetically distinct from the other taxa in the complex and, in fact, demonstrates that *spengeli* is not even closely related to other *xanthopterygius* specimens as it was grouped within a clade they considered to be part of the *Forpus passerinus* complex.

Within *Forpus xanthopterygius*, the taxa *crassirostris*, *flavissimus*, *flavescens* and *olallae* are here considered as synonyms. This species is widely distributed through different biomes in South America, in both drier and humid regions. Plumage patterns observed within this species are not uniform and can vary between individuals from the same site. In addition, we observed character variation that did conform to the distributions proposed for the subspecies described (Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997, Forshaw 2010).

Comparisons of individuals from different localities demonstrated that the individual variation in head color (including forehead, crown, and ear coverts; Figure 2) is not randomly distributed. Most of the darker specimens were found in the Amazon basin, although specimens with this pattern were also found at many localities from the southeastern and southern Atlantic forest, including Paraguay and Argentina. Birds from northeastern Brazil are lighter and more yellowish; however, the yellow tonality varies geographically, ranging from a darker yellow in Bahia (scores 2 and 3) to a bright light yellow in Maranhão (score 4 and 5), with populations in-between being intermediate. In west-central Brazil the yellow tonality is not as light and yellowish as in the northeast, where an intermediate pattern is observed (score 2), with some darker individuals (score 1) as well. In southeastern and southern Atlantic Forest, including Paraguay and Argentina, a mixture of states (0, 1, 2) was observed. Thus, in the Atlantic Forest there were both lighter forms resembling Cerrado and Bahia (score 2) birds and darker forms as in Amazonia (score 0 and 1), without any detectable distribution pattern.

This overall plumage variation, from darker to lighter and yellowish, was the basis for subspecies descriptions in the complex. We believe that the absence of larger samples prevented previous authors from noticing that this kind of variation could be more associated with environmental variables than with the evolution of independent lineages, regardless of taxonomic status. This phenotypic variability in plumage pattern indicates that these birds may respond to some broad environmental differences across biomes.

Species such as *Forpus xanthopterygius* that occur in both forested habitats (Amazonia and Atlantic forest) and dry open vegetation habitats (Cerrado and Caatinga) could exhibit different phenotypes related with selective pressured in each habitat (Zink & Remsen 1986). Forests and open vegetation habitats differ in numerous aspects, such as luminosity levels, humidity and climate, and this scenario could generate different selective pressures on adaptive traits between habitats, resulting in morphologically differentiated populations despite the presence of gene flow (Zink & Remsen 1986, Smith *et al.* 2005, Vilaça & Santos 2010, Cabanne *et al.* 2011).

The pattern found in our study is in accordance with Gloger's rule (Zink & Remsen 1986), which states that there is a tendency for populations in more humid areas to be more heavily pigmented than those in drier areas. Association between pigmentation and humidity is thought of as a manifestation of background matching, to reduce detectability by predators, prey or competitors (Miller & Miller 1951). Such geographic variation in pattern coloration has been documented in many North American (Zink & Remsen, 1986) and European birds (Snow 1954), as well as Neotropical birds such as *Basileuterus culicivorus*/*Basileuteurus hypoleucus* (Vilaça & Santos 2010) and *Dendrocolaptes platyrostris* (Cabanne *et al.* 2011). Our results suggest that the morphological divergence found may have evolved by divergent selective regimes between habitats.

Morphometric analyses also present patterns of variation that do not correspond to subspecific patterns. Morphometric characters follow Bergmann's rule according to linear regression tests results; Bergmann's rule is the tendency for body size to be positively correlated with decreasing temperature and humidity (James 1970), and this correlation is a response to physiological advantages of larger body sizes in more severe climates (Zink & Remsen 1986). Although correlation values were not elevated for exposed culmen, bill width and tarsus length, we can assume that wing length and tail length are strongly influenced by latitude, and this might explain why *crassirostris* is smaller than other taxa and why this disparity was used as a diagnostic feature to describe this subspecies (Taczanowski 1883, Gyldenstolpe 1945, Forshaw & Cooper 1989, Juniper & Parr 1998, Collar 1997). Amazonian specimens are smaller than southern populations because of latitudinal influence in body size, and this does not correspond with any taxonomic limit.

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APPENDIX

Specimens examined. For collections' acronyms see methods.

Forpus spengeli: **COLOMBIA: Amazonia:** Rio Caqueta (1 ♂-MNHN CG: 1993 nº 246, 1 ♀-MNHN CG: 1993 nº 245); **Atlantico:** Puerto Giraldo (1 ♂-MCN 10622, 1 ♀-MCN 10621); Ponedera (1 ♂-MCN 10621); La Playa, near Barranquilla (2 ♀-AMNH 133025, AMNH 474922, 2 ♂-AMNH 133023, AMNH 133024); **Bolívar:** Cartagena (2 ♀-FMNH 72336, AMNH 44080, 2 ♂-FMNH 72335, USNM a17829); Calamar (1 ♀-AMNH 833893); **Magdalena:** Isla de Salamanca (1 ♀-MCN 17957); Los Almendios, Isla de Salamanca (1 ♀-IAVH 775, 1 ♂- IAVH 65).

***Forpus xanthopterygius*: ARGENTINA: Corrientes:** 30 km w-nw Ituzaingó (2 ♂-AMNH 798864, AMNH 798865, 1 ♀-AMNH 798863); **Missiones:** (1 ♂-AMNH 9647, 1 ♀- AMNH 154174); Iguazu (2 ♂-AMNH 154176, AMNH 9647). **BOLIVIA: El Beni:** Rio Yacuma (1 ♀-AMNH 791779); **Santa Cruz:** (2 ♂- ZMB 1, ZMB 2, 2 ♀-ZMB 3, ZMB 4); Buena vista (1 ♀-FMNH 11918, 1 ♂-FMNH 62941); Guitiérrez (11 ♂-ZMB 371, ZMB 304, AMNH 474870, AMNH 474874, AMNH 474869, AMNH 474872, AMNH 474871, AMNH 474876, AMNH 474877, AMNH 474873, AMNH 474875, 3♀- AMNH 474880, AMNH 474879, AMNH 474878). **BRAZIL: Alagoas:** Palmeiras dos Indios (1 ♂-MZUSP 37236); Usina Sinimbú (3 ♂-MZUSP 37237, MZUSP 38950, MZUSP 38951, 2 ♀-MZUSP 38949, MZUSP 38952); Marg. Esq. Faz. Poço do Coeri, Apa Piaçabuçu (1 ♀-MZUSP 84509); **Amazonas:** Manacapuru, Rio Solimões (2 ♂-MZUSP 16525, MZUSP 16528, 1 ♀-MZUSP 16526); R. Amazonas (Norte), Itacoatiara (4 ♂-MZUSP 17756, MZUSP 17757, MZUSP 17762, MZUSP 20430); Caitau Uará, MD Rio Solimões (2 ♂-MPEG 49822, 48820, 1 ♀-MPEG 48821); Rio Madeira, igarapé Aurara, margem direita (1 ♂-AMNH 279075, 1 ♀-AMNH 279076); Santo Isidoro, Tefé (3 ♂-AMNH 308981, AMNH 308982, AMNH 308980, 2 ♀-AMNH 308983, AMNH 308984); Tefé, rio Solimões (3 ♂-AMNH 474883, AMNH 472881, AMNH 474882, 1 ♀-AMNH 474884); Rosarinho, Lago Sampaio, leste do Rio Madeira (3 ♂-AMNH 281452, AMNH 281451, AMNH 281454, 2 ♀-AMNH 281453, AMNH 281455); Lago Canaçari (1♂-NRM 569809); **Bahia:** (12 ♂-AMNH 474858, AMNH 474865, AMNH 474860, AMNH 474859, AMNH 474866, AMNH 474864, AMNH 474861, AMNH 163148, AMNH 474862, AMNH 474863, AMNH 474867, USNM 46723, 3 ♀-AMNH44638, AMNH 163149, AMNH 474868); Buritirama, Mun. de Barra (4 ♂-MZUSP 40852, MZUSP 40853, AMNH 241765, AMNH 241766, 4 ♀-MZUSP 40854, MZUSP 40855, MZUSP 40856, AMNH 241767); R. Jucurucu, Cachoeira Grande (1 ♂-MZUSP 14004); Madre de Deus, Recôncavo (1♂-MZUSP 14005); Curupeba, próximo a Ilha Madre Deus (1 ♀-MZUSP 14006); Riacho de Santana, Barra do Rio das Râs (1 ♂-MPEG 46980, 1 ♀-MPEG 46981); Lamarão (3 ♂-MNHN CG: 1903 nº 769, AMNH 474854, AMNH 474855); Humildes (1 ♂-AMNH 44677); Ituassu (1♀-AMNH 241762, 1 ♂-AMNH 241761); Jaguaquara (1 ♂-AMNH 241763); Rio Gongoji (1 ♂-AMNH 241760, 1 ♀-AMNH 241759); Salvador (2 ♀-AMNH 163152, AMNH 163151); Baixão (1 ♂-AMNH 241769); **Ceará:** Baturité, Açudinho (4 ♀-MZUSP 33051, MZUSP 41522, MZUSP 41523, MCN 10991, 7 ♂-MZUSP 41518, MZUSP 41519, MZUSP 41529, MZUSP 41521, MPEG 46148, MPEG 19987, MCN 10991); Faz. Poço Verde, Itapipoca (1 ♂-MZUSP 41524); Juá (2 ♂-FMNH 47019, FMNH 47018); Ipu (1♀-ZMB 73); Ladeira Grande (1 ♂-ZMB 311900); Quixadá (1♀-AMNH 241785, 4 ♂-AMNH 241782, AMNH 241789, AMNH 241783, AMNH 241781); **Distrito Federal:** Brasília, setor aeroporto (1 ♂-MPEG 15668, 1 ♀-MPEG 15669); **Espírito Santo:** (2 ♂-MZUSP 6411, MZUSP 6475, 2 ♀-MZUSP 6412, MZUSP 6414); Pau Gigante (2 ♀-MZUSP 24563, MZUSP 33050, 1 ♂-MZUSP 33049); Colatina, Linhares (1 ♂-MZUSP 24564); Guarapari (1 ♂-MZUSP 28089, 1 ♀-MZUSP 28090); Barro Novo, Linhares (3 ♀-MBML 2656, MBML 2676, MBML, 2649, 1 ♂-MBML 2661); Bebedouro, Linhares (1 ♂-MBML 2666); Gravata, Linhares (1 ♂-MBML 2669); Jataí Peba, Linhares (2 ♀-MBML 2662, MBML 2663); Lagoa do Teste, Linhares (1 ♂-MBML 2667); Lagoa das Piabas, Linhares (5 ♀-MBML 2657, MBML 2658, MBML 2659, MBML 2671, MBML 2653, 1 ♂-MBML 2670); Lagoa do Meio, Linhares (1 ♂-MBML 2660); Lagoa Juparaná, Linhares (2 ♂-MBML 2665, MBBML 2648); Lagoa Nova, Linhares (1 ♂-MBML 2668); Parque Estadual de Itaúnas, Conceição da Barra (1 ♂-MBML 7108); Santa Teresa (5 ♀-MBML 2672, MBML 2677, MBML 2644, MBML 2651, 7 ♂-MBML 2673, MBML 2674, MBML 2675, MBML 2650, MBML 2652, MBML 2654, MBML 2655); Baixo Guandu (1 ♂-AMNH 317293, 1 ♀-AMNH 317294); Lagoa Juparaná (2 ♂-AMNH 317295, AMNH 317296, 2 ♀-AMNH 317297, AMNH 317298); Vitória (1- undetermined-ZSM 12215); **Goiás:** Inhumas (2 ♀-MZUSP 14900, MZUSP 65089, 2 ♂-MZUSP 14902, MZUSP 65089); Jaraguá, Faz. Thomé Pinto (1 ♂-MZUSP 14901); Cana Brava, Nova Roma (1 ♀-MZUSP 15763, 1 ♂-MZUSP 1764); Goiânia (13 ♂-MZUSP 52373, MZUSP 72248, MZUSP 75165, MZUSP 75166, MNHN CG: 1969 nº 491, MNHN CG: 1969 nº 492, MNHN CG: 1969 nº 494, MNHN CG: 1969 nº 495, MNHN CG: 1969 nº 493, MNHN CG: 1968 nº 457, MNHN CG: 1968 nº 460, MNHN CG: 1968 nº 459, MNHN CG: 1968 nº 458, 13 ♀-MZUSP 72245, MZUSP 72246, MZUSP 72249, MZUSP 75167, MZUSP 75168, MPEG 21956, MNHN CG: 1969 nº 498, MNHN CG: 1969 nº 497, MNHN CG: 1969 nº 496, MNHN CG: 1968 nº 461, MNHN CG: 1968 nº 463, MNHN CG: 1968 nº 462, MNHN CG: 1968 nº 464); Neropolis (1 ♂-MZUSP 75166); Iaciara, Fazenda São Bernardo (3 ♀-MPEG 44773, MPEG 44772, MPEG 44771, 2 ♂-MPEG 44770, MPEG 44769); São Domingos, Fazenda Cipasa (1 ♂-MPEG 51082); Nerópolis, Fazenda Dois Irmãos (2 ♂-MPEG 44467, MPEG 44466, 1 ♀-MPEG 44468); Esperança (2 ♀-AMNH 474856, AMNH 474857); **Maranhão:** Mun. de Bacabal, rio Estiva, afluente esquerdo do rio Mearim (1♂-MPEG 48748); Mun. de Santo Antonio do Balsas, Matão afluente dir. do rio Balsas (2 ♂-MPEG 50735, MPEG 49747); Mun. de Riachão, Fazenda Malhadinha (1 ♀-MPEG 42100, 2 ♂-MPEG 42099, MPEG 42098); Tury-assu, Maranhão (1 ♂-FMNH 62909); Codó, Cocos (1 ♀-FMNH 62912, 1 ♂-FMNH 62915); Tabocas, São João dos Patos (4 ♀-AMNH 241777, AMNH 241776, AMNH 241775, AMNH 241778, 4 ♂-AMNH 241774, AMNH 21773, AMNH 241771, AMNH 241772); Kelru, Rosario (1 ♀-AMNH 241770, 2 ♂-AMNH 241769, AMNH 241768)

Mato Grosso: Chavantina, Rio das Mortes (1 ♂-MZUSP 32301); São Domingos, Rio das Mortes (3 ♂-MZUSP 35018, MZUSP 35019, MZUSP 35021); R. Pindaíba (1 ♂-MZUSP 42872); Barra do Garças (1 ♂-MPEG 28162); **Mato Grosso do Sul:** Rio Ivinhema (6 ♂-ZSM 38970, ZSM 38931, ZSM 38972, ZSM 38961, ZSM 38966, ZSM 38965, 3 ♀-ZSM 38973, ZSM 38968, ZSM 38969); **Minas Gerais:** Vargem Alegre (1 ♂-MZUSP 1584); Maria da Fé (1 ♂-MZUSP 16009); R. Doce, baixo Piracicaba, margem esq. (1 ♀-MZUSP 24825); São José da Lagoa, Faz. Boa Esperança (2 ♂-MZUSP 24827, MZUSP 24830, 2 ♀-MZUSP 24828, MZUSP 24829); Baependi (2 ♀-MZUSP 34630, MZUSP 34631); Extrema (1 ♂-MZUSP 61525); Arinos (♂-MZUSP 74742); Fazenda Ribeirão das Cachoeiras (1 ♀-MZUSP 88324, 1 ♂-MZUSP 88339); Itacarambi, Fazenda olho d'água (3 ♀-MPEG 41048, MPEG 41049, MPEG 41050, 1 ♂-MPEG 41051); Arinos, Fazenda Tira Teima (1 ♀-MPEG 41389); Água Suja (1 ♀-MNHN CG: 1934 nº 282, 3 ♂-ZSM 1772, ZSM 1770, ZSM 32397, 2 undetermined-ZSM 1773, ZSM 1771); São Benedicto (1 ♂-AMNH 318095); **Pará:** (1 ♂-MPEG 2806); Monte Alegre (3 ♀-ZMB 311904, ZMB 57, ZMB 311902); **Paraíba:** Coremas (11 ♂-MZUSP 39554, MZUSP 39555, MZUSP 39556, MZUSP 39557, MZUSP 39558, MZUSP 39559, MZUSP 39560, MZUSP 39561, MZUSP 39562, MZUSP 39563, MZUSP 39564, 2 ♀-MZUSP 39571, MZUSP 39572); Mamanguape, Uruba (3 ♂-MZUSP 39565, MZUSP 38566, MZUSP 38567, 3 ♀-MZUSP 39568, MZUSP 39569, MZUSP 39570); **Paraná:** R. 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Pinheiro, R. T. 2009. [WA589090, *Celeus obrieni* Short, 1973]. www.wikiaves.com/589090 (access on 05 March 2012).

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