

Harpy Eagle sightings, traces and nesting records at the “Reserva Natural Vale”, a Brazilian Atlantic Forest remnant in Espírito Santo, Brazil.

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ABSTRACT: We present 25 records of sightings, feathers and nests of the Harpy Eagle *Harpia harpyja* in the last 27 years and also the first detailed description of a nest of a Harpy Eagle in the Brazilian Atlantic Forest, found at the “Reserva Natural Vale” (RNV), Linhares, Espírito Santo, Brazil. Most Harpy Eagle records were obtained along the RNV roads by researchers and the RNV staff. Two nests have been mapped at the RNV until now. An especially relevant record occurred in 1997 when a juvenile Harpy Eagle was found dead, 4 km distant from the nest mapped and measured in 2010. The nest was 1.8 m X 1.6 m in diameter, and was built 28 m above ground, on the main fork of an *Astronium concinnum* tree measuring 37 m height and 1 m in diameter at breast height (DBH). This nest was the second of the species to be reported at RNV, being 5 km away from the first one, found in 1992, and built 30 m above the ground on the main fork of a *Cariniana legalis* tree 36 m high and 1.1 m in DBH. All Harpy Eagle records at RNV indicate that this protected area offers enough resources and has carrying capacity to maintain at least two Harpy Eagle pairs. However, because of the fragmentation around RNV, the local Harpy Eagle population cannot expand due to reduced habitat availability. The data gathered in this study confirm the importance of the RNV for the conservation of the critically endangered Harpy Eagle population of the Brazilian Atlantic Forest. We recommend the establishment of a reforestation program to increase the size and the connections of fragments around the RNV. We suggest that the creation and effective implementation of protected areas may contribute to Harpy Eagle protection in the Brazilian Atlantic Forest, but the long-term conservation of remaining populations is an essential step to allow for the occupation and re-colonization of other areas.

KEY-WORDS: Birds of prey, conservation, Harpy Eagle nest, Neotropics, Brazilian Atlantic Forest.

INTRODUCTION

The Harpy Eagle *Harpia harpyja* (Accipitridae) is the largest flying predator of Central and South America (Sick 1997), and occurs in dense forest areas in Brazil (Pinto 1964). Several nests of this species have been studied in British Guiana (Rettig 1978, 1995), Venezuela (Kung & Alvarez 1997) and Brazil (Ruschi 1979, Galetti & Carvalho Jr. 2000, Luz 2005, Sanaiotti *et al.* 2007, Aguiar-Silva 2007, Piana 2007, Banhos *et al.* 2008, Luz *et al.* 2010). The Harpy Eagle was included in the Brazilian Official List of Threatened Species under the category of Threatened until 2003 (Bernardes *et al.* 1990); currently, it is considered nationally a Near-Threatened species

(Machado *et al.* 2008). According to regional state lists in Brazil, it is regarded as probably Extinct in the Wild (EW) in Rio Grande do Sul (Bencke *et al.* 2003); in Rio de Janeiro it is listed as Endangered (EN) (Alves *et al.* 2000), whereas in the states of Paraná (Mikich & Bérnils 2004, Instituto Ambiental do Paraná 2011), Santa Catarina (IGNIS 2008), Minas Gerais (Fundação Biodiversitas 2007) and Espírito Santo (Simon *et al.* 2007) it is considered Critically Endangered (CR). The decline of Harpy Eagle populations in Brazil is attributed mainly to forest destruction and hunting pressure (Vargas *et al.* 2006).

Harpy Eagles are rare in remnants of the Brazilian Atlantic Forest (Albuquerque 1995, Galetti *et al.* 1997,

Pacheco *et al.* 2003), where in some regions there have been no records of this species for almost 90 years (Scherer-Neto & Straube 1995), although the species apparently is still abundant in the Brazilian Amazon, as highlighted by several nesting records in the region (Vargas *et al.* 2006, Banhos *et al.* 2008, Luz *et al.* 2010, Aguiar-Silva *et al.* 2011; Aguiar-Silva *et al.* in press). The forests in the Amazon have been threatened for only about four decades, whereas the Brazilian Atlantic Forest has suffered severe fragmentation throughout the last five centuries, resulting in remnant areas covering 16% of the original area, including secondary forests and fragments smaller than 50 ha (Ribeiro *et al.* 2009). Nevertheless, some Brazilian Atlantic Forest remnants still host Harpy Eagles, with recent reports for the states of Bahia (Silveira *et al.* 2005, Sánchez-Lalinde *et al.* 2011) and Espírito Santo (Srbek-Araujo & Chiarello 2006).

In northern Espírito Santo, the "Reserva Natural Vale" (RNV) covers approximately 23,000 ha, and the "Reserva Biológica de Sooretama" (Rebio Sooretama) covers 24,250 ha; together, these continuous areas of native vegetation correspond to about 10% of the Atlantic Forest remaining in the state (Fundação SOS Mata Atlântica & INPE 2009). The RNV is the second largest reserve of lowland rainforest or Lowland Coastal Zone ("Hiléia Baiana") in Espírito Santo (Srbek-Araujo & Chiarello 2006), where an active Harpy Eagle nest was found in 1992 (Galetti *et al.* 1997).

Since 1999, the Brazilian Harpy Eagle Conservation Program (PCGR) has been mapping Harpy Eagle nests in the Amazon, Atlantic Forest, and forest enclaves of the Cerrado. Interviews with researchers, riverside dwellers, fishermen, hunters, farm workers and staffs from the protected areas, are sources of information about Harpy Eagles nests (Sanaiotti *et al.* 2007).

The PCGR carried out a protocol for mapping Harpy Eagle records in the Atlantic Forest, sampling in 2004 a Harpy Eagle nest located on the Macanaíba-pele-de-sapo Road at the RNV, based on literature and information from local collaborators and researchers (Peixoto & Peixoto 1986, Galetti *et al.* 1997, Pacheco *et al.* 2003). The aim was to evaluate the physical characteristics of the tree where the nest was discovered in 1992, and to determine potential locations where the pair could have built an alternative nest, given that nesting had not been reported in the original tree since 1995.

Here, we summarize the Harpy Eagle records at RNV since 1985 to evaluate the conservation status of the species in the area. We also report on the results of a new PCGR survey conducted in September 2010 at RNV with the aim of revisiting locations where both old (Peixoto & Peixoto 1986, Galetti *et al.* 1997, Pacheco *et al.* 2003) and recent records of Harpy Eagle were obtained (Srbek-Araujo & Chiarello 2006).

METHODS

Harpy Eagle records were obtained through interviews with current RNV staff, photos, sightings and feathers found on the forest floor, scientific publications (Ruschi 1979, Peixoto & Peixoto 1986, Galetti *et al.* 1997, Pacheco *et al.* 2003, Srbek-Araujo & Chiarello 2006, Banhos & Sanaiotti 2011), and from specimens deposited in museums collected in the region of the Espírito Santo.

Given the rarity of sightings and the few records of Harpy Eagle nests in the Brazilian Atlantic Forest, a protocol for the location of nests in fragmented forests has been used by the PCGR since 2005. The technique consists of accessing the forest canopy at specific points, defined by the locations where direct and indirect records (sightings, photos, traces and/or vocalizations) of the Harpy Eagle have been made. From these points, the top of a nearby emergent tree (or the tree of the past sighting event itself, when possible) is accessed with the use of a static rope, which can be released in an emergency and which is anchored to the base of a nearby tree or the climbed tree itself. Ventral and manual ascenders with automatic locking are used to climb the rope. The climber uses binoculars to look for emergent trees of the climbed tree within an area of about 300 m. When nest sightings are not reported for the nearby trees, the climber in the canopy plays begging calls of the species (11 sequences) with the use of speakers, for around 30 min, to attract individuals or stimulate them to call.

RESULTS

Sightings and feathers

In the last 27 years there have been 25 different Harpy Eagle records including sightings ($n = 23$) and feathers ($n = 2$) at the RNV (Table 1). The records include a juvenile Harpy Eagle founded dead in 1997 about 500 m from the northern edge of the RNV (Figure 1). This specimen is deposited at the Elias Lorenzutti Museum in Linhares, Espírito Santo state (MEL120). Harpy Eagles reuse the same tree for breeding in successive reproductions (Rettig 1978), but there have been no other records of any juvenile at RNV since. Three records of successful predation on two mammal species: Sloth and Capuchin Monkey (Table 1).

Nests

Two Harpy Eagle breeding areas were identified at the RNV (Table 1). In September 2010, the PCGR protocol was conducted at the RNV at five points (Boleira, Oiticica, Gávea, Flamengo and Macanaíba-pele-de-sapo Roads), corresponding to the locations where Harpy

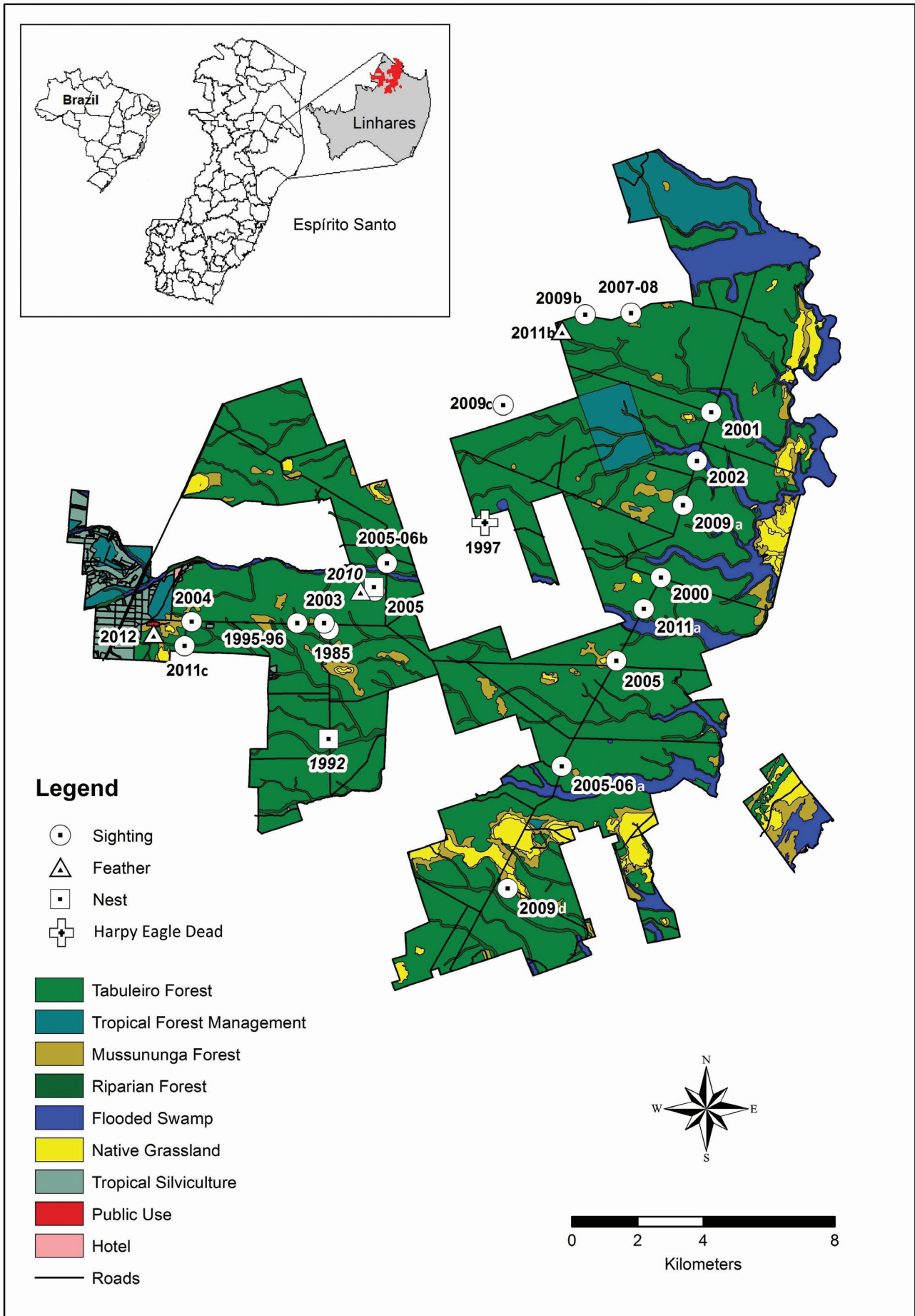


FIGURE 1. Vegetation map of the RNV, Espírito Santo state, Brazil, showing the locations of Harpy Eagle records obtained in the last 27 years, including Nest 1 (1992 at Macanaíba-pele-de-sapo Road) and the new nest record - Nest 2 (2010 at Oiticica Road).

Eagle records were obtained over the last 27 years (Figure 1, Table 1). Success was obtained by the find of the new Harpy Eagle nest (Nest 2) at Oiticica Road where, in 2005, A. C. S. sighted and photographed an adult male Harpy Eagle (Table 1) perched on a “farinha-seca” tree (*Pterygota brasiliensis* (Fr. All.) K. Schum. (Sterculiaceae), which was over 30 m high (Srbek-Araujo & Chiarello 2006). This tree was climbed by O. J. in September 2010 and, from the main fork, a nest was sighted about 130 m away. Feathers of the Harpy Eagle were collected below the tree where the tree climber saw the nest (Nest 2) in 2010, and probably may be from the adults of that nest (Nest 2). This record suggests that this nest existed since 2005.

The first Harpy Eagle nest was observed at RNV (Nest 1) in 1992 (Pacheco *et al.* 2003). It was found on the Macanaíba-pele-de-sapo Road, being built on the main fork, 30 m above ground, in a “jequitibá-rosa” (*Cariniana legalis* (Mart.) Kuntze 1898; Lecythidaceae) 36 m high and measuring 1.1 m in DBH (Table 2). Since its structure was lost and the same fork had not

been reused since 1994 (Table 1), it was not possible to measure the nest dimensions, only the fork that held it.

The second nest (Nest 2), found in 2010, was positioned on the main fork, 28 m above the forest floor, on an emergent “gonçalo-alves” tree (*Astronium concinnum* Schott ex Spreng., 1827; Anacardiaceae) 37 m high and measuring 1 m in DBH (Table 2). The nest measured 1.80 m X 1.60 m in diameter and 1.60 m in external height. It was built with thick sticks (the largest measuring 5 cm in circumference), and lined with dry leaves. Adult white downy feathers and recently dried leaves in the nest indicate that it was being used by adults.

Breast band feathers from Harpy Eagle adults were collected on the ground below the nest tree, as well as two fragmented vertebrae, a femur from a medium-sized mammal, and a pellet containing sloth nails and fur. The nest dimensions (Table 2), the feather, and prey remains confirm that it was a Harpy Eagle nest.

All trees mentioned above were identified in 2005 by G. S. based on comparisons with material at the RNV Herbarium.

TABLE 1. Description of Harpy Eagle records, feathers, nests and evidence of prey taken over the past 27 years at the RNV, Espírito Santo, Brazil.

Author(s)	Record description	Month / Year	Source
<i>Harpy Eagle sighting/photofeather</i>			
A. L. Peixoto & O. L. Peixoto	Photo of Harpy Eagle adult female found on Flamengo Road at Macanaíba-pele-de-sapo Road.	1/1985	Peixoto & Peixoto 1986
	Harpy Eagle preying on a sloth, perched 5 m above ground.	8/1992	Galetti <i>et al.</i> 1997
	Harpy Eagle perched 20 m above ground.	12/1992	Galetti <i>et al.</i> 1997
E. Costa	Sighted large bird flying and leaving a dead sloth with a hole on the back over a bunch of twigs on the Flamengo Road, nearby tower, old path.	1995-96	This study
Museu Elias Lorenzutti (MEL120)	João A. Rocha found on the forest floor a fledgling Harpy Eagle dead. Fazenda Santa Terezinha, at the edge of the RNV.	1997	This study
P. R. Paz	Sighted near intersection of the Gávea Road and Jequitibá Rosa Road.	2000	This study
J. C. Silva – RNV	Sighted adult perching on a tree. Gávea Road with Caingá Road intersection.	2001	This study
A. C. Santos – RNV	Sighted a Harpy Eagle on the Gávea Road near the Alberico stream.	2002	Pacheco <i>et al.</i> 2003
J. C. Silva – RNV	Sighted adult on the forest floor. Flamengo Road at the tower patio.	2003	This study
J. C. Silva, A. Hartuique & E. Silva – RNV	Sighted adult Harpy Eagle eating an individual Capuchin Monkey (<i>Sapajus robustus</i>) on the ground, where Flamengo Road meets the Roxinho Road.	2004	This study
D. Folli & M. Cruz – RNV	Sighted Harpy Eagle flying from the ground at the intersection of Gávea and Flamengo roads.	2005a	This study
A. C. S. – RNV	Photo of adult male Harpy Eagle on a “farinhaseca” tree (<i>Pterygota brasiliensis</i>) about 250 m inside the forest on Oiticica Road.	8/2005b	Srbek-Araujo & Chiarello 2006
E. Costa	Sighted Harpy Eagle adult perched on dead tall tree, on Gávea Road with Ipê Amarelo Road.	2005-06a	This study

E. Costa	Reported adult Harpy Eagle perched in a tree ca.40 m inside the forest at the intersection of Oiticica Road with Rancho Alto stream.	2005-06b	This study	
J. C. Gonçalves & P. P. Reis - RNV	Reported young Harpy Eagle on the ground, on the road at the border between RNV and Rebio Sooretama.	2007-08	This study	
A. Hartuique, J. S. Santos, A. S. Coutinho, Alan & Ectori - RNV	Adult Harpy Eagle photographed on a dry tree on the intersection of Gávea Road and the road that continues to the Tropical Forest Management plot.	3/2009a	This study	
A. C. S. - RNV	Adult Harpy Eagle adult vocalizing in the canopy, above a birdwatching group, on the border with the Rebio Sooretama.	7/2009b	This study	
J. Negrelli – Rebio Sooretama	Sighted a Harpy Eagle pair on the imbuia tree (<i>Ocotea porosa</i>) near Fazenda Santa Terezinha 500 m from border of the RNV.	2009c	This study	
G. S. - RNV	Sighted Harpy Eagle while accompanying Harri Lorenzi during botanical collections at the Boleira Road.	2009d	This study	
D. Folli, C. C. Silva & A. A. Cruz	Sighted Harpy Eagle eating a Capuchin Monkey (<i>Sapajus robustus</i>) on the floor of Gávea Road 1º T. A Harpy Eagle feather was collected.	2/2011a	This study	
Equipe Brigadistas Rebio Sooretama	Found a feather of the Harpy Eagle on the forest floor at Caingá Road on the border with the Rebio Sooretama.	6/2011b	This study	
G. S. - RNV	Reported adult between the Roxinho Road and Acero Ceolin.	8/2011c	This study	
K. T. Biancardi – RNV	Harpy Eagle feather found on the RNV environmental education trail.	6/2012	This study	
Harpy Eagle nests				
A. J. Batista - RNV	Nest branches on jequitibá-rosa (<i>Cariniana legalis</i>) of the Macanaíba-pele-de-sapo Road nest.	Nest 1	1992	This study
R. M. Jesus – RNV	Nest on the Macanaíba-pele-de-sapo Road.	Nest 1	1992-95	Galetti <i>et al.</i> 1997, Pacheco <i>et al.</i> 2003
J. C. Silva - RNV	Adult on the left side of the nest on the Macanaíba-pele-de-sapo Road, photographed by Bret M. Whitney.	Nest 1	Before 1994	This study
E. Costa - RNV	Adult in the nest on a jequitibá-rosa at the Macanaíba-pele-de-sapo Road.	Nest 1	Before 1994	This study
E. O. Willis (<i>pers. comm.</i>)	Nest branches on the nest tree at the Macanaíba-pele-de-sapo Road.	Nest 1	1995	-
E. Setz (<i>pers. comm.</i>)	Photo of the empty Harpy Eagle nest, partly undone on the jequitibá-rosa. Field notes include the Domingos Folli report “it was occupied until August of 1994”.	Nest 1	1/1995	-
B. M. Whitney (<i>pers. comm.</i>)	Absence of branches that used to form the nest on the main fork of the jequitibá-rosa (<i>Cariniana legalis</i>).	Nest 1	2001	-
T. M. S. (<i>pers. obs.</i>)	Absence of branches forming a nest on the main fork of the jequitibá-rosa (<i>Cariniana legalis</i>).	Nest 1	2004	-
F. H. A.-S., O. J. & A. Hartuique	Absence of branches forming a nest on the main fork of the jequitibá-rosa (<i>Cariniana legalis</i>).	Nest 1	2010	This study
F. H. A.-S., O. J., A. C. S & G. S.	New nest mapped on Oiticica Road. Harpy Eagle feather found 130 m away from the new nest.	Nest 2	9/2010	This study
L. Avelar & G. S. – RNV	Adult vocalizing near the nest tree, arriving and staying for few minutes on the nest. Oiticica Road.	Nest 2	3/2011	This study
A. B., J. N. Silva & R. C. Silva - PCGR	Adult on the nest.	Nest 2	2/2012	This study

TABLE 2. Dimensions of the trees with Harpy Eagle nest at the Reserva Natural Vale, Linhares, ES, Brazil. SH = shaft height, TTH = total tree height, DBH = diameter at breast height, NMB = number of main branches, D = diameter of the fork branches, B = branch (B1, B2 and B3 represent the number of each branch supporting the nest), DFB = distance between the fork branches. Dimension of the nests: LDN = largest diameter of the nest, SDN = smallest diameter of the nest, HNS = height of the nest structure, IDN = inner depth of nest, CTB = circumference of the thickest branch of the nest, nn = no nest.

Dimensions	Nest 1 (<i>Cariniana legalis</i>)		Nest 2 (<i>Astronium concinnum</i>)	
	Macanaíba-pele-de-sapo Road (m)		Oiticica Road (m)	
SH		30		28
TTH		36		37
DBH		1.1		1
NMB		1		1
D	B1	0.4		0.6
	B2	0.5		0.4
	B3	0.4		0.5
	B1-B2	1.6		0.8
DFB	B2-B3	1.3		0.9
	B1-B3	1.6		0.9
LDN		No nest		1.8
SDN		No nest		1.6
HNS		No nest		1.6
IDN		No nest		0.15
CTB		No nest		0.05

DISCUSSION

Harpy Eagles use large emergent trees to nest, which, in the Amazon, are on average 43.7 m high and 1.4 m in DBH; there, nests are positioned on average 32 m above ground (Luz 2005). The nests at RNV were built on slightly shorter emergent trees. The trees used by the eagles were 36 - 37 m high and 1 m in DBH, and nests were on average 29 m above ground. According to Peixoto *et al.* (1995), the dense lowland forest at RNV can be divided into arboreal, bush and herbaceous strata, with the canopy reaching an average of 24 m (19 - 31 m) height and being discontinuous, with emergent trees up to 40 m.

The last Harpy Eagle nests recorded in Espírito Santo were described by Ruschi (1979), who reported on three nests: one in Linhares, 1944, on a jequitibá-rosa tree (*Cariniana estrellensis*), one in Santa Teresa, in 1945, also on a jequitibá-rosa tree (*Cariniana legalis*) and one in São Gabriel da Palha, before 1946, on a sapucaia tree (*Lecythis urnigera*). Ruschi (1979) further reported that a Harpy Eagle nestling was collected in the Santa Teresa

nest and deposited in the Museu de Biologia Professor Mello Leitão (MBML 2098), Santa Teresa, Espírito Santo. However, this specimen was later re-identified as a Crowned Solitary Eagle *Urubitinga coronata* (Banhos & Sanaiotti 2011). Ruschi (1979) did not report on any other nestlings collected from the other remaining nests, so there is no way to confirm that they were really Harpy Eagle nests (Banhos & Sanaiotti 2011).

We believe that the Harpy Eagle nest (Nest 1) on the Macanaíba-pele-de-sapo Road has not been reused since the 1992-1995, and that the pair may have remained at the RNV, based on sightings and other records obtained by local collaborators at the RNV (Figure 1, Table 1).

Since 1985, there have been about 25 sight reports of Harpy Eagle at the RNV (Table 1). Most records took place along the Gávea Road, probably because it corresponds to the largest forest corridor for the species at the RNV, and also because it is an often used road during activities such as seed collection and forest management research (Figure 1). The new nest (Nest 2, at Oiticica Road) is about 5 km away from Nest 1 (at Macanaíba-pele-de-sapo Road), and at least 6 km away from the

region with the most sightings (Figure 1). We believe that the sightings on the Gávea Road are of another pair, based on the distance from the new active nest. We expect to confirm this hypothesis by searching for the nest from these records.

Inter-nests distances between active pairs were on average 3 to 5 km as reported in Venezuela and Panama by Álvarez (1994) and Álvarez-Cordero (1996) (n = 9 nests, 45 - 79 km² per pair; n = 6 nests, 10 - 20 km² per pair, respectively) and Vargas-González & Vargas (2011) (n = 25 nests, 16 km² per pair). Piana (2007) reported three active nests in the Peruvian Amazon that were 7.4 km from each other (43 km² per pair). In a protected area in the Brazilian Amazon, the average distance between active nests was 8 km (n = 6, range 5 km - 12 km) (Aguiar-Silva *et al.* 2011). Here, we provide for the first time the distance between two nearby breeding Harpy Eagle nests in the Atlantic Forest and, in conjunction with the total area of the RNV, estimate that this conservation unit harbors at least two Harpy Eagle pairs.

It is not possible to confirm whether nests 1 and 2 at RNV were used by the same pair, since no biological material was collected from the first nest (Nest 1). However, genetic material from feathers found in 2011 and 2012 are available to allow the analysis of individuals associated with Nest 2 (Table 1, Figure 1) and those sighted at Gávea Road, which may confirm the existence of a second pair at the study site. Also, with genetic analysis, we can clarify whether the Harpy Eagle juvenile found dead in 1997 came from Nest 2 or elsewhere.

Harpy Eagle records at RNV in Espírito Santo indicate that this reserve offers enough resources and has carrying capacity to maintain a Harpy Eagle population of reduced size. Evidenced by the records of sightings of the Harpy Eagle preying successfully sloths and monkeys, and prey remain found on the forest floor below new nest (Nest 2) (Table 1). Sloths are the main Harpy Eagle prey at the Brazilian Amazon forest (Aguiar-Silva 2007, Aguiar-Silva *et al.* in press).

Recently, Harpy Eagles have also been recorded at “Reserva Biológica Augusto Ruschi” (Rebio Augusto Ruschi; Novaes *et al.* 2010) a 3,598.41 ha protected area in the Brazilian Atlantic Forest in Espírito Santo. Together with the data reported here, both the RNV and the state of Espírito Santo as a whole constitute very important conservation areas for Harpy Eagle populations in the Brazilian Atlantic Forest.

We recommend the establishment of a reforestation program to increase the size and the connections of fragments around the RNV. We suggest that the creation and effective implementation of protected areas may contribute to the Harpy Eagle protection in the Brazilian Atlantic Forest, but the long-term conservation of remaining populations is an essential step to allow for the occupation and re-colonization of other areas.

Finally, the RNV and the Rebio Sooretama, together, protect species of great ecological importance that have become rare or extinct in other Atlantic Forest regions. Such groups of species include the Brazilian Harpy Eagle, and a range of large forest eagles, such as the Crested Eagle (*Morphnus guianensis*) and the Ornate Hawk-Eagle (*Spizaetus ornatus*), as well as their prey species.

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