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LIFE HISTORY OF THE WHITE-BREASTED HAWK (*ACCIPITER CHIONOGASTER*)

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Resumen. – **La historia de vida del Gavilán Pechiblanco (*Accipiter chionogaster*). –** Presento las primeras descripciones de los nidos, de los huevos, de la muda de plumas y de la conducta reproductiva del Gavilán Pechiblanco (*Accipiter chionogaster*), basado en un estudio de 20 nidos en Honduras y El Salvador. También son presentadas las primeras descripciones y sonogramas de las vocalizaciones del Gavilán Pechiblanco. Los nidos fueron construidos en pinos (*Pinus oocarpa)* por ambos padres entre Diciembre y Abril a una altura promedio de 19.7 m del suelo y a una altitud de 896 a 1711 m.s.n.m. La proporción de ramitas de angiospermas en los nidos, comparada con la de las gimnospermas, aumenta significativamente con la inclinación de las vertientes. Los huevos fueron un color blanco-azul, con variada cantidad de manchas café, y el número promedio de huevos por nido fue 2.7. Las hembras incubaron entre Marzo y Abril y continuaron el cuidado de los polluelos en el nido por un par de semanas después de su nacimiento. Los polluelos nacieron en Abril, llegaron a ser volantones entre Mayo y Junio, y abandonaron el área del nido entre Junio y Julio. Los polluelos fueron alimentados principalmente con aves pequeñas y medianas, con algunas pocas lagartijas, murciélagos y grillos en la dieta. La presa más grande fue la Paloma Encinera (*Patagioenas fasciata).* Los machos trajeron toda la comida para las hembras que empollaban y para los polluelos más pequeños. Ambos padres trajeron comida para los polluelos mayores y para los volantones. La densidad de los nidos fue un estimado de 5.1 nidos por km^2 en el Cerro El Pericón, Morazán, El Salvador. Aunque la abundancia de las presas era baja durante las etapas de polluelo y volantón, la salida de los volantones del nido coincidió con la mayor abundancia de las aves presas juveniles. La mayoría de los jóvenes mudan las plumas cobertoras del cuerpo antes de Diciembre. Las hembras suspendan la muda mientras están empollando sus huevos. La principal muda anual fue entre Mayo y Agosto.

Abstract. – I present the first descriptions of nests, eggs, nesting behavior, and molt of the White-breasted Hawk (*Accipiter chionogaster*), based on a study of 20 nesting attempts in Honduras and El Salvador. I also present first descriptions and sonograms of White-breasted Hawk vocalizations. Nests built by both parents between December and April averaged 19.7 m from ground in pine trees (*Pinus*

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oocarpa) between 896 and 1711 m a.s.l. Proportion of broadleaf twigs in nest, compared to pine, increased significantly with slope of surrounding land. Eggs, bluish white with varying amounts of brown spots, averaged 2.7 per clutch. Females incubated eggs in March and April and continued brooding for a couple of weeks after hatching. Eggs hatched in April and nestlings fledged in May and June, leaving the nest area in June and July. Nestlings mainly fed on small to medium sized birds, with a bat, lizards, and grasshoppers also recorded. Largest recorded prey was a Band-tailed Pigeon (*Patagioenas fasciata*). Males brought all food for brooding females and smaller nestlings. Both parents brought food to larger nestlings and fledglings. Nesting density was estimated at 5.1 nests per km^2 on Cerro El Pericón in Morazán, El Salvador. Although prey abundance was low during nestling and fledgling stages, fledging coincided with peak abundance of juvenile birds. Most juveniles molt contour feathers before December. Females have a suspended molt while they brood eggs. Main annual molt was between May and August. *Accepted 2 March 2010.*

Key words: *Accipiter chionogaster*, White-breasted Hawk, nest, eggs, molt, vocalizations, food, nest density, El Salvador, Honduras.

INTRODUCTION

The White-breasted Hawk (*Accipiter chionogaster*) (Fig. 1) is a little known resident of the highlands from south-east Mexico to north-west Nicaragua (Howell & Webb 1995). Its taxonomic status has not been fully resolved (reviews in Bildstein & Meyer 2000 and Ferguson-Lees & Christie 2001). I follow Ferguson-Lees & Christie (2005) and many earlier authors (e.g., Sibley & Monroe 1990, del Hoyo *et al.* 1994) in treating the form at the species level rather than as a subspecies of Sharp-shinned Hawk (*A. striatus*) which differs in plumage and behavior.

No field study results have been reported previously on the White-breasted Hawk. The little that is known about this species is mainly from studies of museum specimens (e.g., Storer 1952, Monroe 1968, Blake 1977), occasional reports made at the time of specimen collection (e.g., Dickey & van Rossem 1938, Edwards & Lea 1955), or from anecdotal observations of field guide authors (e.g., Land 1970, Howell & Webb 1995, Edwards 1998). Most of this material is concerned with identification, specimen measurements, and distribution; virtually nothing is known about behavior or ecology; no nest has been reported, and no calls previously described (del Hoyo *et al.* 1994, Ferguson-Lees & Christie 2001). The aim of this study was to investigate the biology of the White-breasted Hawk. As no monograph has been published on this species, a secondary aim was to review the limited published literature and unpublished data collected by local ornithologists.

STUDY AREAS

The first nest site was discovered by chance at Celaque National Park (hereafter referred to as Celaque) which lies in the Lempira district of western Honduras (14º33'N 88º39'W). Established in 1987, it protects a total area of 266 km^2 at altitudes of between 1000 and 2849 m, with a core area of 165 km^2 above 1800m (Southworth *et al.* 2004). The main study area in Celaque was on the north side of the park which is characterized by steep, pine-covered slopes, with cloud forest occupying much of the area above 1800 m and small areas of riparian forest, farmland, and second growth in the valleys.

The second study area was located at Cerro El Pericón (13º56'N 88º07'W) which lies south of the town of Perquín in the department of Morazán in north eastern El Salvador, near the border with Honduras. I chose this location because it is known for regular sightings of White-breasted Hawks (O. Komar pers. com.). The site lies roughly

FIG. 1. One year old male White-breasted Hawk, Montecristo N. P., El Salvador 17 May 2006 (Jorge Jiménez/SalvaNATURA).

at the transition point between broadleaf dry forest and farmland habitat to the south and pine-oak areas to the north. The study area was on a ridge about 5 km in length extending northwards from the town of Arambala (at 800 m) to the highest point at 1379 m. The brow of the ridge is mainly covered with pine forest, rarely more than 500 m wide and in places broken up by farmland. The ridge mainly has open pine savannah to the north, with farmland and dry thorn forest to the south, east, and west.

METHODS

Between April 2001 and June 2008, I collected data during 21 field days at Celaque (mainly in 2001 and 2002) and 90 field days at Cerro El Pericón (2003 to 2008). Some incidental observations from other locations in northern Central America are also included. In February and March 2008 all pine areas on the ridge at Cerro El Pericón were mapped using GPS. The 1.37 km^2 of pine forest was divided into 16 smaller areas of similar size, such that each could be thoroughly checked several times by a single observer in the first few hours of the day, and all areas covered in four days by four observers. We located nests in these areas by walking back and forth through suitable habitat listening for calling adults. We checked every area at least twice, two to three weeks apart, to ensure that no nests were missed. Other than attempts to re-build, we found no

additional nests after the initial 4 day search between 8 and 11 February 2008, suggesting the procedure had been thorough on the first attempt. There is always the possibility that a nest could have been missed, especially if a pair had nested early and already had eggs or nestlings when we conducted our search (Boyce *et al.* 2005). Nest density in pine forest was calculated from these data.

I made detailed observations at 17 of the 20 nests found for a total of 253 hours: 12 during early courtship between October to December; 96 during the nest-building stage; 44 during the egg stage; 80 during the nestling stage; and 21 after nestlings had fledged. I recorded all observations onto a hand-held cassette recorder, enabling duration of activities to be timed. Effort was not equally distributed throughout the day, so effort for each hour of the day was calculated to the nearest minute for each stage of the study and then used to calculate rates for each hour of the day for each activity (e.g. food deliveries, mating, deliveries of nesting material, and presence of each adult at the nest site). For example, between 07:00 and 08:00 h a total of 935 minutes of observation were made during the nest-building stage, during which 66 twigs were delivered to nests, giving an hourly rate of 4.2 deliveries for that hour of the day. A sum of all the hourly rates was used to determine daily rates. As few nests were observed during all time periods, data from all observations had to be combined to obtain these figures, allowing no scope for measures of variance. In some cases, short observation periods were removed from these analyses where the data were unclear, such as when only one of a pair could be reliably observed.

Eight nests were collected for further analysis the year after they had been active, after it was clear that they would not be re-used. Two others were collected in 2008 soon after clutch failures. Nest codes in the text refer to the site (C for Celaque and P for El Pericón), the year any eggs would have hatched (rather than the year nest-building commenced) and a lower-case letter to identify nests at the same site in the same season.

I examined and measured all 26 White-breasted Hawk specimens at the British Museum of Natural History (BMNH), Tring, UK. I examined molt in 10 females and six males that were dated to at least the month of collection. I identified molted flight feathers and feathers of prey species collected near nests by comparisons with BMNH specimens.

Capture data from SalvaNATURA's bird monitoring project in El Salvador were used to estimate availability of avian prey. This included data collected from 174 field visits each of approximately 400 net hours following the MoSI protocol (except that data was collected in all months of the year), in highland cloud forest at Montecristo National Park (14º24'N, 89º22'W), pine-oak forest at Montecristo National Park (14º23N 89º22'W), highland cloud forest at Los Volcanes National Park (13º51'N, 89º37'W), dry semi-deciduous forest at El Imposible National Park (13º49'N 89º94'W), and shaded coffee plantation at Finca Nuevos Horizontes (13º49'N, 89º39'W) (Komar *et al.* 2009). Although only the Montecristo sites have a White-breasted Hawk population, other sites give an indication of avian prey densities in habitats equivalent to those regularly utilized by White-breasted Hawks throughout their range. SalvaNATURA data from 10 captures of 7 individual White-breasted Hawks were used in analyses of movements, biometrics and molt.

I documented vocalizations using a Radioshack CTR-117 tape recorder and a Sennheiser MKE 300 microphone and made sonograms using Avisoft-SAS Lab Light. I compared my recordings with Sharp-shinned Hawk recordings from the Macauley Library, Cornell Laboratory of Ornithology, Plain-

breasted Hawk (*Accipiter ventralis*) recordings provided by John V. Moore, and Rufous-thighed Hawk (*Accipiter erythronemius*) recordings by Gustavo Cabanne (obtained from xeno-canto.org, downloaded June 2008). I mapped pine forest boundaries and recorded nest positions using a Garmin 12 GPS and measured the slopes of land at nest sites using an Osmiroid clinometer. I measured masses of nests, nestlings, and eggs using Salter and Pesola spring balances and pellets using a Philip Harris Status S1502. Vernier calipers were used to make nestling measurements and egg morphometrics.

Measurements of total length, flattened wing, tarsus, and length of head and bill were compared between males and female specimens (housed at BMNH) using t-tests. I used a t-test to compare mean duration of nest visits by males and females. Rates of chattering calls were compared using t-tests, with separate sonograms counted as separate data points. All t-tests were two-sample, two-tailed tests. To determine the relationship between the slope of land at the nest site and the amount of broadleaf twigs in the nest, % broadleaf twigs in each nest was regressed on the log of slope of the surrounding land. Correlation and regression analyses were used to compare measurements of nestling mass and tarsus length. All statistics were carried out using Minitab software version 15.

RESULTS AND DISCUSSION

Habitat. The predominant tree throughout most of the White-breasted Hawk's range is *Pinus oocarpa*: a pine species with which it shares a very similar world distribution (Dvorak 2003), though other pine species, such as *P. maximinoi* are also found, especially at higher elevations. The White-breasted Hawk is not found in the lowland pine forests (mainly *P. caribaea*) on the Caribbean slope of Honduras and Nicaragua (Howell 1972). Understory species vary throughout the range, but typically include *Byrsonima crassifolia*, *Quercus* spp., and *Miconia* spp. I regularly saw White-breasted Hawks ranging into neighboring cloud forest, tropical dry forest, and farmland to hunt for food and one was seen hunting in the main plaza of a small town (A. Narish pers. com.).

Differing altitudinal ranges have been suggested for the White-breasted Hawk by authors who have worked in the region, without providing sources (presumably pers. observ.). Land (1970) gave 350–2600 m and Howell & Webb (1995) gave 600–3000 m and rarely lower, while Monroe (1968) stated 'primarily above 600 m, but rarely as low as sea level'. All of my observations, including those inside and outside of the study areas, have been within a range of 650–2300 m. *Pinus oocarpa* is found between 350 and 2500 m altitude (Dvorak 2003), though I have seen *Pinus* spp. to around 3000 m in the region which probably gives the rough altitudinal limits for White-breasted Hawk breeding sites. Any individual outside this range would probably be either a foraging or wandering bird.

No nests were ever found in suitable habitat near the top of Cerro El Pericón, despite searching in several nesting seasons. Adults at nests further down the ridge brought food up from the valleys on either side, so areas further up the ridge may have been unsuitable for nest sites because of the high energetic costs of carrying food back up the hill. No nests were found on the northern slopes of Cerro El Pericón (only thoroughly searched in the 2008 season), possibly because of a lack of suitable hunting habitat in the pine savannas nearby.

Movements. I occasionally saw hawks several km from suitable nesting areas. Adults, especially males, departing nest sites at Cerro El Pericón regularly left the pine forest and flew down the sides of the ridge to the valleys on

either side and were later seen returning from the valleys with food. Several prey species recorded at nest sites, including White-tipped Dove (*Leptotila verreauxi*), Rufous-naped Wren (*Campylorhynchus rufinucha*), and Rufous-capped Warbler (*Basileuterus rufifrons*), were never seen in the pine forest at Cerro El Pericón, though were common in the valleys. Two White-breasted Hawks trapped in pine-oak forest at Montecristo National Park on 16 May 2006 (a one year old male) and 17 May 2006 (a full adult male) were re-trapped in cloud forest in the same park on 14 May 2007 and 22 June 2006 respectively; both movements of 2.37 km (SalvaNATURA unpubl. data).

White-breasted Hawks are thought to be year round residents of their nesting habitat, but data to support this assumption are sparse; extralimital records appear in published lists from Tikal in northern Guatemala (Beavers 1992) and Monteverde in Costa Rica (Fogden 1993). The Tikal bird was an adult seen at an altitude of 193 m 27 February 1988 (Bret Whitney pers. com.) and the Monteverde bird was an adult seen at close range on 20 September 1982 at an altitude of 1530 m (Michael Fogden pers. com.). A third unpublished record involved a bird seen well by several observers at Cerro Verde in El Salvador 17 Oct 2009 at an altitude of 1994 m (J. Fagan pers. com.). Bildstein (2004) described the White-breasted Hawk as an altitudinal migrant. He based this on Ferguson-Lees and Christie's (2001) comments that Central and South American populations of Sharp-shinned Hawk are probably resident, apart from altitudinal movements in some areas (Bildstein pers. com.). However Ferguson-Lees and Christie only discuss movements of South American forms and I have found no evidence, other than the Tikal sighting, to show that White-breasted Hawks are regular altitudinal migrants. For example, the SalvaNATURA database of bird records from El Salvador, which includes data compiled from field notes of most active birders in the country since 1925, includes no lowland records of White-breasted Hawk.

Nest densities. Seven pairs occupied 1.37 km^2 of pine forest at Cerro El Pericón in 2008, giving a population density of 5.1 nests per km^2 of pine forest (Fig. 2). Nests averaged 0.58 km from their nearest neighbors, assuming all nests were located. Closest simultaneously occupied nests were 0.26 km apart. This density is considerably higher than in Sharp-shinned Hawk studies reviewed by Bildstein & Meyer (2000), where all densities were below 1.0 per km^2. The high density at Cerro El Pericón may not be representative of all pine forest within the species' range. As noted above, an adjacent area of pine savannah appeared to have no hawk population (though never surveyed thoroughly).

Biometrics. In the BMNH specimens measured, females were larger than males with little or no overlap (Table 1). Females were significantly larger in total length ($t = 7.5$, $df = 19$, $p < 0.0001$), tarsus length ($t = 4.6$, $df = 17$, $p < 0.0001$), length of head and bill ($t = 7.4$, $df = 19$, $p < 0.0001$), and wing ($t = 15.7$, $df = 19$, $p < 0.0001$). In size and shape the White-breasted Hawk is very similar to the migratory subspecies of Sharp-shinned Hawk (*A. s. velox*), which is sympatric during the northern winter. Dickey & van Rossem (1938) commented that the only observable structural differences between *chionogaster* and *velox* were the slightly longer bill and slightly longer middle toe of *chionogaster*.

Iris color. As with many other small Accipiters, iris coloration changed with age, though probably cannot be used to age individuals with accuracy (Rosenfield & Bielefeldt 1997). The iris was dark-grayish brown in down covered nestlings, becoming paler grey shortly

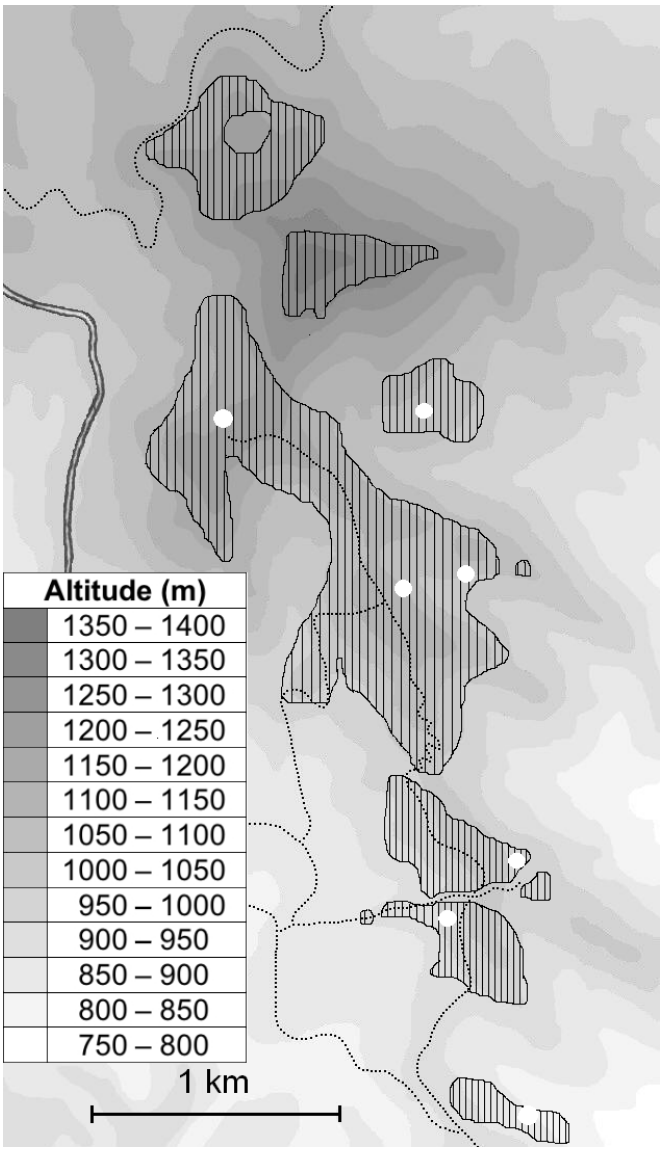

FIG 2. Map of the ridge at Cerro El Pericón showing all pine areas surveyed (hatched) and location of nesting pairs during February and March 2008 (white spots). Double solid lines show a paved road and dotted lines are dirt roads.

before leaving the nest. The dark iris became dull yellow and brightened while still being fed by parents. Three one year old females had an orange iris. All birds in full adult plumage of both sexes had red irides.

Timing of nesting. The earliest courtship behavior I observed was 31 October, but a local resident reported that the pair had been active and calling since mid October. The White-breasted Hawk breeding season (see Fig. 3 for

TABLE 1. Measurements of White-breasted Hawk specimens by Blake (1977), Storer (1952), from the British Museum of Natural History collection (BMNH), and of live birds from the SalvaNATURA database. Three specimens from the BMNH are not included because they could not be sexed with certainty.

Measurement	Source	Male range (mean, no.)	Female range (mean, no.)
Length (mm)	BMNH	266–298 (275.9, n = 8)	310–365 (329.7, n = 15)
Wing flattened (mm)	Blake (1977)	160–175 (169.8, n = 6)	197–210 (204.2, n = 5)
	BMNH	164–180 (172.5, n = 8)	191–211 (203.4, n = 15)
Wing arc (mm)	Storer (1952)	166–175 (169.7, n = 3)	198–209 (203.1, n = 6)
	SalvaNATURA	163–179 (170.9, n = 9*)	201 (n = 1 juv)
Tail (mm)	Blake (1977)	125–145 (132.5, n = 6)	154–163 (158.2, n = 5)
	Storer (1952)	130–135 (132, n = 6)	156–164 (160.1, n = 6)
	SalvaNATURA	129–137 (133, n = 2)	-
Tarsus length (mm)	Blake (1977)	48–52 (50.2, n = 4)	57 (57, n = 1)
	BMNH	48.2–59.6 (52.0, n = 7**)	54.4–60.5 (56.6, n = 14**)
Culmen length, tip to cere (mm)	Blake (1977)	10–12 (10.8, n = 6)	13–15 (14, n = 5)
Head and bill (mm)	BMNH	39.6–44.2 (41.2, n = 8)	44.2–50.0 (48.8, n = 15)
Mass (g)	SalvaNATURA	94–114 (105, n = 9*)	165 (n = 1 juv)

the main stages) lasted about nine months from the start of courtship behavior to the departure of fledglings. Other tropical relatives, such as Puerto Rican Sharp-shinned Hawks (*A. s. venator*) (Delannoy & Cruz 1988) and Rufous-thighed Hawks (Seipke & Cabanne 2008), have a similarly protracted breeding season compared to temperate populations, such as *A. s. velox* (Bildstein & Meyer 2000). Laying and brooding of Puerto Rican Sharp-shinned Hawks occurred during periods of relatively low prey abundance, but fledging coincided with the peak of prey abundance (determined from transect sampling of avian prey species) (Delannoy & Cruz 1988). Nesting of Eurasian Sparrowhawks was timed for dependent nestlings to coincide with fledging of avian prey species (Newton 1986). Prey abundance was not measured in the current study, but abundance of avian prey at five banding sites in equivalent White-breasted Hawk hunting habitats in El Salvador (measured from capture rates in mist nets) decreased between June and September after winter migrants departed (Fig. 4), so less prey is available when White-breasted Hawk young are in the nest and fledglings are starting to hunt for food. Capture rates of juvenile birds are at their highest in El Salvador between July and October (Fig. 4), when recently fledged hawks start hunting for themselves. This suggests that fledging of White-breasted Hawks is timed to coincide with fledging of avian prey species, so availability of easily caught prey may be a more important factor than the number of potential prey items in the area per se. Very few prey items were identified during the hawks' fledgling stage, so the proportion of juvenile birds in the diet remains unknown.

Courtship and mating behavior. Between late October and January (and later in a pair where the male was replaced) pairs often had their undertail coverts and breast feathers puffed out and during this period males and females sometimes chased one another. Few aerial display flights were observed given the time spent in suitable habitat and observing nests. One bird circled near the nest site with its

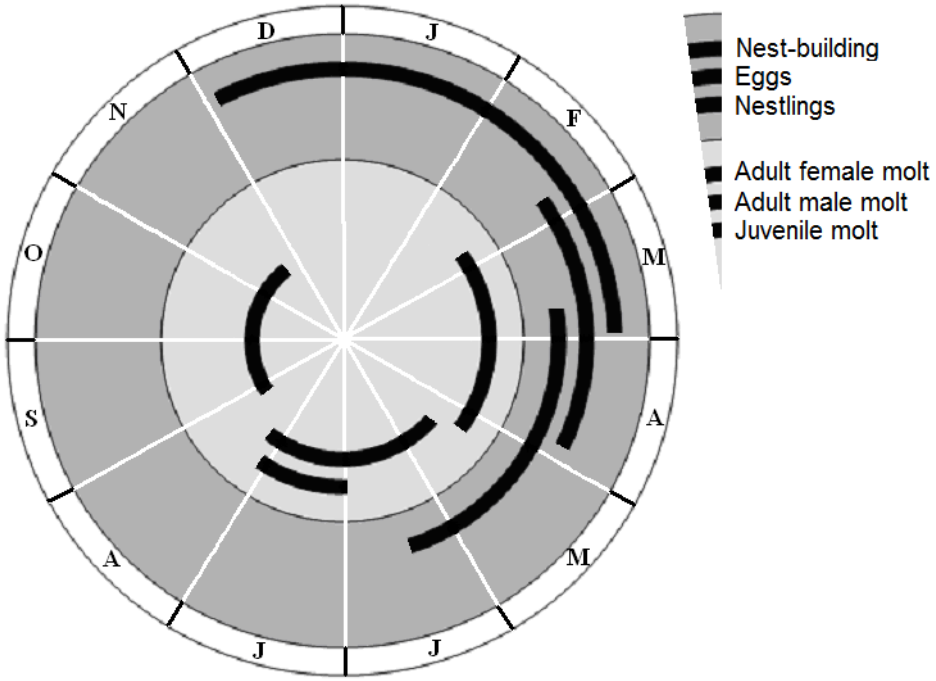

FIG. 3. Timing of major stages of the nesting and molt cycles. In all cases dates are limited by the dates of field visits, discovery of nests and information on molting birds so are probably conservative. Only first broods are included in nesting data.

undertail coverts puffed out, then made a steep dive and went out of view. On three occasions a male circled near a nest site then closed its wings and dived about 5 m before swooping back up a few meters and diving again. This undulating flight was sometimes repeated as it lost altitude. This is the typical display flight of several *Accipiter* species, such as Puerto Rican Sharp-shinned Hawk (Delannoy & Cruz 1988), Rufous-thighed Hawk (Seipke & Cabanne 2008), and Eurasian Sparrowhawk (*A. nisus*) (Newton 1986). On two occasions the horizontal flight included exaggerated deep wing beats and on one occasion the bird gave the wailing call (see vocalizations section). I saw a male and female circling together on two occasions, but with no obvious signs of display. J. S. Gómez described to me a pair that performed undulating flights together over Cerro El Pericón for about 10 minutes. On one occasion I saw a bird circling high, doing slow deep flaps while rocking side to side (flashing its white underparts) before it dived down close to a ridge around 200 m below, circled back up, and flew out of sight. Displaying birds sometimes made unclear movements in the air, such as tail movements and temporary closing of the wings without diving. The white underparts of birds displaying and chasing was very noticeable as they turned in the air, producing flashes of white. Most display occurred in the mornings, though one display flight occurred in the afternoon.

I saw 18 breeding individuals closely enough to determine age from plumage (see molt section for details). Three of nine males and six of nine females were yearlings. All

seven pairs, where both adults were aged, included a yearling paired with a bird in full adult plumage. At one nest, where both birds had adult plumage, there was no activity at the nest during one visit and on the subsequent visit a bird in juvenile plumage (though with dark eyes) had joined the resident female and was copulating and building the nest that was started by the original male. This might suggest that birds in juvenile plumage find it difficult to hold a territory unless the original bird is lost.

Copulation was observed on 37 occasions. Other than single observations at 15:15 and 17:04 h, all copulation occurred between first light and 09:40 h. Copulation was first observed on 31 October before nest building had commenced and was seen twice after eggs were laid. Copulation frequency (calculated from all data during the early stages of courtship and nest building) was calculated at 3.15 times per day. One pair copulated five times during a period of 2 hours 51 minutes. Copulation duration (measured as the time the male was on top of the female) lasted 6.8 s on average (SD = 2.4, n = 20). On 21 occasions, copulation occurred after a bout of nest-building by the male (or occasionally the female) and on seven occasions it occurred after the male had just passed food to the female. The chattering call was usually made by the male during copulation and sometimes by both birds, though occasionally both were silent. The female often gave wailing calls after copulation, which the males never did. Often one or both birds would preen together after copulation.

On several occasions, a non-resident male entered the nest area and was chased away. There may have been other incidences of non-resident males entering the nest areas, but study birds were not marked and intruders could have gone undetected. One intruder male arrived with a twig. Another intruder male sat 50 cm from the resident female on the same branch for 9 mins before attempting unsuccessfully to copulate. Although no extra-pair copulations were observed, the behavior of the intruding male and the tolerance of the female to him suggest it could occur.

Nests and nest building. All nest trees were *Pinus oocarpa* and were located on or near brows of pine covered ridges. Nest trees were often not the tallest or bushiest in the vicinity, though half grown trees were never used. Isolated trees were also never used. Nests were positioned in either a fork between branching trunks or on small side branches beside the main trunk; one nest was placed on an open branch about 3 m from the trunk. Some were partly concealed by foliage, others in exposed locations with no foliage to conceal them. There was no indication that White-breasted Hawks built nests on a particular side of the tree (Table 2), unlike Eurasian Sparrowhawks, which tend to build on the south side of the tree where the branches are stronger (Newton 1986).

Nests were either circular (usually when on an open side branch), or oval in shape (usually when fitting in a fork between two trunks). During egg and early nestling stages, nest cups measured 21.0 cm (SD = 2.14, n = 11) across and 9.0 cm in depth (SD = 2.93, n = 13). The main broadleaf species used as a source of twigs was *Byrsonima crassifolia.* The hawks used higher proportions of broadleaf branches in nests located on steeper slopes (% broadleaf twigs regressed on log of slope, $R^2 = 54.7\%$, $F_{1,8} = 9.64$, $p = 0.015$), presumably because it was energetically easier to reach the lower broadleaved trees (rarely growing more than a few meters from the ground) on steeper slopes, as they could be reached by flying horizontally from the nest. Pine twigs tended to be longer (mean 17.0 cm, SD = 8.8, n = 2638 twigs from three nests) than broadleaf twigs (mean 13.9 cm,

TABLE 2. Location, site characteristics, dimension, composition and success of nests of White-breasted Hawks. The final column refers to the condition of the nest when it was last visited prior to a failure or following successful fledging. With the exception of the two nests that were still active at the final visit, any nests that did not fledge young were unsuccessful. *Nests built close to recently failed nests; ** no counts possible, even though eggs or nestlings could be seen in the nest; ***nests still active during the final visit (June 2008).

Nest	Nest site and location in tree					Nest dimension and composition						Nesting success	
	Altitude (m a.s.l.)	Tree DBH (cm)	Slope of land (°)	Nest height (m)	Side of main trunk	Depth (cm)	Widest diameter (cm)	Mass (g)	% pine by mass	Number twigs	% pine by twig number	Max. no. eggs/ nestlings observed	Last active stage observed
C01	1711	45	-	20.0	E	15	28	-	-	-	-	3	2 fledged
C02	1608	41	-	17.0	S	10	-	-	-	-	-	2	Eggs
P03	1161	27	16	28.2	S	32	34	981	67	750	54	2	Nestlings
P04	1099	-	10	20.7	N	47	56	1517	100	1220	100	2	2 fledged
P05a	1148	-	16	21.0	NW	30	56	-	-	-	-	3	Eggs
P05b	1039	-	22	16.8	E	-	38	1693	85	1427	70	1	Nestling
P05c*	1015	-	32	10.9	W	24	36	1030	62	1784	51	0	Building
P05d	1020	-	-	-	S	-	-	-	-	-	-	0	Building
P07a	1008	62	16	23.4	NE	38	39	975	100	697	100	3	3 fledged
P07b	1005	40	19	-	W	-	-	-	-	-	-	0	Building
P08a	896	56	32	17.6	E	36	38	1639	45	1458	23	?**	Eggs
P08b	971	38	24	19.6	S	48	36	1936	53	1387	29	0	Building
P08c	1002	48	7	22.1	SE	38	36	-	-	-	-	3	2 fledged
P08d	1118	40	33	19.0	SE	38	41	1579	51	1484	27	0	Building
P08e	1061	50	24	25.5	NW	26	38	369	2	378	2	2	Eggs
P08f	1100	37	20	12.2	SW	25	48	-	-	-	-	2	2 fledged
P08g	1241	-	24	-	W	-	-	-	-	-	-	0	Building
P08h*	921	53	25	18.7	E	30	43	-	-	-	-	?**	Nestlings***
P08i*	1028	38	26	-	SW	-	-	-	-	-	-	?**	Nestlings***
P08j*	1239	45	24	22.7	Above	28	38	885	54	717	27	1	1 fledged
Average	1120	44.34	22	19.7		31.0	40.3	1260	62	1130	48		
S.D.	207	8.96	7.3	4.4		10.47	7.70	483	29	458	33		

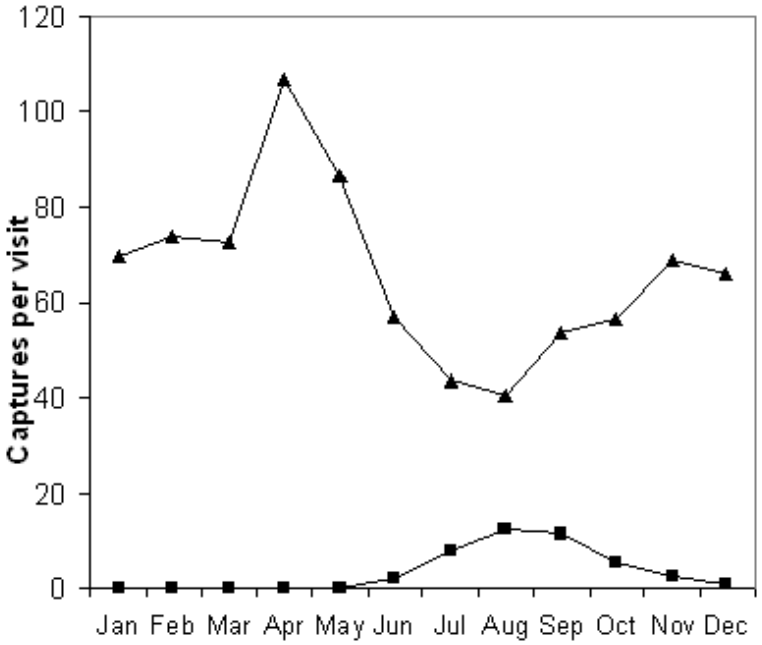

FIG. 4. Mean capture rates by SalvaNATURA bird monitoring project (unpublished data) from 174 equal-effort field visits and 11,692 captures of small birds in El Salvador, showing total captures (triangles) and captures of local juveniles (squares).

SD = 6.7, n = 793 twigs from three nests). One nest with no branches above (P08j) contained 117 pieces of bark with a mass of 33 g which must have been brought in by the hawks. Counts of 204 and 211 pine needles were found in two nests collected soon after they failed. Bark and pine needles in other nests may have fallen in before or during nest collection, so counts are not included. Typically, the base and perimeter of nests was made mostly of larger pine twigs, fitted concentrically around the nest core, which was most commonly filled with smaller to very fine broadleaf twigs in no obvious arrangement. Nest cups and to a lesser extent the lower structure often contained pieces of bark. Nests with this structure were the hardest to disassemble. Some nests were entirely pine twigs and one poorly constructed nest mostly broadleaf twigs.

Birds constructed nests between 3 December and 27 March (not counting second broods which continued until 24 May), though I saw individuals searching for material and occasionally breaking off twigs without using them from as early as 31 October. Material was collected uphill from the nest tree with only one instance of a bird bringing material from an area below.

The latest twig delivery was at 10:27 h and 95% of deliveries were before 09:00 h (n = 223 twig deliveries). An average of 19.6 nest visits per day was calculated, so, given that the number of twigs in the average nest was 1130, the average nest would take 58 days to build, with about 16 additional days to bring bark and needles for lining. I saw males deliver nesting material 125 times and females 51 times out of 176 observations where sex was recorded, though in 4 of 12 nests observed,

females made more deliveries than males. On average, males were in the nest for 19.7 s per delivery (SD = 8.7, n = 10) and females 30.9 s (SD = 14.9, n = 7), but the difference was not significant (t = 1.8, df = 8, $p > 0.1$).

New nests were built each year and no nest was ever used twice. Four pairs re-built after the first brood failed, though I could not confirm that these pairs involved the same individuals. Three rebuilt nests appeared to be completely new, but a very large nest that was never used (containing 1784 twigs) constructed after a recent nest failure, may not have been started from scratch. The hawks were clearly capable of building a nest quickly when required, because a pair found nest building 10 February (P08g) was rebuilding a new nest 8 March (P08j), and incubating eggs 27 March after the first nest tree was felled. This nest, which successfully raised one offspring, contained only 717 twigs, so rapid building may result in smaller nests.

Eggs and incubation. White-breasted Hawk eggs are very similar to those of close relatives such as Sharp-shinned Hawk (Bildstein & Meyer 2000) and Eurasian Sparrowhawk (Cramp & Simmons 1980), having a subelliptical shape, pale bluish white ground coloration, marked mostly with rusty brown, but sometimes dark brown, spots and blotches (Fig. 5). Eggs averaged 38 x 31mm (Table 3), with similar measurements in nests containing two or three egg clutches. Markings varied in extent, even within a clutch, from a few small specks to large blotches covering around 30% of the surface (Fig. 5). They were generally distributed randomly about the egg, though sometimes markings were concentrated around the widest point or at one end. Two inspected nests contained two eggs and four nests contained three eggs. Another nest contained two nestlings and an unhatched egg that was not present the following week. From these data clutch size averaged 2.7 (SD = 0.49). Two nests not examined until the nestling stage contained one nestling and one contained two nestlings. The only previous reports of brood size are by Edwards & Lea (1955), who collected a juvenile from a group of four fledglings in Chiapas, Mexico and by Efrain Caal who reported two fledged young near a nest in Alta Verapaz, Guatemala (Jones & Komar 2008).

I never recorded exact dates of egg laying and hatching. I observed eggs in nests between 27 March and 27 April (not including re-builds which had eggs until 24 May at least), though a pair with a nestling aged about two weeks on 9 April probably laid around the end of February. One pair nest-building 20 March had small nestlings 1 May. Another pair nest-building 30 March had eggs 25 April and small nestlings 10 May. A third nest being built 11 March, had eggs 11 April and small to medium sized nestlings 5 May. Sharp-shinned Hawk incubation averaged 30–35 days (Bildstein & Meyer 2000), Rufous-thighed Hawks averaged 35 days (Seipke & Cabanne 2008), and Eurasian Sparrowhawks averaged 33 days (Newton 1986), with incubation not commencing in these species until the last egg is laid. The dates above suggest the incubation period of White-breasted Hawks is probably similar, or at least no longer than recorded in congenerics of similar size.

All incubation was by females, though on five occasions in the final days of nest building I saw males sit in the nest, as if incubating, for about 10–30 seconds. On none of these occasions did I know whether an egg was in the nest. I observed seven nests during incubation for a total of 43 hrs 44 min, during which, females left the nest on eight occasions for a total of 2 hrs 43 min. Females never left the nest area during the incubation stage and used the time off the nest mainly for feeding and body maintenance (preening, shaking, tail wagging, pellet regurgitation, and defecation); one female copulated twice with a male that

FIG. 5. White-breasted Hawk nest and eggs, Celaque N. P., Honduras May 2001 (Tom Jenner).

brought food, one female removed half-fallen tail feathers, one attacked a Bushy-crested Jay (*Cyanocorax melanocyaneus*), and one sat inactive for the 10 min it was off the nest. Males often sat on open branches just up from the nest preening or sitting inactive while females incubated. Males were present for 38.5% of the time during incubation, rising to 68.1% when the female was off the nest. This increase was partly because females sometimes left to receive food from the male, but there were other occasions where the female left the nest shortly after the male arrived without food. I only once observed a female leave the nest when the male was not present, suggesting that the males offer added protection when the nest is uncovered, though males often departed before the female returned to the nest. When females left the nest, males became more protective, mobbing animals near the nest that were mostly ignored at other times, such as a passing Turkey Vulture (*Cathartes aura*), Bushy-crested Jays, Band-tailed Pigeons (*Patagioenas fasciata*), and a Variegated Squirrel (*Sciurus variegatoides*). Females continued brooding until nestlings were about half grown.

Nestlings and fledglings. I observed nestlings between 9 April and 10 June (not including re-builds which continued until at least mid June), though a nestling on 9 April weighed 107 g and was probably a couple of weeks old, so the nestling stage can begin at the end of March. Exact dates of hatching were never recorded. In six days one nestling grew from 73 to 107 g and its sibling from 76 to 150 g; in seven days one grew from 31 to 91 g and its sibling from 39 to 131 g; and in 14 days one grew from 17 to 141 g and its sibling from 17

TABLE 3. White-breasted Hawk egg morphometrics. *Egg failed to hatch in a clutch of 3 (not measured).

Nest	Length (mm)	Width (mm)	Mass (g)
C02	38	32	22
C02	40	32	22
C02	39	32	22
P03	38	31	20
P03	38	30	18
P05a	37	30	18
P05a	39	30	18
P05a	36	30	17
P07b	37	30	17
P07b	38	31	19
P07b	38	30	18
P08c*	40	31	-
P08d	35	31	17
P08d	37	30	13
Mean	38	31	19
SD	1.4	0.8	2.5

to 131 g. These data give an average growth rate of 9.5 g per day. There was a close correlation of 0.96 (r = 0.68) between nestling mass and tarsus length ($F_{1,12} = 127$, $p < 0.001$).

Males usually brought plucked and headless food to females, who fed the nestlings. When feeding younger nestlings the female would usually eat the legs, wings, and intestines and then feed the young on pieces of meat from the remaining torso, often finishing off the remaining carcass after the nestlings were fed. Uneaten remains were removed by females. When nestlings were older, both parents hunted for food, though the male still brought in far more. The female would often disappear from the immediate nest area, but when the male returned with food and called, she would reappear, take food from him and feed the nestlings, implying that she did most of her hunting within earshot of the nest.

I recorded fledged nestlings in the nest area between 24 May and 28 June. Fledglings at the nest site 28 June had left the area by 27 July. At one nest where adults brought food to recently fledged birds, they dropped the food in the nest. At nests with older birds, with fully grown tail feathers, adults often retained food for a few minutes while the fledglings chased them. Food was often dropped for fledglings to catch in mid air. On two occasions a fledgling removed a pine cone from a tree in flight, dropped it, and then swooped down to catch it in mid air. Another did the same with a stick. One of these birds was also seen pulling pieces off a pine cone. Presumably the chasing and dropping of the food by the parents and the activity with the pine cone and stick were hunting and plucking practice. Juveniles often chased each other, with no obvious signs of aggression.

Nesting success. Table 2 shows the success of birds in each nest observed. Twelve young successfully fledged from 18 nesting attempts that were observed through to completion. Two nests (P08h and P08i) still had nestlings 21 June when the last visit was made. The nest tree of P08g was felled for wood during the nest-building stage. Nest P05a containing eggs was completely removed, possibly by locals at a nearby house who had previously informed me that White-breasted Hawks hunted their chickens. Nest P08e had a loose structure made mostly of deciduous twigs and the eggs sank deep into the nest, presumably preventing incubation. Nest P08c, which successfully fledged two individuals, contained an egg with a hole possibly made by the claw of an adult. An intact dead nestling with feathers in pin was found beneath nest C01. Other nests containing eggs or nestlings were found empty on the subsequent visit. In nest P05b the single nestling had a serious warble fly (Oestridae) infection, which might have caused its death, though nestlings infected with warble flies successfully fledged in two other nests. Some of these birds had lumps on the face or feet caused by the flies that could

have interfered with hunting and later survival. In Puerto Rico, warble flies accounted for 69% of failures of Sharp-shinned Hawk nests (Delannoy & Cruz 1988).

Molt. Four nestlings I observed closely weighing 38 g or less were covered with short pure-white down. Nestlings weighing 73 g or more had longer down, with a white head and underparts and varying shades of grey on the back (including the four nestlings that had pure-white down when younger). Bent (1937) described the second down of Sharp-shinned Hawks as pale pinkish buff and whiter on the belly, though Bildstein & Meyer (2000) described the second down as white. Thus it seems that *chionogaster* differs from *striatus* (at least the *velox* subspecies) in the back color of the second down.

A summary of the main stages in the molt cycle is shown in Fig. 3. I have only three records of birds with juvenile body plumage after November: a bird nest-building in April; a bird mist-netted in May, and a BMNH specimen (in active molt) collected 22 August that was >1 year old, based on feather wear. Although some individuals retained juvenile plumage for the first year of life, most molted all juvenile contour feathers and sometimes some flight feathers by November. One BMNH specimen collected 29 September had already molted its contour feathers and two rectrices and was in the process of molting primaries 3 and 4. The rest of its flight feathers were juvenile, but with little wear showing that it was only a few months old. All five BMNH specimens with juvenile tail feathers collected between January and April had replaced all contour feathers and two had also replaced some tail feathers. After replacing juvenile body feathers, individuals seen well could be aged in the field because juvenile tail feathers were easily recognizable, being browner with buff tips compared to grey with white tips of adult feathers. Nine out of 18 adults paired at nest sites between October and April that were seen closely enough to age had some juvenile flight feathers but had replaced all contour feathers. This is in contrast to Sharp-shinned Hawk (Bildstein & Meyer 2000) and Eurasian Sparrowhawk (Newton 1986), which retain their juvenile plumage and have a complete post-juvenile molt in spring the year after hatching.

While incubating eggs, females have a partial molt that is suspended when the eggs hatch; the larger feathers occasionally complete growth while the nestlings are young. By contrast, female Sharp-shinned Hawks in Puerto Rico continued molting during the nestling stage (Delannoy & Cruz 1988). Feathers found at White-breasted Hawk nest sites never included the four outer primaries and this pattern was matched by several BMNH specimens collected around this time that had replaced all but the four or five outer primaries. Varying numbers of rectrices were molted at this stage, with some birds just replacing the outer rectrices and others just the inner ones. Some body feathers and tertials were also replaced. One female attending fledged young was molting some tail feathers and one female BMNH specimen collected in July was molting some tail and primary feathers, suggesting that the female's main annual molt occurs at the end of the nesting cycle or after the nestlings have departed the nest area.

I never saw a molting male at a nest site. One-year-old males mistnetted at Montecristo National Park, El Salvador 16 May and 25 June were molting primary feathers. One adult male BMNH specimen had just started molting when collected 10 July and a one-year-old male observed 1 August was molting its central and outer rectrices, which were about two-thirds grown. These data suggest males molt late in the nesting cycle or after young have fledged. It is not known whether any of these molting males was breeding. Male Eurasian Sparrowhawks (Newton 1986)

and Sharp-shinned Hawks (Bildstein & Meyer 2000) begin their molt a few weeks after the female, while eggs are still in the nest.

Vocalizations. I heard two main types of adult call, with some variations. A fast series of high pitched notes 'tu tu tu tu tu tu', with a mean rate of 5.9 notes per s (SD = 0.8, n = 30) tended to be used in periods of high activity. This call was given frequently when the nest tree was climbed to take measurements, given by both birds during nest building, usually made by males on arrival at the nest site, and also during mating (Fig. 6a). In all these situations the call sounded the same and produced a similar sonogram. It is similar to what is described as the 'alarm call' of Sharp-shinned Hawk by Bildstein & Meyer (2000), but it was also used in situations such as food deliveries, so I prefer to use 'chattering call' as used by Seipke & Cabanne (2008) to describe similar calls of Rufous-thighed Hawk. The number of notes in each bout was highly variable and seemed to increase with the levels of distress of the birds. Males tended to give a shorter series of notes (mean = 6.9, SD = 4.1, n = 115), compared with females (mean = 15.1, SD = 4.2, n = 50), which might have been related to the types of situations where they were recorded (i.e., nest inspections for females compared to bringing in food for males), rather than being a sexual difference per se. There was variation between individuals (especially males) in the note given, which could be described as ee ee ee ee, or peep peep peep peep, or kyip kyip kyip kyip with other variations also heard. Each individual used one variant consistently.

The other main call had a similar tone, but each note was longer (mean 0.35 s, SD = 0.13, n = 37) with a longer gap in between (0.81 s, SD = 0.14, n = 26) 'eeeeeee - eeeeeee - eeeeeee', with usually 2–6 (mean 3.0, SD = 1.5, n = 189) notes in each bout. I refer to this call as the 'wailing call', the term used to describe a similar call given by Rufous-thighed Hawk (Seipke & Cabanne 2008). The wailing call was only rarely given by the male, but commonly given by the female, especially after mating or after receiving food. It was also the begging call given by recently fledged juveniles, who would give the call for long periods when no adult was present (Fig. 6b). The call of fledglings tended to speed up and rise in pitch during activity, such as when adults arrived with food, or during chases. Recently fledged birds often returned calls, as if dueting, with one bird adopting a slightly higher pitch than the other, even though it was later evident that they could both make calls of the same pitch.

I sometimes heard a slightly longer version of the wailing call that slightly lowered in pitch towards the end, given by birds flying high overhead (unrecorded). On one occasion, this call was made when birds from two different nests mobbed a Short-tailed Hawk (*Buteo brachyurus*). A male gave this call while doing the undulating display flight, and added a rising whistle as it swooped back upwards. Occasionally, birds started off with the wailing call and then changed into the chattering call: the notes and gaps in each case being very similar to when the calls were given separately. There was no observable pattern to when this call was used. On two occasions a high pitched squeal was heard when one member of a pair appeared to attack the other (see agonistic behavior below), though on neither occasion was it clear whether the attacker or the attacked individual made the call.

Males tend to make slightly higher pitched calls than females, which may be related to size differences. Birds almost never called away from the nest site, though I once heard a few 'kyip' calls from a male deep within cloud forest that had approached a group of passerines attracted to 'pishing' during August. Small and medium sized nestlings gave a

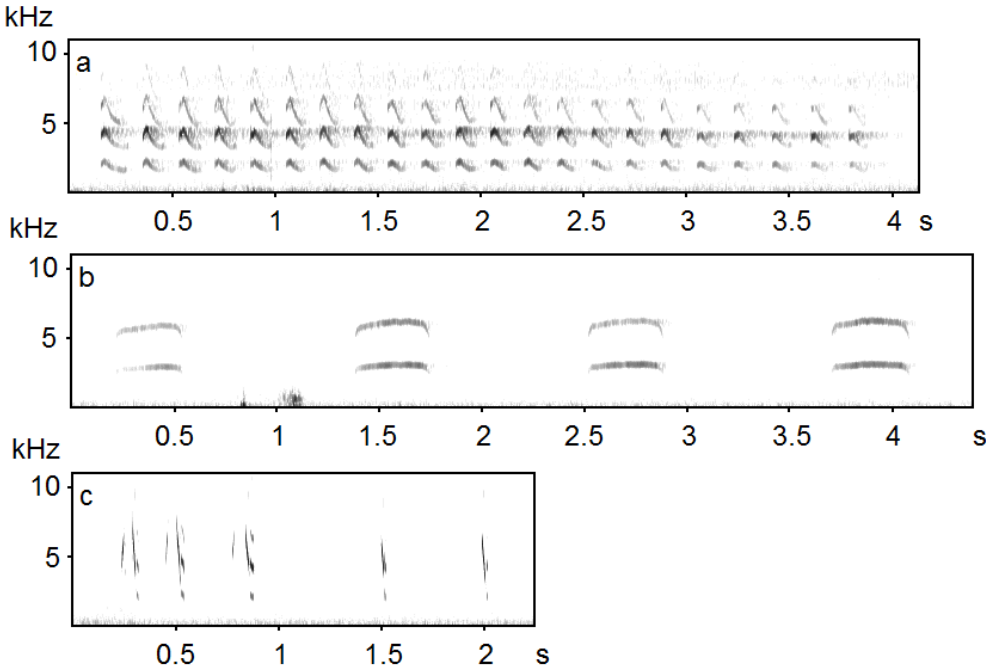

FIG. 6. Sonograms from White-breasted Hawk vocalizations recorded at Cerro El Pericón, Morazán, El Salvador. (a) chattering call of female during climb to check nest, 10 April 2005 (b) begging call (wailing call) of juvenile, 19 June 2004 (c) call of nestling during handling, 10 April 2005.

series of high-pitched 'sip', or 'siwip' calls when handled (Fig. 6c).

White-breasted Hawk chattering and wailing calls are similar to calls of Sharp-shinned Hawk. Rufous-thighed Hawk has similar calls, but some of the chattering calls were slightly slower (averaging 5.3 notes per second, SD = 1.1, n = 7) and lower pitched and the wailing call was shorter and lower pitched. Plain-breasted Hawk calls were similar, with a slower chattering call (averaging 5.4 notes per second, SD = 0.4, n = 7) that was lower in pitch and wailing calls that were shorter in duration, repeated more frequently and a slightly different tone. Small sample sizes limited comparisons between each species, but the South American species combined had significantly slower rates of chattering calls than White-breasted Hawks ($t = 2.3$, $df = 40$, $p < 0.05$). Eurasian Sparrowhawks give a more complex variety of calls than White-breasted Hawks. For example there is a specific call given when the female begs for food, when the male calls the female to collect food, or when the female solicits the male to mate (Newton 1986). Similarly, male and female Sharp-shinned Hawks give distinct calls before a food pass (Bildstein & Meyer 2000). I never had any indication from the sounds heard or sonograms that specific calls were given by White-breasted Hawks in such circumstances.

Food and feeding behavior. Although food of the White-breasted Hawk is widely described as unknown (e.g. del Hoyo *et al.* 1994, Howell & Webb 1995), Dickey & van Rossem (1938) found the remains of small birds in stomach

contents in El Salvador and Edwards & Lea (1955) observed an immature Masked Tityra (*Tityra semisfasciata*) captured by a White-breasted Hawk in Mexico. Of 38 identifiable food items brought to nests by adults at Celaque and Cerro El Pericón, 24 were very small birds (around the size of a warbler), nine were small to medium sized birds, one was a bat, two were lizards, and two were grasshoppers (see Table 4 for identified prey items). Two unsuccessful attacks on Yellow-backed Orioles *Icterus chrysater* and one on an Inca Dove *Columbina inca*, were probably attempts to capture prey, but could have been nest defense. Virtually all observed feeding behavior occurred at the nest site and I do not know whether the food observed is typical of the diet at other times.

The main hunting strategy observed at nest sites was to sit and wait for prey to pass close by before attacking. On a number of occasions, I saw adults fly rapidly from their perch and glide horizontally, or at a slight downward angle, towards a bird and then swoop around in a final chase over the last couple of meters. Although used near the nest, it cannot be assumed that this type of sit and wait strategy was used elsewhere. I saw one hawk unsuccessfully attack a Band-tailed Pigeon flying high along an open valley and the capture of a Barn Swallow (*Hirundo rustica*) also suggests that surprise attacks in forest are not the only means of attack. On several occasions hawks were seen to close wings and dive downwards in a stoop, but it was never possible to determine if these were an attacks on prey. On several occasions I saw a bird suddenly drop to the ground from a perch as if to capture something on the ground. The only prey item successfully caught by this method was a lizard.

On two occasions away from known nest sites a White-breasted Hawk came in close to me while I made pishing sounds to attract small passerines. On both occasions, the hawks came in much closer to me than any individual has ever done away from a nest site, suggesting that they were attracted to the sounds. No passerines had been attracted before one hawk arrived, suggesting that it was the pishing sound rather than the aggregation of birds that attracted the hawks.

Food was delivered to the nest site at a rate of 1.9 items per day during the nest-building stage, 1.4 during the incubation stage, 3.6 during the nestling stage, and 6.7 after fledging. I never saw food brought during courtship prior to nest building. Remains were rarely found near the nest when nestlings were quite small, and those that were found were from small passerines. Once females began hunting to feed larger nestlings, the remains of larger food items (such as the non-passerines in Table 4) were found. The largest recorded prey item was a Band-tailed Pigeon, which weighs approximately 315 g (Stiles & Skutch 1989). Females spent progressively less time at the nest as the nestlings grew (Table 5), and presumably more time hunting. However, the rate of delivery of food items dropped over the nestling period from a daily rate of 4.4 items per day for small nestlings (barely visible in the nest) to 3.0 for both medium (downy and in pin) and larger nestlings (down mostly lost). The drop in the number of deliveries may have been offset by the increase in size of food items delivered, as in Eurasian Sparrowhawk (Newton 1986).

Avian prey delivered to females by males was mostly plucked, or partially plucked, while fledglings were mostly given unplucked birds. Food was passed to females in the air, or by the male standing on the food and then flying up at the last moment, leaving the food on the branch for the female to take as she flew past.

All 18 pellets examined (nine from under plucking posts and nine found in nests) contained feathers and I found no remains of reptiles or mammals. Four adult pellets and

TABLE 4. Identified prey items of White-breasted Hawks, from observations of prey captured or brought to nests, and remains near the nest.

English name	Scientific name	Evidence	Source
Band-tailed Pigeon	*Patagioenas fasciata*	Remains	This Study
White-winged Dove	*Zenaida asiatica*	Remains	This Study
White-tipped Dove	*Leptotila verreauxi*	Remains	This Study
Turquoise-browed Motmot	*Eumomota superciliosa*	Observed prey	This Study
Domestic chicken	*Gallus domesticus*	Remains	This Study
Barred Antshrike	*Thamnophilus doliatus*	Remains	This Study
Masked Tityra	*Tityra semifasciata*	Observed prey	Edwards & Lea 1955
Bushy-crested Jay	*Cyanocorax melanocyaneus*	Remains	This Study
Barn Swallow	*Hirundo rustica*	Observed prey	This Study
Rufous-naped Wren	*Campylorhynchus rufinucha*	Observed prey	This Study
Brown-backed Solitaire	*Myadestes occidentalis*	Observed prey	This Study
Clay-colored Thrush	*Turdus grayi*	Observed Prey	Adam Narish pers. com.
Swainson's Thrush	*Catharus ustulatus*	Remains	This Study
Magnolia Warbler	*Dendroica magnolia*	Remains	This Study
Black-throated Green Warbler	*Dendroica virens*	Observed prey	This Study
Wilson's Warbler	*Wilsonia pusilla*	Observed prey	This Study
Rufous-capped Warbler	*Basileuterus rufifrons*	Observed prey	This Study
Bat	sp.	Observed prey	This Study
Lizard	sp.	Observed prey x 2	This Study
Giant Brown Cricket	*Tropidacris dux*	Observed prey x 2	This Study

six nestling pellets contained remains of small insects, and one contained small seeds. The origin of these cannot be determined, but they presumably came from the stomach contents of avian prey.

Body maintenance. Preening sessions at nest sites lasted up to 90 minutes, usually with short breaks, and occurred at any time of the day, though longer sessions were more common in the afternoons. Sometimes males and females preened together, especially after mating. Downy nestlings also preened. Water was not present at any nest sites, so no bathing was observed, though van Rossem collected a bird splashing in shallow water at the edge of a rocky stream (Dickey & van Rossem 1938).

I saw hawks regurgitating pellets on 13 occasions. All were before 13:00 h, but there was no time in the morning when it was particularly common. Pellets found under perches used by adults and fledglings averaged 0.23 g (SD = 0.06, n = 9) in mass and measured 21 x 11mm. Pellets found in nests, presumably from nestlings, were smaller and averaged 0.08 g (SD = 0.02, n = 9) in mass and measured 15 x 8 mm. Defecation of adults was recorded on 19 occasions at scattered times throughout the day. On five occasions, fledglings stood up and squirted feces over the edge of the nest.

Roosting. This behavior was observed at nest sites in pine (high in the main canopy) and in broadleaf trees. Hawks roosted on branches near the main trunk in dense foliage, presumably to break up the silhouette and stop aerial predators from approaching undetected. Incubating females roosted on the nest. I had no opportunity to observe roosting away from nest sites.

TABLE 5. Percentage of time that male and female White-breasted Hawks were present at the nest site during each stage of the nest cycle. Nestling sizes are estimates, with small nestlings referring to those around the age where they have their first down; medium nestlings meaning those with the second coat of down but no contour feathers and large nestlings referring to those with growing juvenile plumage.

Stage in nest cycle	Male % time at nest	Female % time at nest
Nest-building	45.2	69.2
Eggs	38.5	100
Small nestlings	42.8	100
Medium nestlings	26.4	89.5
Large nestlings	11.1	47.9
Fledglings	<1	<1

Agonistic behavior. The only major fight between two White-breasted Hawks occurred in poor light at 05:50 h on 1 November when I saw two males tussling on the ground on a dirt road through open farmland between two nest sites. The initial interaction was not observed. I saw a male display then fly towards another male in flight about 100 m away and dive at it. On two occasions a male chased another male out of the nesting area and a female pecked at an intruder male that tried to mate with her. There were two aggressive interactions between males and females that were probably mated pairs. One was a female that dived at a male that did not pass food to her after a display; the other was a male that dived at a female that would not mate when solicited. No agonistic interactions were observed between females.

Predators and human disturbance. I saw White-breasted Hawks mobbing a Variegated Squirrel, a Red-tailed Hawk (*Buteo jamaicensis*), Short-tailed Hawks, a Turkey Vulture, a Black Vulture (*Coragyps atratus*), and Bushy-crested Jays. Although Bushy-crested Jays formed part of the hawks' diet, several attacks appeared designed to remove them from the nest area rather than capture them, because long after the element of surprise had been lost, they would continue the chase. Webber & Brown (1994) came to a similar conclusion after observing a White-breasted Hawk chase a juvenile Unicolored Jay (*Aphelocoma unicolor*), then pass it in flight without capturing it. On one occasiona male left the nest site and joined another male to mob a Short-tailed Hawk. The first male had possibly come from another nest located 260 m away in the direction from which the birds arrived.

There is little evidence that White-breasted Hawks are much disturbed by human presence. Many of the nests were within a few meters of paths and dirt roads and several were within 100 m of active farmhouses. At nearly all nests I was able to approach within about 20 m of birds without any obvious signs of agitation.

CONCLUSION

White-breasted Hawks share many characteristics with congeners, such as Sharp-shinned Hawks (Delannoy & Cruz 1988), Rufous-thighed Hawks (Seipke & Cabanne 2008), and Eurasian Sparrowhawks (Newton 1986). One of the main differences between White-breasted Hawks and other members of the Sharp-shinned Hawk complex already studied is the early onset of the post-juvenile molt, with most White-breasted Hawks molting out of juvenile plumage before the start of the nesting season. The proportion of White-breasted Hawks nesting in their first year was also higher than in related species. Adult Eurasian Sparrowhawks tended to mate with other adults and yearlings with other yearlings (Newton 1986), which was not the case with White-breasted Hawks. An early post-juvenile molt may increase the chances of breeding in the first year and of pairing with

experienced partners. The degree of stability of the Cerro El Pericón population was not determined, which is a factor that can also affect recruitment of yearlings into a population (Squires & Kennedy 2006).

White-breasted Hawk vocalizations are more similar to Sharp-shinned Hawk than to either of the South American forms, though they have a more simplistic vocal repertoire. The timing of molt and the down coloration of nestlings also highlight differences between Sharp-shinned and White-breasted Hawks. Of 102 records of Sharp-shinned Hawks in the SalvaNATURA database, only four occurred before October, by which time most juvenile White-breasted Hawks have molted and formed pairs. The early onset of courtship to precede the arrival of most wintering Sharp-shinned Hawks and the distinctive flashing of the white underparts during courtship are possible isolating mechanisms.

White-breasted Hawks at Cerro El Pericón nested at higher densities than in any of the Sharp-shinned hawk studies reviewed by Bildstein & Meyer (2000). This might be explained by the way they use different habitats, defending only a small nesting territory in pine forest, but hunting over a much wider home range with different habitats. IUCN and BirdLife International do not recognize the White-breasted Hawk as separate from the Sharp-shinned Hawk and therefore there is no information on its status on the global red list (BirdLife International 2009). Although White-breasted Hawks have a very limited distribution, local forestry practices are likely to ensure that the habitat is not lost. I would therefore suggest that the White-breasted Hawk, if treated as a full species, should be considered a species of least concern. No systematic phylogenetic study or DNA comparison has been made of groups within the Sharp-shinned Hawk complex and it seems unlikely that any firm conclusions about taxonomic relationships can be made until this is done.

There are still many aspects of White-breasted Hawk biology in need of study. Almost nothing is known about their biology outside of the breeding season, away from nest sites, or of non-breeders. Movement data collected from birds fitted with radio transmitters would help answer many questions about the way the hawks use the wide variety of habitats at their disposal. It would be interesting to know whether their use of these habitats correlates with abundance and fledging of resident prey species, whether they adapt their hunting behavior according to the habitat they are in, and whether they use different habitats for different activities throughout the day or at different times of the year. Satellite tracking would provide data on movements of adults and dispersal of juveniles and help to determine whether the species shows any regular migratory habits. The effects of White-breasted Hawks on local bird species also warrants further study, as do the factors affecting White-breasted Hawk population dynamics.

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