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Nesting territory characteristics of a migratory South American forest hawk, the White-throated Hawk (*Buteo albigula*) (Aves: Accipitridae), in temperate rainforest remnants of Araucanía, southern Chile

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During four successive breeding periods (2007–11) we characterized the nesting territories of the white-throated hawk (*Buteo albigula*) in southern Chile. Territories were located in mountainous areas with mature native forest ($n = 17$) or mature pine plantations ($n = 1$). Most of the territories were distant from urban centres (>2 km). Only one or two adult hawks and one young per pair/year were observed in each territory. All nest sites were located in the upper parts of ravines. Nests were built on large, living mature trees. Platforms were bulky (>50 cm diameter) and oval or round. Eggs were white and subelliptical in shape (40.0 × 50.0 mm). Hawk pairs reproduced asynchronically extending the reproductive period for 6 months. Although some white-throated hawk pairs were tolerant of human-modified habitats, it is possible that decline in forest cover represents a potential threat for the population viability of this migratory forest hawk.

Keywords: white-throated hawk; *Buteo albigula*; forest-specialist hawks; migratory hawks; pine plantations

Introduction

The loss of old-growth forest is considered to be the most serious threat to the Chilean forest biota (Fuentes 1994; Willson et al. 1994; Armesto et al. 1996; Echeverría et al. 2006), including to several species of raptors that rely on forests (Jaksic and Jiménez 1986; Stotz et al. 1996; Trejo, Figueroa et al. 2006). Even though the population viability of forest raptors depends strongly on the protection of old-growth forest remnants, knowledge of their natural history is pivotal to better guide their conservation. However, their secretive behaviour, low population densities, extensive movements and the complexity of their habitat make forest raptors difficult to study and, consequently, most of them are poorly known.

The white-throated hawk (*Buteo albigula*) is the only long-distance migratory forest raptor in South America. The species is distributed along the Andes from Venezuela and Colombia, where it winters, to central and southern Chile and southwestern Argentina, where it breeds (Casas and Gelain 1995; Pavez 2000; Trejo et al. 2007).

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In Chile, the white-throated hawk has been recorded mainly in Andean localities (Pavez 2000, 2007, Figueroa et al. 2001, 2002, Alvarado and Figueroa 2005), but its presence was recently confirmed in an extensive area of the coastal mountain range (Silva-Rodríguez et al. 2008). The white-throated hawk is considered a rare species, and its population size has supposedly been declining as a result of the increasing forest loss (Jaksic and Jiménez 1986; Jaksic et al. 2001). Because of this, the species has legal protection (Ley de Caza No. 19.473; República de Chile 1996) and some authors have proposed that it be considered for maximum priority of conservation (Pincheira-Ulbrich et al. 2008).

Although the white-throated hawk was described a century ago (Philippi 1899; Goodall et al. 1951), its natural history and ecology have only recently begun to be known (see Trejo, Figueroa et al. 2006). Despite the fact that Chile represents the largest breeding area of this hawk species, very little is known about the reproduction of the Chilean population (Goodall et al. 1951; Pavez et al. 2004). Here we summarize information collected during 5 years about nesting territories of the white-throated hawk in Araucanía, southern Chile. Our aims were to (i) identify and characterize the nesting territories, (ii) describe the nesting sites, nests, eggs and young, and (iii) describe the reproductive phenology.

Material and methods

Our study was conducted during four successive breeding periods from September 2007 through to April 2011 in Araucanía, southern Chile. The Araucanía region extends from the Maule province (35°24′ S, 71°43′ W) to Reloncaví gulf (41°28′ S, 72°54′ W) and is characterized vegetationally by having a high diversity of forest types (Donoso 1993; Hoffmann 1998). The study area encompassed three orographic zones: (i) coastal mountain range, (ii) central valley, and (iii) Andean mountain range. The coastal mountain range is differentiated from the Andean mountain range by its greater geological age, lower elevations (<1600 m above sea level), and less slanted slopes (Mardones 2005).

On the coast, our field surveys were undertaken in the periphery of the city of Concepción (36°50′ S, 73°02′ W), vicinities of the city of Valdivia (39°49′ S, 73°13′ W) and Nahuelbuta mountain (37°49′ S, 73°00′ W). In the central valley, field surveys were conducted on Adencul hill (38°14′ S, 72°31′ W), near the town of Victoria. In the Andean range, field surveys were conducted between Tolhuaca National Park (38°19′ S, 71°39′ W) and Villarrica volcano (39°21′ S, 71°56′ W). In some cases, the information was complemented with observations made occasionally during 2006 and with observations provided by other researchers.

Our identification of a nesting territory was based on the definition from Newton and Marquiss (1982) and Steenhof and Newton (2007). Hence, a nesting territory was the area that contained at least one nest within the home range of a mated pair, and where no more than one pair was known to have bred for at least one season. However, when we could not find the nest, the presence of young (nestlings or fledglings) or adult hawks transporting food to young was considered as evidence of nesting. Factors that prevented us from finding nests were the restricted visibility, complexity of the terrain and density of the forest.

Preliminary field surveys to detect potential nesting territories were made by visiting areas that we suspected had breeding pairs according to direct or indirect signs (e.g. adults carrying prey or nest material, vocalizations, aerial displays, feathers, droppings). Occasionally, we found territories based on information provided by local villagers familiar with the species. In addition, by using satellite images (e.g. www.earth.google.es) we marked out potential nesting territories using as criteria the existence of adequate conditions for nesting. Such conditions included a set of variables of the vegetation cover, topography and land use (Tables 1 and 2), which were derived from our successful findings of nesting territories and from information reported by other authors (Gelain et al. 2001; Trejo et al. 2004; Pavez et al. 2004).

To confirm the reproductive activity in suspected nesting territories we established vantage points located at the feet of hills or midway up the slope in sites with little vegetation and with direct views of forest remnants. Observations were conducted from sunrise to sunset (08:00–20:00 h) using binoculars (10 × 50, 8 × 32–50) and/or spotting scopes (20–60 ×).

Within each territory, we recorded the number of adult hawks and the number of young produced per pair/year during the monitoring time. Adult hawks were identified on the basis of patterns in plumage coloration; when possible we recognized hawks by distinctive natural markings (e.g. damaged wing or tail feathers). In several territories we were able to visually follow flying hawks (Altmann 1974; Lehner 1996) and mark off the maximum distances that they reached in their movements from the nest site. However, because we observed unmarked hawks, the size of the nesting territories was not estimated.

Each nesting territory was characterized physiognomically by range of elevation (m above sea level), habitat types (e.g. forest, field, tree plantation), forest types (e.g. evergreen, deciduous, coniferous) and size of forest remnants (hectares) where the reproductive activity occurred. In addition, we estimated the linear distance (km) from the nest sites to the margin of urban centres.

Within a nesting territory, a nest site was defined as the exact place where a hawk pair established their nesting platform or, when nests could not be found, where fledgling young showed the greatest activity (Reynolds et al. 1982; Reynolds 1983). Because we could not thoroughly inspect all the nest sites that were found, the area around each nest site was described by arbitrarily establishing a radial distance of approximately 100 m taking as central point the nest tree or tree where the fledged young had greatest activity. Nest sites were qualitatively characterized according to the following variables: (i) elevation at the point of the nest tree, (ii) cardinal orientation, (iii) topographic location of nest trees, i.e. if ravine, flatland or hilltop, (iv) size in area of the forest patch where the nest was located, (v) habitat types of the forest patch, (vi) successional stage of the forest patch, (vii) minimum linear distance from the nest tree to the nearest stream or body of water, (viii) minimum linear distance from the nest tree to the nearest open area, and (ix) minimum linear distance from the nest tree to the nearest human activity site (Rivas-Fuenzalida et al. 2011). Elevations, cardinal orientation, size of forest patches and distances were all derived from scaled satellite images (www.earth.google.es) and expressed in conventional metric units (Table 2). Topographic locations, habitat types and successional stages were directly measured in the field.

Nest trees and nesting platforms were characterized according to previous studies (Trejo et al. 2001, 2004; Figueroa et al. 2007; Rivas-Fuenzalida et al. 2011). Each tree was described according to species, height (in m) and trunk diameter at breast height (cm). Logistical limitations meant that we could only climb to three platforms.

However, as all the located platforms were visible from some point near the nest tree, it was possible to estimate for all of them the height above the ground (i.e. distance between the tree base and the lower edge of the platform), their location inside the crown, and their shape and composition (i.e. building material). When the nest trees were climbed, the tree height and height to the platforms were measured in plumb-line distance to ground level by using climbing ropes, which were later measured. When the nest trees could not be ascended, tree and platform height were derived from triangulation by using a home-made clinometer based on recreative geometry (Perelman 2003). The morphometrics of the nesting platforms were measured based on the minimum and maximun diameter of platform, depth of the platform and depth of nest cup (in cm).

Because we could not monitor each nesting territory constantly, it was not possible to determine the exact date and length of each reproductive stage. However, we made a rough estimation of the reproductive phenology based on dates recorded during our visits to the territories. We recognized the following reproductive stages: courtship, incubation and brood rearing.

Results

During our study we identified 18 territories with nests or young (Table 1). In 21 other localities we observed breeding attempts (e.g. courtship or nuptial displays) and/or territorial defence (e.g. chasing off intruders), but because the presence of nests or young could not be determined, they were not included in our analysis. In nesting territories that were periodically monitored ($n = 8$), the hawks concentrated their movements within a radius of <2 km of nest trees, reaching maximum distances of almost 3.5 km. Only one or two breeding adult hawks and one young per pair/year were observed in each territory during the whole period of monitoring (Table 1).

All the nesting territories were located in mountainous terrains with water courses that ranged from small streams to large rivers. The elevation of the nesting territories was highly variable, reaching the greatest elevations in the Andes mountains (Table 1). All the territories had native forest remnants, this being the vegetation type that was spatially dominant in almost all the cases (Table 1). Only in one nesting territory was a non-commercial Monterey pine (*Pinus radiata*) plantation the dominant vegetation. In many nesting territories the forest remnants were surrounded by agricultural fields or commercial pine plantations (Table 1). The forest remnants within the nesting territories were continuous or fragmented and included three types of forests in different combinations: mixed deciduous forest, evergreen forest and coniferous forest (Table 1).

The remnants of mixed deciduous forest included emerging individuals of southern beeches (*Nothofagus obliqua*, *Nothofagus alpina* and *Nothofagus dombeyi*) accompanied by a high diversity of other tree species (*Laureliopsis philippiana*, *Laurelia sempervirens*, *Persea lingue*, *Eucryphia cordifolia*, *Aextoxicon punctatum*, *Gevuina avellana*, *Aristotelia chilensis*) in the storey immediately underneath. However, due to differences in topography, microclimate and human use, the dominant tree species varied among territories. Remnants of evergreen forest included a high diversity of plant species and plant layers; the overstorey was mainly composed of *Eucryphia cordifolia*, *Laureliopsis philippiana*, *Aextoxicon punctatum* and *Weinmannia trichosperma*, sometimes with emerging individuals of *Nothofagus dombeyi*. Common species in the subcanopy were *Drimys winteri*, *Caldcluvia paniculata*, *Podocarpus saligna*,

Table 1. Characteristics of White-throated hawk (*Buteo albigula*) nesting territories in Araucanía, southern Chile.

Territory	Zone	LOC	ALT	HAB*	FORT* †	SREM	DURB	NIND	YMON
Caracol hill	Cm (C)	36°50′ S, 73°02′ W	20–220	Pp	–	250	0.2	2ad	2011
Nonguén	Cm (C)	36°54′ S, 73°00′ W	40–420	F	De	2000	1.63	2ad, 1 y	2007–12
Trongol Alto	Cm (N)	37°42′ S, 73°06′ W	740–1380	F, Pp	De, Ev	>3000	17.5	2ad	2008–10
San Alfonso	Cm (N)	37°43′ S, 73°09′ W	450–1100	F, Af	De, Ar	>3000	13.4	2ad, 1y	2009–11
San Román	Cm (N)	37°42′ S, 73°16′ W	150–810	F	De	>3000	10.6	2ad	2009
Huilquehue	Cm (N)	37°52′ S, 73°18′ W	30–450	F, Af	De	510	7.6	2ad	2010–11
El Natri	Cm (N)	37°53′ S, 73°16′ W	10–540	F, Af	De	330	8.4	2ad, 4y	2006–11
San Ernesto	Cm (N)	37°54′ S, 73°14′ W	50–600	F	De, Ev	520	10.7	2ad, 1y	2008–11
Licahue	Cm (N)	37°58′ S, 73°14′ W	10–570	F, Af	De, Ev	620	4.4	2ad, 2y	2009–11
Contulmo	Cm (N)	38°01′ S, 73°12′ W	80–530	F	De, Ev	470	2.5	2ad, 2y	2009–11
Quitaqui II	Cm (V)	39°41′ S, 73°17′ W	10–700	F, Af	Ev	>3000	15.4	2ad, 1y	2010
Cutipay II	Cm (V)	39°49′ S, 73°19′ W	0–210	F, Af	De, Ev	620	6.3	2ad	2009–11
Cutipay III	Cm (V)	39°50′ S, 73°19′ W	0–210	F, Af	De, Ev	620	5.6	2ad, 2y	2009–11
Sta. Elvira	Cm (V)	39°47′ S, 73°09′ W	0–370	F, Af	De	950	2.5	2ad, 1y	2010–11
Buenaventura hill	Cm (V)	39°48′ S, 73°08′ W	0–420	F, Af	De, Ev	>3000	4.4	2ad, 1y	2010–11
Llancahue	Cm (V)	39°51′ S, 73°09′ W	0–340	F, Af	De, Ev	>3000	2.9	2ad, 2y	2009–11
Las Raíces	Am	38°33′ S, 71°29′ W	980–1600	F, Af	De, Ar	>3000	26.4	1ad, 1y	2009
Conguillío I	Am	38°37′ S, 71°41′ W	1180–1700	F, Af	De, Ar	>3000	26.9	2ad	2009

*Order in the Table indicates the plant cover extent in a decreasing importance.
†Follow classification of Donoso (1993).
Zone: Cm = coastal mountain range (C = Concepción, N = Nahuelbuta, V = Valdivia), Am = Andean mountain range; LOC = geographic location (south, west); ALT = altitude (m a.s.l.); HAB = habitat type: F = native forest, Pp = pine plantation, Af = agricultural fields; FORT = native forest type: Ev = evergreen Valdivian forest, De = mixed deciduous forest, Ar = Araucaria forest; SREM = size of forest remnants where breeding activity was observed (ha); DURB = linear distance from the centre of the nesting territory to the border of the nearest urban site (km); NIND = number of adult (ad) and young (y) resident hawks recorded during the monitoring time; YMON = years in which monitoring was conducted.

Podocarpus nubigenus, *Cryptocarya alba*, *Amomyrtus meli* and *Amomyrtus luma*. The remnants of coniferous forest were composed of *Araucaria araucana* associated mainly with *Nothofagus dombeyi* and *Nothofagus pumilio*. Other accompanying tree species were *Nothofagus antarctica*, *Nothofagus alpina*, *Drimys winteri*, *Aristotelia chilensis*, *Embothrium coccineum* and *Rhaphithamnus spinosus.* In all cases, the understorey was dominated by austral bamboo (*Chusquea* spp.) accompanied by ferns (*Blechnum* spp., *Hymenophyllum* spp., *Lophosoria* spp.) and various immature tree species that varied in composition according to forest type. The forest remnants within each nesting territory showed different degrees of succession, but constituted mainly old-growth (>200 years) and secondary growth (100–200 years; *sensu* Martínez and Jaksic 1996) forests. Overall, these remnants were multilayered with values of canopy coverage >50%. The size of forest remnants where breeding activity was concentrated varied widely among territories, but most of these remnants were relatively extensive (>1000 ha, Table 1). Except for nesting territory in the Caracol Hill (Table 1), all remaining territories tended to be distant from urban centres (mean ± SD 9.8 ± 7.8 km; range 2.5–26.9 km).

The elevation of the nest sites varied (mean ± SD 287 ± 120.7 m above sea level; $n = 9$; Table 2). The cardinal direction of nest sites also varied, but most of them were oriented to the southwest. All the sites were established in the upper third of slopes of ravines. Seven sites were established within relatively extensive forest remnants (>300 ha) and one site was established within a stand of mature Monterey pine located on the periphery of the city of Concepción (Caracol hill; Table 2). At all nest sites, the forest was at an advanced successional stage with multilayered vegetation, closed canopy (>50%) and evident presence of standing dead trees. The latter were

Table 2. Characteristics of White-throated hawk (*Buteo albigula*) nest sites in Araucanía, southern Chile.

Sites	ALT	CO	SREM*	FORT*†	SUCC†	LNEST	DWC	DOA	DHUM
Caracol hill	190	NE	250	Pp	Pma	Rav (s)	30	0.5	0.5
Nonguén	350	SE	2000	De	Sec	Rav (s)	20	0.2	1.5
El Natri	370	SW	330	De	Sec, Old	Rav (s)	40	1.3	1.1
San Ernesto	417	SW	520	De, Ev	Old, Sec	Rav (s)	10	0.9	1.7
Licahue	450	SW	620	De, Ev	Sec, Old	Rav (s)	30	0.7	0.8
Contulmo	340	SW	470	De, Ev	Old, Sec	Rav (s)	5	0.9	1.1
Cutipay III	150	NW	620	De, Ev	Old	Rav (s)	5	1.0	1.1
Buenaventura hill	220	NW	>3000	De	Old, Sec	Rav (s)	40	0.4	0.6
Llancahue	160	SE	>3000	De, Ev	Sec, Old	Rav (s)	5	0.8	0.7

*Note that information is the same as included in Table 1.
†Order in the Table indicates the plant cover extent in a decreasing importance.
Zones and geographical locations are detailed in Table 1. ALT = altitude (m a.s.l.), CO = cardinal orientation; SREM = size of forest remnants where nests were located (ha); FORT = forest type: De = deciduous forest, Ev = evergreen forest, Pp = pine plantation; SUCC = successional stage of the forest remnants where hawks reproduced: Old = old growth forest, Sec = secondary growth, Pma = mature pine plantation; LNEST = location of the nest: Rav = ravine (*s* = upper third); DWC = linear distance from the nest tree to the nearest water course (m); DOA = linear distance from the nest tree to the closest open area (km); DHUM = linear distance from the nest tree to the closest site of human activity (km).

used as roosts and platforms for mating. The nest site found in the pine plantation had a multilayered structure with very large old pines (>40 years in age, 35–40 m tall, and almost 1 m in diameter at breast height). These pines were accompanied by adult individuals of eucalyptus (*Eucalyptus* spp.), Monterey cypress (*Cupressus macrocarpa*) and Australian acacia (*Acacia melanoxylon*). The subcanopy was composed of diverse species of native trees and shrubs. Overall, the white-throated hawk pairs established their nest sites very close to water courses (linear distance: mean ± SD 20.6 ± 15.7 m; range 5–40 m; $n = 9$), and relatively far from open areas (linear distance: mean ± SD 0.8 ± 0.3 km; range 0.4–1.3 km; $n = 9$) and from rural sites with human activity or residences (linear distance: mean ± SD 0.95 ± 0.4 km; range 0.5–1.7 km; $n = 9$; Table 2).

The white-throated hawk pairs constructed their platforms in trees of several different species (Table 3). All the platforms were placed ≥ 15 m above the ground on forked branches of large, living mature trees (Table 3). The nesting platforms were visually bulky and oval or round in shape. The morphometric variables of the three measured platforms (Llancahue, Buenaventura Hill and Cutipay III) had the following values: diameter 77 ± 5.6 by 57 ± 4.6 cm (mean ± SD; ranges 71–82 cm in length, 52–61 cm in width), outer depth 52.7 ± 2.5 cm (range 50–55 cm), and depth of the nest cup 5.0 ± 0.5 cm (range 4.5–5.6 cm). In Cerro Buenaventura, the supporting branches had a thickness of 16.4 ± 7.1 cm (mean ± SD; range 10–26 cm; $n = 5$). The trunk diameter immediately under the platform reached 40, 38 and 30 cm in Llancahue, Buenaventura Hill and Cutipay III, respectively. In all the cases, the building material consisted of small dry and green twigs and sticks of native trees (*Nothofagus dombeyi*, *Eucryphia cordifolia*, *Laurelia sempervirens*) and shrubs (e.g. *Chusquea* spp.). The nest structure was strongly interlaced and reinforced internally with lichens and small green and dry leaves. Among leaves, those from aromatic plants (*Laurelia sempervirens*) predominated. In addition, in the inner part of nest cups we found some pellets and prey remains (bones and feathers).

Eggs could only be described in two nests. A fresh egg was found in Llancahue and an unhatched egg was found in Buenaventura after the nest was abandoned. The outer surface of both eggs was white, but the egg from Llancahue had some spots of dirty pale yellowish brown (Figure 1). Both eggs were subelliptical and similar in size measuring 51.5 × 40.5 mm and 47.0 × 40.0 mm, respectively. The recently hatched young from Llancahue had white down all over its body. After 1 month the young had feathers emerging, but still retained white down on most of its body. The sides of the breast were covered with chestnut brown feathers arranged in longitudinal stripes. The upper side of the wings and part of the back were covered with dark brown feathers. The borders of its ears had small blackish feathers. The wing and tail feathers were still developing.

According to our records, the breeding period spanned almost 6 months with all breeding pairs staying in their territories from September or October (early spring) to April (early autumn). After winter, hawks were observed in Nahuelbuta and Valdivia nearly 2 weeks apart. In Nahuelbuta, we observed the first white-throated hawks on 13 September (late winter) and in Valdivia on 6 October (early spring). In Nahuelbuta, however, most of the hawk pairs apparently returned to their territories during the last week of September (early spring). Courtship began immediately after the hawks reoccupied their territories and was maintained until late November (late spring). However,

Table 3. Characteristics of white-throated hawk (*Buteo albigula*) nest trees and nesting platforms in Araucanía, southern Chile.

Site	Nest tree			Nesting platform			
	Species	Height (m)	DBH* (m)	Nest height† (m)	Position inside the tree crown	Shape	Composition‡
Caracol hill	*Cupressus macrocarpa*	25	0.93	23	At the bottom	Oval	B, Lv
Nonguén	*Nothofagus obliqua*	20	0.47	18	At the bottom	Oval	B, Lv
El Natri	*Nothofagus dombeyi*	27	0.86	25	At the bottom	Oval	B, Lv, Re
San Ernesto	*Laurelia sempervirens*	30	1.05	28	At the bottom	Round	B, Lv, Li, Re
Licahue	*Nothofagus obliqua*	25	0.87	17	At the centre	Round	B, Lv, Re
Contulmo	*Nothofagus obliqua*	28	0.84	23	At the centre	Round	B, Lv, Li
Cutipay III	*Nothofagus dombeyi*	29	0.95	27	At the bottom	Oval	B, Lv, Li, Re
Buenaventura hill	*Laurelia sempervirens*	30	0.94	27	At the upper	Oval	B
Llancahue	*Laurelia sempervirens*	16	1.28	15	At the upper	Oval	B, Lv, Li, Rp

*DBH = diameter at breast height.
†Distance between ground at the tree base and the lower border of the platform.
‡B = long branches, Li = lichens, Lv = leaves, Bk = bark, Rp = remains of prey (bones and feathers).

Figure 1. white-throated hawk (*Buteo albigula*) egg (A) and 31-day-old nestling (B) found on one nesting platform in Llancahue, Valdivia, southern Chile.

one pair kept mating until mid-December (early summer). Courtship activity was evidenced by nuptial flights, repeated calls to mates and copulations. During the entire period of courtship the females concentrated their movements within a radius <1 km around the nest tree. Incubation extended from mid or late November until mid or late December (late spring to early summer). Brood rearing period lasted from mid or late December until early or mid February (early to mid summer). Overall, in Nahuelbuta the nestlings fledged between the last days of January and the first days of February (mid summer). In contrast, in Valdivia all nestlings fledged between the second and third weeks of February. In the latter locality, the last record of a young hawk was 4 April (early autumn).

Discussion

Before our study, Silva-Rodríguez et al. (2008) documented a number of records of the white-throated hawk all along the coastal mountain range of Chile, and suggested that some sites could constitute breeding territories. Our records corroborate the existence of a reproductive population in this mountainous zone. Our observations of only one or two adult hawks and one young per pair/year within each breeding territory in Araucanía agrees with the pattern found by Gelain et al. (2001) in southwestern Argentina. Hence, results from Chile and Argentina suggest that the white-throated hawk is a monogamous species with a very low reproductive rate.

All nesting territories identified in our study were located in mountainous terrain covered with well-developed forests which is consistent with observations made in other localities of Chile and Argentina (Figueroa et al. 2001; Gelain et al. 2001; Pavez et al. 2004). It is possible that white-throated hawks prefer mountainous areas to establish their nesting territories, but their choice of terrain could be the result of the scarce availability of forest remnants in extensive flat areas (Pavez et al. 2004).

On several occasions, we observed white-throated hawks searching for prey and hunting within human-made habitats. Among the prey remains collected at nest sites we found the remains of a Chilean tinamou (*Nothoprocta perdicaria*), a bird species that inhabits agricultural fields. In addition, the white-throated hawk pair that nested in the pine stand in Concepción hunted prey in gardens and urban parks (authors, personal observation). Similarly, in Bariloche, southwestern Argentina, white-throated hawks prey on several species inhabiting open areas and on some birds associated with urban environments (*Passer domesticus*, Trejo, Ojeda et al. 2006). In this same location, Gelaín et al. (2001) also found a nesting pair at a site that had been recently burned and another in a human-altered wooded site within an urban area. All of these findings indicate that some hawk pairs can tolerate a certain degree of loss of native forest cover within their breeding territories and occasionally accept non-native habitats for nesting and hunting.

Most of the nest sites were within old-growth or second-growth forest remnants. These successional stages were characterized by having a complex vegetation structure that was associated with a high diversity of plant and animal species (Rozzi et al. 1996; Smith-Ramírez 2004; Smith-Ramírez et al. 2007). These mature forest remnants ensured sufficient shelter, refuge and food for forest-specialist raptors. In addition, the emerging trees and ones of great size within old-growth and second-growth remnants constituted pivotal elements for nesting, resting, mating and facilitating the search for prey (Figueroa et al. 2000; Norambuena et al. 2012). In Araucanía, several hawk pairs mated conspicuously, apparently as a way of delimiting their nesting territory, on large standing dead trees and large live trees. Other forest-specialist raptor species inhabiting the rainforest also tend to establish their nest sites within remnants with similar structural attributes (Figueroa et al. 2000, 2007; Ojeda et al. 2004; Wallace 2010; Beaudoin and Ojeda 2011). In addition, the fact that all white-throated hawk pairs established their nest sites in ravines within extensive forest remnants suggested that this hawk species prefers to reproduce in well-protected and hidden sites, possibly to minimize the presence of predators or human activity.

The occupancy of a pine plantation by one white-throated hawk pair could be interpreted as an adaptation to the substitution of native forest by monospecific non-native tree plantations. However, the structural features of this pine plantation were closer to the structure of old-growth forest remnants than the typical homogeneous pine plantation. It is also possible that hawks occupied the pine plantation because of the total lack of native forest in the area, the pressure to reproduce or fidelity to an old nest site (Knick and Rotenberry 2000; Penteriani and Faivre 2001). Some habitat-specialist species may persist at a site to the extent that the changed habitat permits survival and reproduction, even at below replacement rates ("the ghost of the past habitat", Knick and Rotenberry 2000).

The characteristics of the nest trees and nesting platforms in our study were consistent with those from southwestern Argentina and central Chile. In southwestern Argentina the nest trees reached heights and trunk diameters of 16.5–25 m and 0.5–1.1 m, respectively ($n = 7$; Trejo et al. 2004). In this same region, the height of platforms above ground reached 13–22 m ($n = 7$; Trejo et al. 2004). Just as in our study areas, the platforms from southwestern Argentina were oval or round, with some of them being similar in size to those we measured in Valdivia (61–67 × 55–65 cm; Trejo et al. 2004). The height of a nest tree found in central Chile (25 m; Pavez et al. 2004) was within the range documented for southwestern Argentina and Araucanía. Possibly, the variation in size and shape of platforms is related to the age of the nests (Trejo et al. 2004). The characteristics of the two eggs we found were similar to those of the only egg found in southwestern Argentina (white without shine, 50.2 × 40 mm; Trejo et al. 2004). It should be mentioned that in the nest where we found an unhatched egg we also recorded a fledgling young. This suggested that white-throated hawks may lay two eggs. The plumage coloration of the nestling at 31 days old was similar to that described by Ojeda et al. (2003) for nestlings of the same age.

The length of the breeding period of white-throated hawks in the Araucanía was consistent with that documented for southwestern Argentina and central Chile (Pavez et al. 2004; Trejo et al. 2004). The difference of almost 2 weeks in the beginning of the breeding period between Nahuelbuta and Valdivia could be because the more southerly pairs arrived later at their breeding territories because of the greater length of their migration. This is consistent with observations made on a larger spatial scale. In central Chile, Pavez et al. (2004) found that white-throated hawk pairs began their reproduction somewhat earlier than those from southwestern Argentina (see Trejo et al. 2004). In contrast, dates of reproduction in Valdivia were more similar to those of southwestern Argentina; both localities are at almost the same latitude. Since white-throated hawks returned to their breeding areas by travelling almost linearly from north to south (Pavez 2000; Trejo et al. 2007), those pairs with more southerly territories would begin their reproductive activity somewhat later. At a more reduced spatial scale, it is also possible that the local availability of prey (Martín 1987; Doyle 2000), body condition (Doyle 2000) and variation in microclimatic conditions (e.g. higher precipitation toward the south) may have influenced the observed asynchronicity.

As was evidenced in our study, white-throated hawks appear to reproduce mostly in old-growth and second-growth forest remnants. The fact that the nesting territories were relatively distant from urban centres suggested that white-throated hawk pairs are more prone to occupy areas with low human activity. Although some hawk pairs seem to tolerate a certain degree of human intervention within their nesting territories, the strong pressure of logging on native forest remnants (Fuentes 1994; Armesto et al. 1996) places them under potential threat. In the case of those hawk pairs that successfully reproduce in pine plantations (e.g. Caracol hill), eventual forestry harvests would leave the hawks without structures for nesting. We did not witness illegal capture or hunting, but that is also a possible threat to some pairs of white-throated hawks. The nest sites established very near to areas of human activity would be easily accessible, and therefore, it is likely that these nests could be destroyed and the young killed (Rivas-Fuenzalida et al. 2011). Our results are still preliminary, but they constitute the most complete information about the reproduction of the Chilean population of the white-throated hawk. We believe that the information provided here will be useful to better understand the natural history and to plan the conservation of this migratory forest-specialist hawk and its habitat.

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