

## BREEDING OF THE RUFIOUS-THIGHED HAWK (*ACCIPITER ERYTHRONEMIUS*) IN ARGENTINA AND BRAZIL

Sergio Hugo Seipke<sup>1</sup> & Gustavo Sebastián Cabanne<sup>2,3</sup>

<sup>1</sup>Calle 57 n 1230 A, La Plata 1900, Buenos Aires, Argentina.

<sup>2</sup>Departamento de Genética e Biología Evolutiva, Instituto de Biociências, Universidade de São Paulo, Rua do Matão 277, 05508–900, São Paulo, SP, Brazil.

**Resumen.** – Reproducción del Gavilán Sureño (*Accipiter erythronemius*) en Argentina y Brasil. – El Gavilán Sureño (*Accipiter erythronemius*) es una rapaz poco conocida que habita selvas, bosques y sabanas del este y sur de Brasil, Paraguay, este de Bolivia, norte y centro de Argentina y Uruguay. Estudiamos la biología reproductiva y los hábitos alimenticios de Gavilanes Sureños de Argentina y Brasil desde 1994 a 2007. Documentamos 14 intentos de reproducción registrados en ocho localidades y nueve sitios de anidamiento. Los gavilanes fueron residentes durante todo el año en las localidades de estudio. La temporada reproductiva duró c. 38 semanas (Junio a Marzo). Los comportamientos territoriales y de cortejo comenzaron en Junio y se observaron por aproximadamente 22 semanas. Observamos pichones en el nido durante Diciembre y el inicio de Enero, y volantones desde finales de Diciembre hasta finales de Marzo. La mayoría de los sitios de anidamiento estuvieron en bosques implantados [edad promedio 32,2 años (DS = 10), superficie promedio 12,6 ha (DS = 11,3)] cuyos árboles promediaban 37,5 cm (SD = 13,5) de diámetro a la altura del pecho. Los nidos fueron construidos en coníferas no emergentes (*Pinus* sp. o *Araucaria angustifolia*) a una altura media de 20,2 m (DS = 5,7). El diámetro a la altura del pecho de los árboles nido fue 44,5 cm (DS = 14). Los nidos fueron construidos con ramitas y tuvieron un diámetro mayor medio de 48,8 cm (DS = 11,4) y una profundidad media de 23,3 cm (DS = 14). Todas las presas (n = 49) fueron aves cuyos tamaños variaron desde c. 10 g [Ratona común (*Troglodytes aedon*)] a c. 140 g [Yerutí común (*Leptotila verreauxi*)]. Los volantones comenzaron a perseguir aves a los 42–45 días de edad a mediados de Enero. Los machos adultos se dedicaron principalmente a entregar comida, pero también fueron activos en la defensa contra otras rapaces. Las hembras adultas incubaron, cubrieron y alimentaron a los pichones y fueron activas en la defensa del sitio de anidamiento contra humanos. Los Gavilán Sureños construyeron nidos sin materiales de revestimiento. Estos nidos estaban situados alto en los árboles y la temporada de reproducción fue muy prolongada.

**Abstract.** – The Rufous-thighed Hawk (*Accipiter erythronemius*) is a poorly-known, small raptor that dwells in forests and wooded savannas in south and eastern Brazil, Paraguay, eastern Bolivia, north and central Argentina, and Uruguay. We studied breeding biology and food habits of the Rufous-thighed Hawk from 1994 to 2007. We documented 14 breeding attempts recorded at nine nest sites in eight localities in Argentina and Brazil. Rufous-thighed Hawks were year-round residents at the study areas. The breeding season was c. 38 weeks long (June through March). Territorial behavior and courtship spanned for 22 weeks starting in mid June. Nest-building started in August. Nestlings were observed throughout December and into early January while fledglings were observed from late December through late March. Most nest sites were conifer plantations averaging 32.2 (SD = 10) years old, 12.6 ha (SD = 11.3) in size with trees averaging

<sup>3</sup>Corresponding author: E-mail: gscabanne@yahoo.com

37.5 cm (SD = 13.5) of diameter at breast height. Nests were placed 20.2 m high (SD = 5.7), near the trunks of non-emergent conifers (*Pinus* sp. or *Araucaria angustifolia*). Nests were made of sticks, greater diameter averaging 48.8 cm (SD = 11.4), while nest depth averaged 23.3 cm (SD = 14). Prey items were birds (n = 49) ranging in size from c. 10 g [House Wren (*Troglodytes aedon*)] to c. 140 g [White-tipped Dove (*Leptotila verreauxi*)]. Young started to chase birds at the age of 42–45 days in mid January. Adult males were primarily food providers but also aided in nest defense against other raptors. Females incubated, brooded, and fed young, and took leading roles in defense against humans. Rufous-thighed Hawks had unlined nests placed high in trees, and breeding season was markedly protracted. *Accepted 15 September 2007.*

**Key words:** *Accipiter erythronemius*, Rufous-thighed Hawk, nest, nest site, prey, *Araucaria angustifolia*, breeding biology, Atlantic forest, Misiones, agroforestry.

## INTRODUCTION

The Rufous-thighed Hawk (*Accipiter erythronemius*) is a small Neotropical raptor that occurs from sea level to nearly 1000 m a.s.l. in dry to wet forests and wooded savannas of eastern Bolivia, east and southern Brazil, Paraguay, Uruguay, and northern to central Argentina (Brown & Amadon 1989, Bierregaard 1994, Ferguson-Lees & Christie 2001) (Fig. 1). Storer (1952) considered it a subspecies of the Sharp-shinned Hawk (*Accipiter striatus*). Remsen *et al.* (2007) regard the Rufous-thighed Hawk as a subspecies of the Sharp-shinned Hawk but acknowledge that the “split is almost certainly good”, stressing that no published data supports this splitting. However, Bierregaard (1994) treated it as a full species on grounds of “differences in morphology, ecology, and probably also behavior”.

Although five nests of the species are mentioned in the literature (Girard 1933, Luciano 1988, Oliveira 2001, Di Giacomo 2005), little is known about fundamental aspects of the natural history of this Neotropical raptor. Here we present data on nests and nest site characteristics, food habits, breeding behavior, and breeding chronology of the Rufous-thighed Hawk recorded from 14 breeding attempts in Brazil and Argentina

## METHODS

*Study localities.* We studied breeding attempts

of the Rufous-thighed Hawk from 1994 to 2007 in eight localities (Table 1 and Fig. 1). São Paulo state, Brazil, is in the Atlantic biogeographical province (Cabrera & Willink 1973) and, prior to deforestation and alteration by humans, study sites were covered by dense ombrophilla rainforest (Veloso 1991). Climate in the area is subtropical and somewhat seasonal, with a wet season from mid November to March. The landscape at São Roque consisted of a mosaic of native secondary forest (about 50% of forest coverage), sugar cane plantations, small plantations of exotic *Pinus* sp. and *Eucalyptus* sp., grasslands for cattle ranching and fruit farms. The study site at São Paulo city was a mixed-species (native and exotic) forest within an urban area.

Misiones, Argentina, is within the Paranaense biogeographical province (Cabrera & Willink 1973) and a semideciduous forest originally covered this study area. The climate is subtropical without a dry season. Study areas showed a mosaic pattern of woodlands and farmlands. Main vegetation types were plantations of *Pinus* sp. and indigenous *Araucaria angustifolia* (hereafter Araucaria), native forests accompanying water streams, *Ilex paraguariensis* and *Citrus* sp. plantations, and recent clear-cuts.

Most of Buenos Aires province is included in the Pampeana biogeographical province, and extensive grasslands and steppes once covered this area (Cabrera &

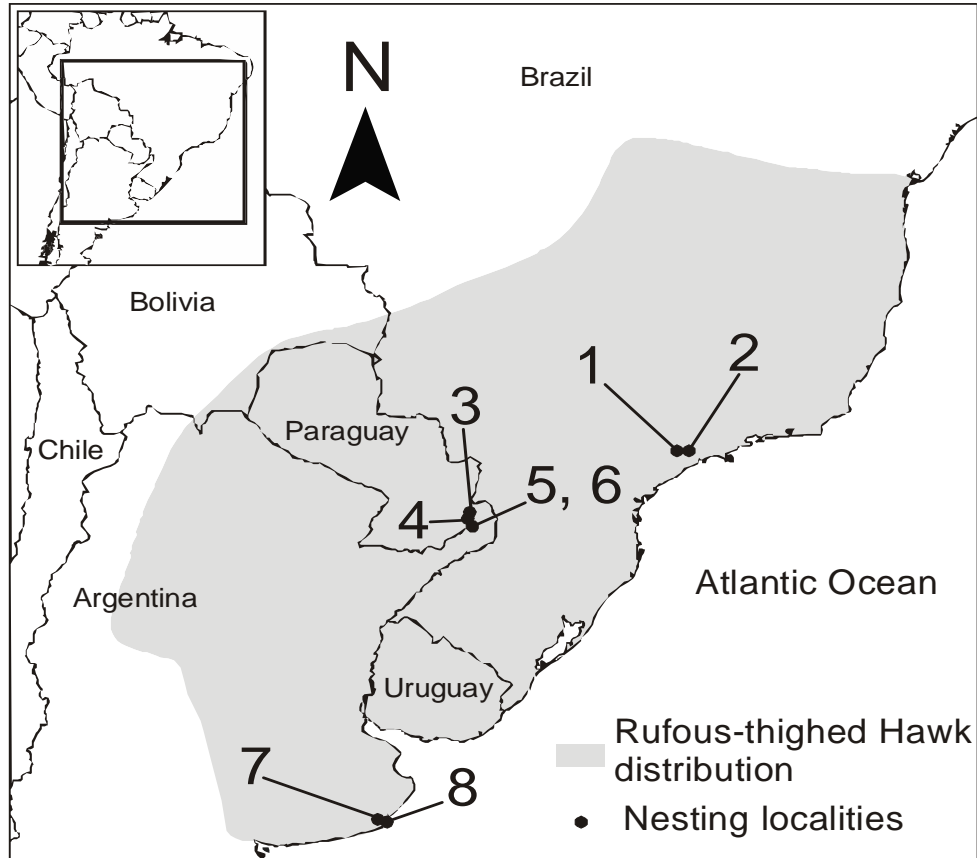


FIG. 1. Range of the Rufous-thighed Hawk (modified from Ferguson-Lees & Christie 2001) and breeding localities studied from 1994 to 2007 in Argentina and Brazil: (1) São Roque, (2) São Paulo city, (3) Puerto Esperanza, (4) Colonia Delicia, (5) Eldorado Km 6, (6) Eldorado Km 9, (7) Laguna de Los Padres, and (8) Mar del Plata city.

Willink 1973). Original vegetation is almost totally modified with patches of grasslands interspersed with stands of *Eucalyptus* sp. and exotic conifers and urban centers dominated the landscape. Climate in the region is temperate without a dry season.

*Field methods.* Nest sites were identified during avian surveys made by us ( $n = 3$ ) or from communication with local people living in the area ( $n = 2$ ) or were discovered as a result of specific searches of Rufous-thighed Hawk

nests in Araucaria plantations ( $n = 4$ ). For these searches, GSC systematically looked for occupied nest sites from October to January. In Puerto Esperanza and Colonia Delicia, the observer walked (11.5 km) parallel transects laid every 170 m within Araucaria stands for nine days, from 07:00 to 10:30 h. Since fledgling Rufous-thighed Hawks are noisy, the observer made listening stops every 200 m (10 min each, 48 listening points). These surveys resulted in seven detections of Rufous-thighed Hawks (three detections of

TABLE 1. Localities, study periods, and number of fledglings recorded at Rufous-thighed Hawk breeding attempts from 1994 to 2007 in Argentina and Brazil.

Localities, coordinates and altitude	Breeding attempts (year)	Study period (day/month/year)	No. of fledglings
1) São Roque, São Paulo, Brazil. 23°32'S, 47°09'W, 960 m.	2003	07/09/03 to 04/04/04	2
	2004	12/12/04 to 26/01/05	0*
2) São Paulo city, São Paulo. 23°33'S, 46°44'W, 765 m. **	2003	17/08/03 to 28/05/04	1
	2004	28/05/04 to 03/02/05	3
	2006	12/06/06 to 01/04/07	2
3) Puerto Esperanza, Misiones, Argentina. 26°01'S, 54°36'W, 230 m.	2001	07/01/02 to 17/01/02	2
	2001	07/01/02 to 17/01/02	2
4) Colonia Delicia, Misiones. 26°12'S, 54°35'W, 210 m.	2001	07/01/02 to 17/01/02	3
5) Eldorado Km 6, Misiones. 26°26'S, 54°38'W, 200 m.	1993	03/01/94 to 30/01/94	3
	1995	01/01/94 to 30/01/94	3
	1997	01/01/98 to 30/01/98	3
6) Eldorado Km 9. 26°22'S, 54°36'W, 173 m.	2006	07/10/06 to 11/01/07	unknown
7) Laguna de Los Padres, Buenos Aires, Argentina. 37°57'S, 57°44'W, 40 m.	2000	01/01/01 to 30/03/01	3
		01/01/01 to 30/03/01	3
8) Mar del Plata, Buenos Aires. 38°05'S, 57°34'W, 50 m.	2000***	01/01/01 to 30/03/01	3

\*Nest failed at the nestling phase.

\*\*São Paulo nest site was active in 2005 but no observations were made then.

\*\*\*Nest reported by Oliveira (2001).

fledglings) and in three nest sites. In Eldorado (year 2006), GSC looked for flying and advertising birds and played recordings of calls of Rufous-thighed Hawks at the edge of Araucaria stands to elicit response of otherwise undetected territorial adults. Each breeding attempt was identified according to its locality and the year at which the breeding activities started.

We made opportunistic observations between 06:00 and 19:00 h totalizing 195 h of effort, observing the birds through binoculars (8x and 10x) and spotting scopes (20 to 60x) and taking photographs, and recorded surrounding vegetation at the sites. Since most of the nests were difficult to reach to take measurements, we estimated their dimensions taking the female as a reference. In the course of our investigation, others logged the nest-tree at Colonia Delicia and at Mar del Plata, thus

we recovered the entire nest to record its make up and looked for prey remains. The breeding attempt at Mar del Plata was reported by Oliveira (2001), but here we present additional original information on this event.

We collected prey remains (bones and feathers) from breeding sites (including two entire nests) and recorded prey delivered by adults at all nest sites. Prey remains were determined by comparison with specimens deposited at the Museo de la Plata, and at the Museo de Zoología da Universidade de São Paulo. We assigned prey to the following size categories: (a) wren-sized (c. 10 g), (b) tanager-sized (c. 25 g) and (c) thrush-sized (c. 55 g).

We established the breeding chronology of the species as whole by pooling data of all attempts across years and sites. Following

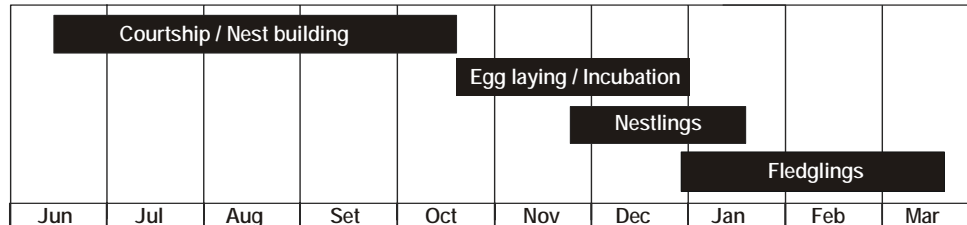


FIG. 2. Breeding chronology of the Rufous-thighed Hawk studied in Argentina and Brazil from 1994 to 2007. Beginning and end of the nestling period was inferred from development of nestlings following Rust (1914).

Delannoy & Cruz (1988), we considered territorial displays those flights that ended in encounters between resident birds and intruders. The nest building stage was defined as the period when the birds added material to the nest but none of the adults remained on it. Egg-laying/incubation was assumed when the female (i.e., appreciably larger bird with slightly lower-pitched voice) remained in the nest but no young was actually seen or fed. The nestling stage was defined between the earliest and latest dates we observed young before fledging. The post-fledgling stage was from the first time we saw the young fly to the last time we saw them around the site, usually wandering >300 m away from the nest, but still begging for food or chasing the adults.

## RESULTS

*Seasonal movements.* We did not find evidence of seasonal movements in this species. We observed Rufous-thighed Hawks in the breeding areas throughout the year in Misiones and in São Paulo. A single individual was observed in August (austral winter) in Laguna de los Padres, Buenos Aires province, Argentina (L. Leveau pers. com.). We also observed hawks in May and June (austral autumn and winter) in Chaco and Catamarca provinces in Argentina.

*Breeding season.* Altogether, including courtship,

the breeding season of the species spanned nearly 38 weeks, from June through March, but egg-laying through dispersal of young only spanned for 20 weeks, from mid-October to late March (Table 1 and Fig. 2).

*Courtship and territoriality.* We observed hawks at nest sites as early as 12 June, and as late as 25 March (Table 1 and Fig. 2). Courtship was observed between June and August (austral winter), and consisted of high altitude (200–500 m) undulating flights, chases, vigorous flapping flights, pair or trios flying together, and perched pairs vocalizing around nest sites. Courtship activities, typically display flights, lasted as much as 5 min at a time. On three occasions we observed males showing obvious territorial behavior. They flew aggressively towards conspecifics while vocalizing, chased and harassed them, and eventually escorted them out of the proximity of the nest site. In contrast with courtship activities, these events lasted less than 30 s. On one occasion we observed two birds soaring together, then one diving at the other, and finally touching feet; a third bird was nearby. All three birds showed their white under-tail feathers widely flared.

*Nest sites, nest trees and nests.* We documented 14 breeding attempts of the Rufous-thighed Hawk at nine nest sites. Sixty-six percent ( $n = 6$ ) of the nest sites were in single species

TABLE 2. Characteristics of nine nest sites of Rufous-thighed Hawks from 1994 to 2007 in Brazil and Argentina.

Localities	Stand age (years)	Stand size (ha)	Average DBH (cm)	Dominant trees	Surrounding vegetation
1) São Roque	31	1.5	25.2	<i>Pinus taeda</i>	<i>Pinus</i> sp., secondary forest, open fields, farmlands
2) São Paulo	> 30*	20	27.3	Broad leaved species	Araucaria, secondary forest, <i>Pinus</i> sp., <i>Eucalyptus</i> sp.
3) Puerto Esperanza A	22	18	31.5	Araucaria	<i>Pinus</i> sp., secondary forest
4) Puerto Esperanza B	20	32	31.6	Araucaria	Araucaria, <i>Pinus</i> sp., secondary forest and a clear-cut
5) Colonia Delicia	39	18.7	46	Araucaria	<i>Pinus</i> sp., <i>Citrus</i> sp., secondary forest
6) Eldorado Km 6	28	2	34	Araucaria	<i>Ilex paraguariensis</i> , <i>Eucalyptus</i> sp., <i>Musa paradisiaca</i>
7) Eldorado Km 9	30	8	37.6	Araucaria	<i>Pinus</i> sp. and Araucaria plantations, clear-cuts and native forest
8) Laguna de Los Padres	40	-	-	-	<i>Pinus</i> sp., <i>Eucalyptus</i> sp., <i>Cupressus</i> sp.
9) Mar del Plata	50	0.5	67	<i>Pinus</i> sp.	<i>Eucalyptus</i> sp., <i>Pinus</i> sp., <i>Casuarina</i> sp., <i>Acacia</i> sp.
Average (SD)	32.2 (10)	12.6 (11.3)	37.5 (13.5)	-	-

\*Not considered for calculation of average stand age.

stands; Araucaria plantations in Misiones, and a stand of *Pinus taeda* at São Roque (Table 2). The remaining three sites were in mixed-species stands with a high proportion of *Pinus* sp. or Araucaria, and within urban habitat. Stand age of all sites averaged 32.2 years, and most trees within the stands were not mature. Average stand size was 12.6 ha ( $n = 8$ ,  $SD = 11.3$ ) and average diameter at breast height (DBH) was 37.5 cm ( $n = 8$ ,  $SD = 13.5$ ). Except for secondary forest patches (in Misiones and São Roque), most vegetation surrounding nest sites were planted exotic species (Table 2). Two sites (São Roque and Laguna de Los Padres) were next to fresh water lagoons. The Mar del Plata nest site was in a 0.5 ha stand 30 m from a house.

All nest trees were living conifers and seven out of nine were the dominant tree species in the stand (Table 2 and 3). In São

Roque 2004, birds chose *Pinus taeda* for nesting when Araucarias were available but a similar though inactive nest was found in a nearby Araucaria (different nest of São Roque 2003). In São Paulo 2006, between 8 August and 28 August, the hawks were observed constructing a nest that was abandoned afterwards (Table 3). DBHs of nest trees were similar to the average in the respective stands (Tables 2 and 3). Nest trees were near the edges of the stands or at the edge themselves.

We found nine nests, all made of dry sticks forming a platform. Nest size varied considerably, from rather small (Eldorado) to quite massive (São Roque 2004 and Mar del Plata) (see Table 3 for measurements). Nest were placed in the upper 1/10 of the nest tree (except in São Roque 2004, where it was placed in the upper 1/4 of the tree), by the

TABLE 3. Nest tree and nest characteristics of nine breeding attempts of Rufous-thighed Hawks from 1994 to 2007 in Argentina and Brazil.

Breeding attempts (year)	Species	Nest trees			Nests		
		Height (m)	DBH (cm)	Distance to nearest edge (m)	Height (m)	Diameter (cm)	Depth (cm)
1) São Roque (2003)	<i>Araucaria</i>	12	30	0	11	40 x 45	15
2) São Roque (2004)	<i>Pinus taeda</i>	30	45	10	26	35 x 55	50
3) São Paulo* (2006)	<i>Pinus</i> sp.	25	40	50	21	-	-
4) Puerto Esperanza A (2001)	<i>Araucaria</i>	16	30	50	15.5	40	25
5) Colonia Delicia (2001)	<i>Araucaria</i>	26.5	45	43	22.4	41	-
6) Eldorado Km 6 (1993)	<i>Araucaria</i>	14	30	25	13	40 x 45	10
7) Eldorado Km 9 (2006)	<i>Araucaria</i>	28	49	40	27.5	45 x 35	20
8) Laguna de Los Padres (2000)	<i>Pinus</i> sp.	25	61	-	22.5	60 x 65	-
9) Mar del Plata (2000)	<i>Pinus pinaster</i> **	24.5	70	10	23	50 x 65	20
Average		22.3	44.5	28.5	20.2	48.8***	23.3
(SD)		(6.5)	(14)	(20)	(5.7)	(11.4)	(14)

\*Nest was abandoned before construction was completed. The definitive nest at São Paulo 2006 was not found.

\*\*From Oliveira (2001).

\*\*\*Average was calculated using greater diameter.

tree trunk, and supported by two or three mostly level branches that started at the same height. In *Araucaria*, all nests ( $n = 5$ ) were built near the top of the tree (Fig. 3). Of 466 pieces of material from the Mar del Plata nest, 67% ( $n = 312$ ) were dry sticks, 15% ( $n = 70$ ) were *Eucalyptus* sp. bark stripes, 15% ( $n = 70$ ) were leaves included in the mass of the structure and strands of artificial fibers, acacia filoids, and dry *Eucalyptus* sp. fruits accounted for 3% ( $n = 14$ ). Average diameter of sticks was 3.7 mm ( $n = 312$ , SD = 3.6 mm), while average length was 15.9 cm ( $n = 312$ , SD = 7.5 cm). Fifty-five percent of the sticks ( $n = 172$ ) were Gymnosperms and 45% ( $n = 140$ ) Angiosperms (mainly *Eucalyptus*). We analyzed two nests placed on *Araucarias* (Colonia Delicia and Eldorado 1993) and found no sticks or leaves of *Araucaria* on them. We found that Rufous-thighed Hawks did not line their nests ( $n = 3$ ) with leaves or other greenery.

*Prey.* We recorded 49 prey items through direct observation of prey delivered ( $n = 30$ ) at nest sites, and prey remains ( $n = 19$ ); all were birds (Table 4). We identified 11 individuals belonging to the following species: White-tipped Dove (*Leptotila verreauxi*),  $n = 1$ ; Picui Ground-dove (*Columbina picui*),  $n = 1$ ; Ruddy Ground-dove (*Columbina talpacoti*),  $n = 1$ ; Tropical Kingbird (*Tyrannus melancholicus*),  $n = 1$ ; House Wren (*Troglodytes aedon*),  $n = 1$ ; Rufous-bellied Trush (*Turdus rufiventris*),  $n = 1$ ; Sayaca Tanager (*Thraupis sayaca*),  $n = 2$ ; Rufous-collared Sparrow (*Zonotrichia capensis*),  $n = 1$ ; Saffron Finch (*Sicalis flaveola*),  $n = 1$ ; and Shiny Cowbird (*Molothrus bonariensis*),  $n = 1$ . The remaining 38 prey items were not identified. Four prey delivered to nests were nestling birds. Distribution of sizes of prey indicated by prey-remains collected, and that of prey items observed directly differed significantly (Mann-Whitney Test,  $Z = -2.98$ ,  $P < 0.01$ , Table 4).



FIG. 3. Location of Rufous-thighed Hawks' nests in Araucaria trees (*Araucaria angustifolia*) indicated by a white circle. All nests in Araucaria trees were placed in the same location: by the trunk and near to top (left). Branches radiating from the trunk at the same height provided a stable foundation for the nest.

TABLE 4. Size distribution of prey of Rufous-thighed Hawk in Brazil and Argentina from 1994 to 2007.

Size classes	Frequency		Total
	Prey remains	Direct observation	
Wren (c. 10 g)	4	19	23
Tanager (c. 25 g)	8	10	18
Thrush (c. 50 g)	7	1	8
Total	19	30	49

*Behavior of the adults at nest sites.* Most behavioral observations were made from two breeding attempts at São Roque (60 h of focal observation) but the behavioral patterns described here were verified in other localities. During the incubation and early nestling periods at São Roque, male and female Rufous-thighed Hawks behaved differently. The males spent 15% ( $n = 9$  h) of the time perching on an exposed dead snag, usually early morning

(06:00 to 09:00 h), and 15% ( $n = 9$  h) of the time perching on a branch within the canopy. Other activities such as territory defense involved 5% ( $n = 3$  h) of the time. Males spent 63% ( $n = 37.8$  h) of their time out of sight, presumably hunting or resting. We did not observe males eating at the nest sites. Males visited the nest rarely and only for a few seconds. Males did not incubate. Females spent 74.5% ( $n = 44.7$  h) of their time on the nest, an additional 16% ( $n = 9.6$  h) perching on an exposed perch (usually, the same one used by the male), 1% ( $n = 0.6$  h) of the time perching unobtrusively within the nest stand, 2% ( $n = 1.2$  h) eating, 4% ( $n = 2.4$  h) feeding nestlings, and 2% ( $n = 1.2$  h) involved in other activities.

*Hunting and feeding behavior.* Adults were observed in pursuit of prey near or away (>100 m) from nest sites ( $n = 4$  times). Hunting also took place in urban habitat. Attacks were performed from concealed perches and



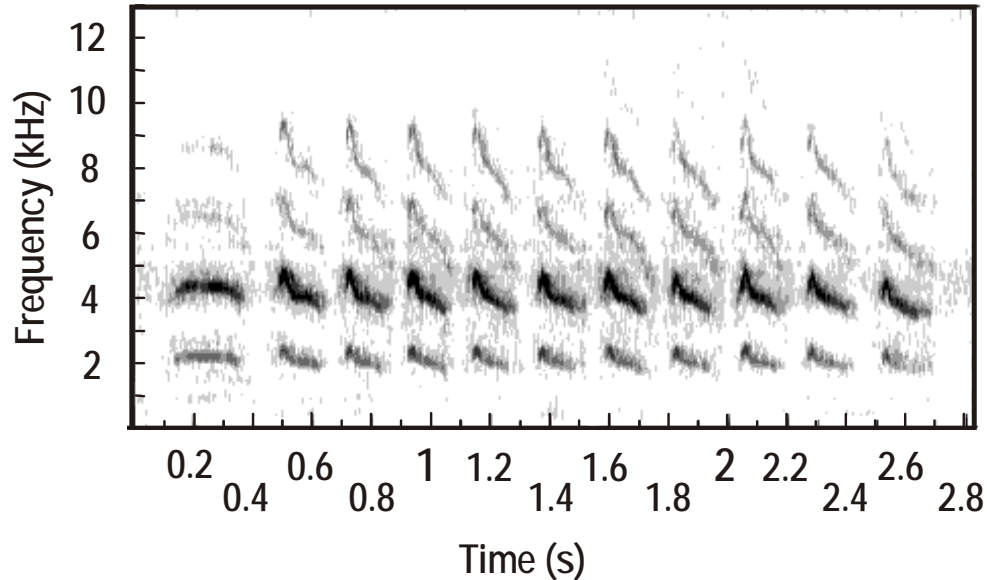


FIG. 4. Representative sonogram of a chattering call of an adult female Rufous-thighed Hawk recorded in São Roque (2003), São Paulo state, Brazil.

consisted of surprise pursuits of prey. Birds attacked by adults included individuals or flocks of Picui Ground-doves, Sayaca Tanagers, Blue-black Grassquits (*Volatinia jacarina*), *Sicalis* sp., and Rufous-collared Sparrows. In São Roque, an adult male flew from a hidden perch, crossed swiftly a lagoon 80 m wide and flew low, close to the water surface, to attack a group of passerines on the ground on the opposite side. Another male was followed away from the nest and was observed hunting within an 800-m radius from the nest site. This bird hunted in secondary forests and stands of fruit trees.

Food was delivered mainly within a radius of 50 m of the nest ( $n = 30$  deliveries). In São Roque, males delivered prey ( $n = 20$ ) unevenly throughout the day; 40% ( $n = 8$ ) in early morning (06:00–9:00 h), 35% ( $n = 7$ ) in late morning (09:01–12:00 h), and 25% ( $n = 5$ ) in the afternoon (12:01–18:00 h). Males vocalized a soft and rapid chattering call, typically “*teee-teee-teee*”, when they delivered prey to the

nest site. Females responded to this call, usually giving a similar (Fig. 4) or a wailing call: a monosyllabic or disyllabic “*wbeeee*”. This last call was also given during food exchanges between male and female. Voices of males were higher pitched than those of females. Prey were eaten, and less frequently also plucked, in medium-height or high, hidden branches of both conifers and broad-leaved trees, usually closer than 50 m from the nest ( $n = 23$ ). Most of the time males delivered prey already plucked; only females fed offspring at nests ( $n = 10$ ).

*Nest site defense.* Breeding hawks defended the nest site against both humans and other raptors. Some of the breeding birds were very aggressive and vocalized loudly when observers approached the nest at 20–30 m, especially during the incubation and early nestling stages. Females started the attacks that consisted of sudden flights from a perch ( $n = 11$ ), vocalizing and aiming at the head of the

observer, but without striking. Defensive vocalizations were of the chanting type (Fig. 4), but notes were louder and uttered slower. These calls were also given when birds defended their nest site against other raptors.

In 132 h of nest observation at Eldorado, Esperanza, São Roque and São Paulo, we observed adults chasing away 13 hawks that flew within 500 m of the nest site. Raptor species pursued included Rufous-thighed Hawk ( $n = 2$ ), Harris's Hawk (*Parabuteo unicinctus*,  $n = 2$ ), Crested Caracara (*Caracara plancus*,  $n = 5$ ), Aplomado Falcon (*Falco femoralis*,  $n = 2$ ) and two unidentified raptors. Turkey Vultures (*Cathartes aura*), Roadside Hawks (*Buteo magnirostris*), Crane Hawks (*Geranoospiza caerulescens*), Black Hawk-Eagles (*Spizaetus tyrannus*) and Short-tailed Hawks (*Buteo brachyurus*) were tolerated within the vicinity of the nest site ( $< 100$  m).

*Behavior of young.* Fledglings perched at canopies of the nest site, usually less than 30 m from one another, and not far from the nest tree or even at nest tree. At 5–6 weeks old fledglings moved and wandered more than 200 m from the nest. Young vocalized frequently during the early and mid-morning hours but only occasionally during the rest of the day. The main vocalization consisted of the wailing-type calls which were similar to those of females, but repeated many times up to 4 min (food-beggings). They also emitted the chattering-type contact call (see above). This last type turned into frenetic vocalization when adults visited the nest site to deliver food.

We observed a young female ( $n = 16$  contacts) in São Roque that started hunting at 42–45 days old (11 and 12 January). The bird ranged away from the nest site ( $< 250$  m) over a semi-open area chasing several species of birds; and one week later, it ranged 500 m away from the nest. This bird emitted a loud

wailing call every time it chased other birds. This chasing behavior was also observed at the São Paulo 2006 site. Species chased were: Picazuro Pigeon (*Columba picazuro*),  $n = 1$  chase; Gilded Hummingbird (*Hylocharis chrysurus*),  $n = 1$ ; Field Flicker (*Colaptes campestris*),  $n = 13$ ; Great Kiskadee (*Pitangus sulphuratus*),  $n = 1$ ; Blue-and-white Swallow (*Notiochelidon cyanoleuca*),  $n = 1$ ; and Bananaquit (*Coereba flaveola*),  $n = 1$ . All chases observed were unsuccessful in prey capture.

*Unusual behaviors.* In São Roque we observed a possible dissuasive behavior. On two occasions, after having attacked the observer, an adult female flew away from the nesting stand into the open and landed on the ground (a road) 40 m away from the nest. She partially opened her tail and wings and remained motionless. The second time we witnessed this behavior, an adult male joined the female on the ground. After about one minute, the female returned to the nest.

On two occasions, fledglings showed an unusual behavior in presence of the observers. On one occasion a juvenile was observed lying on a branch of a tree for 3 min, its tail fanned, and its wings partially opened and drooped; and another time, a fledgling glided down and landed on the ground, fanned its tail and wings like it was “mantling” a prey, and stayed there allowing the observers to approach closely. No prey was observed when the bird took off.

## DISCUSSION

We studied 14 breeding attempts of Rufous-thighed Hawks from eight localities of Brazil and Argentina accounting for a large portion of the geographical and altitudinal range of the species. Caution should be taken, however, in extrapolating our results to unaltered habitats because our observations were limited to anthropogenic landscapes.

*Seasonal movements.* While several authors regard the Rufous-thighed Hawk as a migratory species, at least in part of its range (see Di Giacomo 2005 and references therein), we observed hawks year round throughout northern Argentina and southeastern Brazil. This suggests the geographical pattern of the migration of the species would be quite complex, some populations being resident and others partially or locally migrants. More research is needed to clarify this.

*Breeding season.* We estimated that the breeding season of the Rufous-thighed Hawk spanned c. 38 weeks (Fig. 2). This is a long period for the size of the bird when compared to the Sharp-Shinned Hawk in North America (Platt 1976, Reynolds & Wight 1978), the Eurasian Sparrowhawk (*A. nisus*) (Cramp & Simmons 1980), or the subtropical Puerto Rican Sharp-Shinned Hawk (*A. striatus venator*) (Delannoy & Cruz 1988).

Raptors in tropical areas tend to have protracted breeding seasons compared to their counterparts in temperate regions (Newton 1979). This is the result of either a long breeding window, i.e., individual breeding attempts are somewhat asynchronous (de Vries 1975, Mader 1982), or of elongation of individual stages of the breeding cycle (Thorstrom & Quixchán 2000, Thorstrom *et al.* 2000a, Thorstrom *et al.* 2000b), or both. We estimated that courtship and nest-building (i.e., pre-laying phases of the breeding cycle) lasted nearly four months in the Rufous-thighed Hawk. The duration of the pre-laying period in Sharp-shinned Hawks in North America is only one month (Platt 1976, Reynolds & Wight 1978, Jones 1979), and nearly three months in Puerto Rico (Delannoy & Cruz 1988). The incubation period in Rufous-thighed Hawks in São Roque was 35 days; similar to Puerto Rican Sharp-shinned Hawks (Delannoy & Cruz 1988) and continental populations of Sharp-Shinned Hawks (Platt

1976, Reynolds & Wight 1978), suggesting that developmental stages in all three taxa are of similar duration. Egg-laying and incubation occurred during a 70-day period in Rufous-thighed Hawks with a degree of individual variation between breeding attempts. In total, the protracted breeding season observed in Rufous-thighed Hawks was due to a longer breeding window (different females laid eggs at different times) and a protracted pre-laying phase.

*Courtship and territoriality.* Territorial encounters were of short duration and spanned throughout the breeding season. Display flights lasted longer, took place between late June and August, and most likely served as territoriality and courtship. These flight behaviors were like those reported for the Puerto Rican Sharp-shinned Hawk (Delannoy & Cruz 1988) and the Eurasian Sparrowhawk (Cramp & Simmons 1980). The Rufous-thighed Hawk was highly aerial at the beginning of the breeding season like other accipiters, but unlike the Bicolored Hawk that rarely, if ever, performs aerial displays (Thorstrom & Quixchán 2000).

*Nest sites, nest trees, and nest characteristics.* Rufous-thighed Hawks were similar to other related hawks such as Sharp-shinned Hawks or Eurasian Sparrowhawks in terms of nest, nest tree and nest site characteristics (Platt 1976, Cramp & Simmons 1980).

In our study, Rufous-thighed Hawks nested in mid aged, monospecific stands of conifers, but less frequently in mixed-species groves. Open fields, clear-cuts, and roads were frequent near nest sites. Rufous-thighed Hawks bred three times at the Eldorado Km 6 site, once every other year during a 5-year period despite trees in the stand (including the first nest-tree in 1993) were cut after the first breeding event, and sites in Brazil were re-used in consecutive years (Table 1), up to four

times in São Paulo, showing fidelity to nest sites.

Nest trees were within 50 m from the nearest stand edge. This fact should be taken into account when looking for Rufous-thighed Hawk nests. Nest trees were non-emergent and typical of the stand, as suggests the comparison of nest-tree DBHs to respective stand DBHs. All nest trees were conifers despite the availability of broad-leaved trees at the sites. Platt (1976) pointed out that conifers have denser foliage than broad-leaved trees, and suggested that was the likely reason Sharp-shinned Hawks nested in them. Where available, even if in low numbers, Rufous-thighed Hawks almost invariably choose Araucaria trees to nest in. Several factors may attribute to placement of Rufous-thighed Hawk nests in Araucarias: (a) the top of these trees are very dense making platforms difficult to detect, (b) the upperparts of the trunks bear thorn-like leaflets with the tips oriented downwards making climbing difficult, (c) trees older than 20 years lack branches in most of the lower part of the trunk (Fig. 3), (d) trees other than the nest tree usually have variable amounts of sticks stacked in the upper branches forming platform-like structures that would confuse potential predators, and (e) nearly horizontal branches radiating from the trunk at the same height provide a stable foundation for nests.

Rufous-thighed Hawks we studied placed their nests higher up in trees (12–30 m) compared to Sharp-shinned Hawks (2–18 m, Jones 1979) or Eurasian Sparrowhawks (6–12 m, Cramp & Simmons 1980), but Luciano (1988) reported on one Rufous-thighed Hawk nest at 6–7 m high and Di Giacomo (2005) reported on two nests at 8.5 and 10 m. Nests we studied were inconspicuously placed next to the trunk and close to the top of the nest tree. While other authors found weeds and flowers (Luciano 1988) or lichens (Di Giacomo 2005) lining the nests, we found no lin-

ing materials. The variation of nest diameter we recorded does not encompass the smaller nests reported by Luciano (1988; 23 x 30 cm) and Di Giacomo (2005; c. 25 cm). Nest depth varied by 500%, perhaps a consequence of nest reuse.

*Prey.* Rufous-thighed Hawks preyed mostly on small to medium-sized birds during the breeding season, as do other small long-toed accipiters. We identified 10 prey species from seven avian families, suggesting a diversified diet of birds.

Sampling procedures are important in studying raptor food habits. Large bones decay slower and are less frequently swallowed than smaller bones, thus studying diet based on prey remains alone creates a bias towards larger prey items (Marti 1987). Collopy (1983) found no statistical difference in taxonomic composition of the diet of Golden Eagles (*Aquila chrysaetos*) assessed either through direct observation or collection of prey remains, but the prey remains method underestimated biomass consumed. In our sample, size-of-prey distributions of prey remains and prey individuals observed directly were different suggesting that each method would estimate a different average prey mass. We observed more prey items delivered at nest sites but species identification was often impossible, whereas prey remains recovered from nests and nest sites were readily identifiable to species level. Future studies of the diet of Rufous-thighed Hawk should include both collecting prey remains and observing prey deliveries at nest sites.

*Number of fledglings.* We observed up to three fledglings per breeding attempt and 58% of these attempts produced three fledglings (Table 1). Di Giacomo (2005) describes two nests of Rufous-thighed Hawks containing three eggs each, and Oliveira (2001) found

three juveniles on the nest in Mar del Plata. This suggests that the maximum number of fledglings per breeding attempt is three; the same for Puerto Rican Sharp-Shinned Hawks (Delannoy & Cruz 1988), whereas Sharp-Shinned Hawks in North America (Reynolds & Wight 1978) and Eurasian Sparrowhawks (Cramp & Simmons 1980) can produce four or more fledglings per breeding attempt.

*Behavior of the adults at nest sites.* Adult males and females behaved differently near nest sites. Adult males perched on the same exposed branches consistently when females were eating or feeding the young, typically closer than 30 m from the nest tree; but perched unobtrusively when females were on the nest. When the male was out of sight, the female usually was on the nest or on an exposed perch. Females only perched unobtrusively when the male was nearby. Thus, at any given time either one or no birds were on an exposed perch. This would make the breeding site less obvious to predators while maximizing surveillance efficiency by the adults. After young fledged, adults were rarely seen at the nest site and only visited the area to deliver food to their offspring, leaving the area immediately.

*Hunting and feeding behavior.* Rufous-thighed Hawks hunted in a variety of habitats including secondary forest, fruit tree plantations and urban grounds showing adaptability to anthropogenic habitats. Adult males hunted but never fed the young, whereas adult females did not hunt during incubation or the nestling period (but hunt after young fledged) and fed the young.

*Nest site defense.* One raptor out of four was chased away from the nest site when it approached within 500 m. The species least tolerated were known bird predators; for instance, Crested Caracaras often rob nests

(Ferguson-Lees & Christie 2001). Both sexes took part in nest defense. Males often had a leading role against other raptors, and they always led attacks at conspecifics, but females were more defensive against humans.

*Behavior of the young.* Juveniles remained in the vicinity of the nest site for the first 2–3 weeks after fledging and vocalized frequently during early to mid morning. This made breeding sites easier to locate. While observing one juvenile alone could or could not indicate the presence of a nest, observation of two or more juveniles together was a reliable indicator of a nest within 100 m.

*Unusual behaviors.* Two adult hawks responded to human presence by landing on bare ground with fanned tails and wings. We think this behavior was dissuasive: a behavior to lure potential, terrestrial predators away from the nest. One juvenile stayed on a branch with open wings and tail. Thorstrom *et al.* (2000b) reported that several nestling Barred Forest-falcons feigned death in presence of researchers. The young we observed could have been feigning death, but most likely were sunning themselves.

*The role of planted woodlands.* Rufous-thighed Hawks seem to favor plantations of Araucaria for breeding in Misiones, and other available conifers elsewhere. Moreover, trees were also chosen for plucking and eating prey, and for roosting. Rufous-thighed Hawks may show habitat preferences for nesting as Jones (1979) states for other accipiters. The preferred habitat for breeding in is conifer plantations when available. This preference, the predation on open-area birds, and observations of hawks hunting in urban areas suggest that Rufous-thighed Hawks are fairly tolerable to anthropogenic habitat. In Misiones, however, the landscape is currently changing from an agroforestry mosaic with remnants of native forest

interspersed with small stands of *Araucaria* to extensive single-species exotic *Pinus* sp. plantations. Habitat heterogeneity, safe nest sites, and suitable food supply are required for Rufous-thighed Hawks to breed successfully, but extensive *Pinus* plantations seem to lack these features.

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#### REFERENCES

- Bierregaard, R. O., Jr. 1994. Rufous-thighed Hawk *Accipiter erythronemius*. Pp. 159 in del Hoyo, J., A. Elliot, and J. Sargatal (eds.). Handbook of the birds of the world. Volume 2. New world vultures to guineafowl. Lynx Edicions, Barcelona, Spain.
- Brown, L., & D. Amadon. 1989. Eagles, hawks and falcons of the world. The Wellfleet Press, Secaucus, New Jersey.
- Cabrera, A. L., & A. Willink. 1973. Biogeografía de América Latina. Monografía N° 13. OEA, Washington D.C.
- Collopy, M. W. 1983. A comparison of direct observation and collections of prey remains in determining the diet of Golden Eagles. *J. Wildl. Manage.* 47: 360–368.
- Cramp, S., & K. E. L. Simmons. 1980. The birds of the Western Palearctic. Volume 2. Oxford Univ. Press, New York, New York.
- de Vries, T. 1975. Breeding biology of the Galapagos Hawk, *Buteo galapagoensis*. *Gerfaut* 65: 29–58.
- Delannoy, C. A., & A. Cruz. 1988. Breeding biology of the Puerto Rican Sharp-Shinned Hawk (*Accipiter striatus venator*). *Auk* 105: 649–662.
- Di Giacomo, A. G. 2005. *Accipiter erythronemius*. Pp. 242–243 in Di Giacomo, A. G., & S. F., Krapovickas (eds.). Historia natural y paisaje de la Reserva El Bagual, Provincia de Formosa, Argentina. Inventario de la fauna de vertebrados y de la flora vascular de un área protegida del Chaco Húmedo. Temas de Naturaleza y Conservación, Monografía de Aves Argentinas 4, Aves Argentinas/Asociación Ornitológica del Plata, Buenos Aires, Argentina.
- Ferguson-Lees, J., & D. A. Christie. 2001. Raptors of the world. Houghton Mifflin, New York, New York.
- Girard, P. 1933. Notas sobre algunas aves de Tucumán. *Hornero* 5: 223–225.
- Jones, S. 1979. The accipiters: Goshawk, Cooper's hawk, Sharp-shinned hawk. Unpubl. report. BLM Contract No. YA-530-PH9-159. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Science Laboratory, Missoula, Montana.
- Luciano, D. 1988. Observaciones sobre un nido de Azor Común *Accipiter striatus*. *Garganchillo* 5: 10.
- Mader, W. J. 1982. Ecology and breeding habits of the Savanna Hawk in the llanos of Venezuela. *Condor* 84: 261–271.
- Marti, C. D. 1987. Raptor food habits studies. Pp. 67–80 in Giron Pendelton, B. A., B. A. Millsap,

- K. W. Cline, & D. M. Bird (eds.). Raptor management techniques manual. National Wildlife Federation. Washington, D.C.
- Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermilion, South Dakota.
- Olveira, L. 2001. Esparvero Común (*Accipiter erythronemius*) en Mar del Plata, provincia de Buenos Aires, Argentina. *Nuestras Aves* 41: 34.
- Platt, J. B. 1976. Sharp-shinned Hawk nesting and nest site selection in Utah. *Condor*. 78: 102–103.
- Remsen, J. V., Jr., A. Jaramillo, M. Nores, J. F. Pacheco, M. B. Robbins, T. S. Schulenberg, F. G. Stiles, J. M. C. da Silva, D. F. Stotz, & K. J. Zimmer. 2007. A classification of the bird species of South America. Available from: <http://www.museum.lsu.edu/~Remsen/SACCBaseline.html> (April 2007).
- Reynolds, R. T., & H. M. Wight. 1978. Distribution, density, and productivity of the accipiter hawks breeding in Oregon. *Wilson Bull.* 90: 182–196.
- Rust, H. J. 1914. Some notes on the nesting of the Sharp-shinned Hawk. *Condor* 16: 14–24.
- Storer, R. W. 1952. Variation in the resident Sharp-shinned Hawks of Mexico. *Condor* 54: 283–298.
- Thorstrom, R., & A. Quixchán. 2000. Breeding biology and nest site characteristics of the Bicolored Hawk in Guatemala. *Wilson Bull.* 112: 195–202.
- Thorstrom, R., J. D. Ramos, & C. M. Morales. 2000a. Breeding biology of the Barred Forest-Falcons (*Micrastur ruficollis*) in northeastern Guatemala. *Auk* 117: 781–786.
- Thorstrom, R., J. D. Ramos, & J. M. Castillo. 2000b. Breeding biology and behavior of the Collared Forest-Falcon (*Micrastur seimitorquatus*) in Guatemala. *Ornitol. Neotrop.* 11: 1–12.
- Veloso, H. P. 1991. Classificação da vegetação brasileira, adaptada a um sistema universal. Fundação Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, Brazil.

