

OBSERVATIONS ON THE ECOLOGY OF THE BLACK-AND-CHESTNUT EAGLE (*Oroaetus isidori*) IN A MONTANE FOREST OF SOUTHEASTERN PERU

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Resumen. – **Observaciones de la ecología del Aguila Poma (*Oroaetus isidori*) en un bosque montano del sureste del Perú.** – El Aguila Poma (*Oroaetus isidori*) es una de las especies de aves rapaces tropicales menos conocida. Iniciamos la búsqueda de individuos en un área de bosque montano en el sureste del Perú y realizamos observaciones del comportamiento de esta especie. Durante los 10 meses de nuestro estudio, observamos a Águilas Pomas durante 25,8 del total de 1370 h que pasamos buscando a esta especie. No encontramos una diferencia significativa en nuestra habilidad para detectar a las águilas durante los meses de nuestro estudio. Pudimos identificar dos parejas y al menos un juvenil. Entre las diferentes actividades observadas, la más frecuentemente detectada fue el remonte de vuelo, el cual alcanzó un 53% del total de nuestro tiempo de observación, seguido de percheo (27%), vuelo activo (16%) y caza (4%). Desde Octubre del 2000 a Julio del 2001, las águilas adultas fueron frecuentemente observadas remontando en pares. Documentamos 12 eventos de interacción de pareja y un apareamiento. Ocho de los 11 eventos de caza observados fueron exitosos. Típicamente, las presas, roedores en su mayoría, fueron obtenidas de la cima de los árboles. En cuanto a encuentros interspecíficos, observamos tan sólo breves interacciones entre el Águila Poma y otras especies de rapaces, lo cual sugiere una clara partición del hábitat y recursos en la comunidad de rapaces del bosque montano. Aunque se considera que el Águila Poma mayormente habita elevaciones intermedias en bosques nubosos, durante nuestro estudio observamos individuos a elevaciones que van de 920 a 3165 m s.n.m, lo que contribuiría con la posibilidad de una gran flexibilidad en el uso de hábitat en un amplio gradiente altitudinal.

Abstract. – The Black-and-chestnut Eagle (*Oroaetus isidori*) is one of the least-studied tropical raptors. We surveyed for and observed the behavior of this species in a montane cloud forest in southeastern Peru. During our 10-month study, we observed Black-and-chestnut Eagles for 25.8 h of the 1370 h that we spent searching for them. There was no significant monthly variation in our ability to detect the eagles. We identified two pairs and at least one juvenile. Soaring was the most frequent activity detected, and comprised 53% of our total observation time, followed by perching (27%), non-soaring flight (16%), and hunting (4%). Pairs of Black-and-chestnut Eagles often soared together and, between October and July 2000, we documented 12 pair-bonding or pair-maintenance interactions and witnessed one mating event. Eight of the 11 hunting attempts that we observed were successful. Hunting eagles typically selected prey from the canopy and rodents appeared to be the most commonly taken prey item. We saw little overt aggression between Black-and-chestnut Eagles and other raptor species, suggesting that habitat and resource partitioning may be clearly delineated among cloud forest raptors. Although Black-and-chestnut Eagles are classified as dwellers of mid-

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elevation cloud forests, we observed individual eagles at elevations from 920 to 3165 m a.s.l. This may suggest a great flexibility in their use of habitats over a high altitudinal gradient. *Accepted 27 June 2003.*

Key words: Black-and-chestnut Eagle, ecology, Isidor's Eagle, Manu Biosphere Reserve, Neotropics, *Oroaetus isidori*, Peru, raptors, tropical montane forest.

INTRODUCTION

Because of the remoteness and isolation of many tropical montane forests, these habitats and many of their inhabitants are little studied. Secretive species, such as many birds of prey, are among the least-known organisms in montane forests of the Neotropics (Thiollay 1985, 1994, Valdez 1999).

One of the least-studied raptor species is the Black-and-chestnut Eagle (*Oroaetus isidori*), formerly known as Isidor's Eagle. Black-and-chestnut Eagles are elusive large forest raptors whose distribution is limited to montane cloud forests of Andean slopes from northeastern Colombia and northwestern Venezuela to Ecuador, eastern Peru, Bolivia and northwestern Argentina (del Hoyo *et al.* 1994, Ferguson-Lees & Christie 2001, Ridgely & Greenfield 2001). This species is considered local and rare throughout its range (Hilty & Brown 1986, Fjeldsa & Krabbe 1990, Collar *et al.* 1994). Only a few reports provide information about the natural history of this species (Lehmann 1959, Strewe 1999, Marquez & Rengifo 2002, Hilty pers. com.).

To learn about the biology and ecology of this poorly known species in the southern portion of its range, we surveyed for individuals in a montane forest that comprises an area adjacent to Peru's Manu Biosphere Reserve. In the course of surveying, we conducted behavioral observations and documented a number of hunting attempts by Black-and-chestnut Eagles, as well as their interactions with other raptor species.

METHODS

Study site. We conducted our study for a total of 10 months between July 2000 and July 2001. Our study site was located in the Cosñipata river drainage on the eastern slopes of the southern Peruvian Andes between the localities of Pillahuata (13°09'47"S and 71°35'42"W) and Llauchayoc (13°02'22"S and 71°30'26"W) in the department of Cusco. Access to this area was only possible by a dirt road from Cusco to the Pilcopata valley. The study area consisted primarily of pristine montane cloud forest in approximately 5100 ha within the Cloud Forest Private Reserve, and adjacent forest to the southern edge of Manu Biosphere Reserve (Fig. 1). Elevation ranged from 1000 to 2800 m a.s.l. Depending on the elevation, mean annual temperature ranged from 8 to 18°C, while annual precipitation ranged from 4510 to 5470 mm (National Meteorological System report). Low clouds and fog occurred throughout the year. The primary habitat type found in the study area was montane tropical forest (also known as cloud forest) consisting of dense vegetation dominated by the families Moraceae, Euphorbiaceae, Melastomataceae, Clusiaceae and Lauraceae. Epiphyte vegetation in the area was abundant and it consisted mainly of Bromeliaceae, Orchidaceae and bryophyte species (Palomino 1999).

Surveys and behavioral observations. We conducted road surveys along 25 km of the Cusco-Pilcopata road (between Pillahuata, 2800 m a.s.l. and Llauchayoc, 1100 m a.s.l.). Two people slowly walked or drove along the

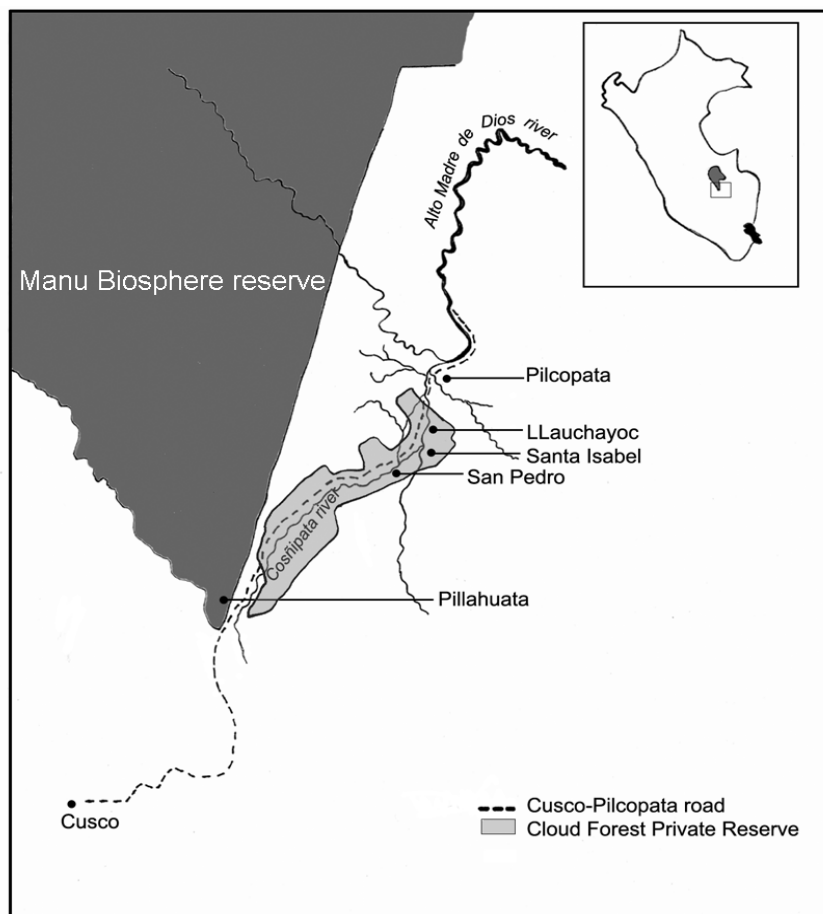


FIG. 1. Location of study area in the Cosñipata Valley and Manu Biosphere Reserve.

road and intensively searched for Black-and-chestnut Eagles. We also conducted stationary surveys from selected viewpoints along this 25 km stretch of road. Every time a Black-and-chestnut Eagle was spotted, we recorded both the location from which we had made our sighting using a GPS and the eagle's behavior at first observation (instantaneous sample). We then continued to observe the individual until it moved out of view. Activities that we recorded in our instantaneous sampling were flapping flight (hereafter flying), gliding, soaring, perching, calling, hunt-

ing, and feeding. In addition, we documented any interspecific or intraspecific interactions that we observed.

Data analysis. We calculated mean time per observation-hour (min/obs-h) that we recorded each of the Black-and-chestnut Eagles' activities in each month of our study. Using analysis of variance (ANOVA), we then determined the monthly variation for each activity. We used a t-test to compare variations in "cool" (more than 75% cloud cover) and "warm" days (less than

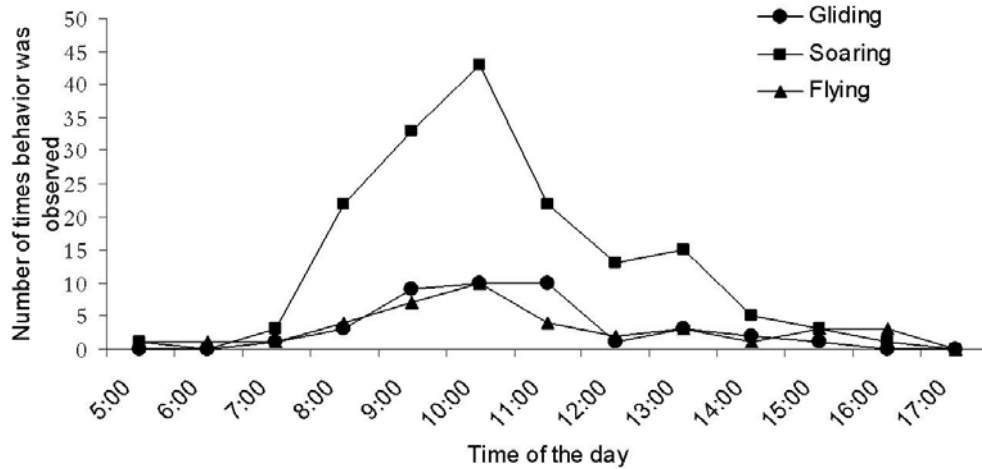


FIG. 2. Diurnal pattern of flying, gliding and soaring behavior of Black-and-chestnut Eagles at the Cosñipata Valley, southeastern Peru.

75% cloud cover). We used a χ^2 test to examine the proportion of time that the eagles spent in the different behaviors observed. Finally, we determined the frequency and amount of time that we observed juvenile activity (# times/month and min/month), as well as adult-pair and juvenile interspecific interactions.

RESULTS

Surveys. We saw our first adult Black-and-chestnut Eagle on 15 August 2000, after 29 days searching in the area. Subsequently, we determined the presence of at least five individuals in the study site. We spent a total of 1370 h actively searching for Black-and-chestnut Eagles, and we were able to see and observe them for 2% of that time (25 h, 48 min). These observations represented a mean of 3.13 min/obs-h. The average time/obs-h during the study period was highest in January and March of 2001 (4.6 min/obs-h and 5 min/obs-h, respectively) and lowest in October of 2000 (1.9 min/obs-h). However, this monthly variation was not significantly differ-

ent along the study period ($F = 0.56$, $df = 7$, $P = 0.78$).

Of the two pairs of Black-and-chestnut Eagles we identified in our study area, one was most frequently seen in forests at higher elevation in the Pillahuata area, and the other pair in the forest of the San Pedro area. Both areas were in the Cosñipata River basin (Fig. 1). On several occasions between October 2000 and April 2001, the pair from the San Pedro area was accompanied by an immature individual. At least one immature was observed with the adult birds an average of 2.25 times/month (highest for October: 10 times/month) and for a total of 111 min during these months (highest for February, 58 min/month). No immature individuals were recorded with the San Pedro adults after April 2001.

Behavior. We concentrated most of our behavioral observations on the San Pedro area Black-and-chestnut Eagles, since they were most readily observed without interference of low clouds and fog. The San Pedro area which also included the Santa Isabel locality was the

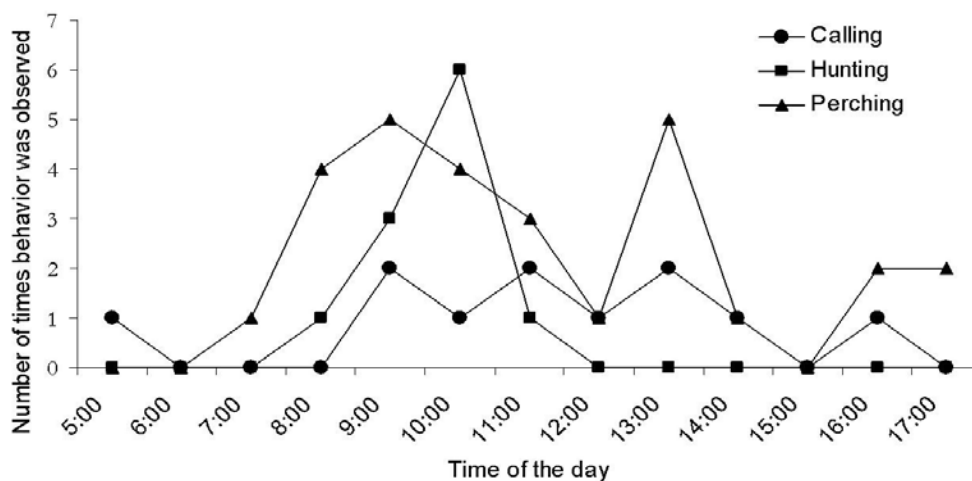


FIG. 3. Diurnal pattern of calling, hunting and perching behavior of Black-and-chestnut Eagles at the Cosñipata Valley, southeastern Peru.

beginning of a wider region of the Cosñipata valley and ranged from 1200 to 1600 m a.s.l. The area was constantly visited by the eagles and consisted of primary forest on the ridges and slopes, and secondary succession dominated by bamboo thickets at the base of the hills and near the river. We typically began seeing these large raptors during the morning hours between 07:30 and 08:00 h. Most sightings of Black-and-chestnut Eagles occurred between 09:00 and 11:00 h. Slight variations in the timing of sightings were dependent on the behavior observed. We observed flying, most often between 08:00 and 11:00 h, as well as soaring and gliding (Fig. 2). Whereas, soaring observations reached a peak between 09:00 and 10:00 h, observations of gliding did not show a defined peak. We also observed hunting behavior most often between 09:00 and 10:00 h (Fig. 3). We observed perching activity mostly by 9:00 and 13:00 h, while we registered calling activity throughout the day (Fig. 3).

Not surprisingly, given the relative ease of viewing soaring raptors, we found that soaring was the most frequently detected behavior

(6.25 times/obs-h), followed by gliding (1.5 times/obs-h), flying (1.5 times/obs-h), perching (1.08 times/obs-h), calling (0.4 times/obs-h) and hunting (0.2 times/obs-h). Of the total amount of time that we recorded the observed Black-and-chestnut Eagles (25 h 45 min), we found that they spent the majority of time soaring (53%), followed by perching (27%), brief flying (13%), hunting (4%) and gliding (4%). Nevertheless, the proportion of time the eagles spent in each type of activity was probably correlated with the ease of viewing that activity. The amount of time that the eagles spent in these activities was significantly different from expected, if assuming randomness of patterns ($\chi^2 = 2330.5$, $df = 7$, $P < 0.001$).

Black-and-chestnut Eagles soared along the mountain ridges for long periods of time (up to 1–2 h), and we did not find any difference in this pattern between warm or cool days ($t = 0.64$, $df = 22$, $P = 0.52$). We also found Black-and-chestnut Eagles soaring in the same areas and at the same time of day on sequential days a total of 23 times. Black-and-chestnut Eagles soared at high altitudes in

TABLE 1. Hunting attempts and prey of Black-and-chestnut Eagles (*Oroaetus isidori*) in the Cosñipata valley, southeastern Peru.

Date	Location	Hunting attempt	Prey attacked or captured
3 October 2000	San Pedro area	Successful	Unidentified small-sized bird
1 April 2001	Santa Isabel ¹	Successful	Unidentified
29 April 2001	Santa Isabel	Successful	Rodent (Sciuridae)
14 May 2001	Santa Isabel	Successful	Unidentified small rodent
12 May 2001	Santa Isabel	Successful	Woolly monkey (<i>Lagothrix lagotricha</i>)
20 May 2001	Santa Isabel	Successful	Unidentified small rodent
20 May 2001	Santa Isabel	Unsuccessful	Columbidae
25 May 2001	Santa Isabel	Unsuccessful	Scaly-naped Parrot (<i>Amazona mercenaria</i>)
3 July 2001	Upper San Pedro area	Unsuccessful	Columbidae
6 July 2001	Santa Isabel	Successful	Rodent (Sciuridae)
10 July 2001	San Pedro area	Successful	Rodent (Sciuridae)

¹Santa Isabel: wide part of the Cosñipata valley (1200 m a.s.l.) that was frequently used by the Black-and-chestnut Eagle San Pedro pair, and possibly served as a main hunting territory.

pairs or by themselves. In addition, the eagles frequently soared with other species of raptors. The eagles typically interspersed soaring with gliding along mountain ridges or above valleys.

We observed perched individuals a total of 28 times. On all but one of those occasions, Black-and-chestnut Eagles favored branches with medium to heavy canopy covering them. The lone exception was when we observed an eagle perched in a snag on top of a ridge.

We witnessed 11 hunting attempts, eight of which were successful. The eagles appeared to use one of two strategies once they spotted possible prey. If the prey was above or close to the canopy, the eagle stooped down to attack directly and rapidly. If the prey was in the forest interior, the eagle came down to perch in a strategic place from which it attacked. We were able to identify the prey items at least to the family level for most of the hunting attempts that we witnessed (Table 1).

During our observations, the San Pedro adult pair of Black-and-chestnut Eagles was detected soaring together a total of 44 times

or 1.7 times/obs-h. Joint soaring was observed for a mean time of 6.7 min/obs-h. On a few occasions, we observed the pair crabbing (establishing physical contact by locking their talons). Between October and July, we documented 12 pair-bonding or pair-maintenance interactions between male and female Black-and-chestnut Eagles. These interactions usually consisted of synchronized flights, in which the male flew above the female and shadowed her every move. During the course of these flights, the male would often stoop at the female who would turn and present her talons and together came down cart-wheeling from the sky toward the forest canopy. On 26 April 2001, we observed a copulation event between the San Pedro pair. The female was perched on a branch under the canopy and the male was soaring above and both were calling constantly. The male came down to the branch where the female was and copulated with her and a moment later flew away. After few minutes both individuals were soaring together above the valley. We observed additional courtship displays between the pair of eagles in the San Pedro area in May 2001. Despite extensive nest

searching efforts, we were unable to find a nest site. We did, however, observe the San Pedro pair carrying nesting material in June 2001.

We observed Black-and-chestnut Eagles soaring together with Solitary Eagles (*Harpohaliaetus solitarius*) on 20 occasions and in the same general area on 30 occasions. Although we saw no overt evidence of aggression or competition between the two species, we did witness escorting behavior (Bildstein & Collopy 1985) on at least one occasion. On 10 October 2000, we observed a pair of Solitary Eagles escorting a Black-and-chestnut Eagle out of an area across from a drainage in which the Solitary Eagles were nesting. A day earlier, we saw a possible instance of a Black-and-chestnut Eagle escorting a pair of Solitary Eagles out of a nearby area.

Occasionally, when close to Turkey Vultures (*Cathartes aura*), Black-and-chestnut Eagles were observed to be aggressive toward them. Other species of raptors, such as Black and White Hawk-eagle (*Spizastur melanoleucus*), Gray-headed Kite (*Leptodon cayanensis*), Roadside Hawk (*Buteo magnirostris*) and White-rumped Hawks (*Buteo leucorrhous*), that were observed soaring or flying close to Black-and-chestnut Eagles, did not seem to elicit any aggressive response. Although we also registered Semi-collared Hawk (*Accipiter collaris*), Bicolored Hawk (*Accipiter bicolor*) and migratory flocks (up to 80 individuals) of Swallow-tailed Kite (*Elanoides forficatus*) in our study area, we did not observe these species in any kind of interaction or flying at the same time with Black-and-chestnut Eagles.

DISCUSSION

The montane forest of the Cosñipata drainage in southeastern Peru seems to be a suitable habitat for Black-and-chestnut Eagles, although the species is not common in the area. We were able to find at least five Black-

and-chestnut Eagles in our study area during a 10-month period. One adult pair was in the Pillahuata area and another pair, which was seen on several occasions in the company of an immature, used the San Pedro area. The difference in the elevation of these two areas is approximately 1700 m and is reflected by a concomitant change in habitat physiognomy. At higher elevations, the air is relatively cooler with less clouds and fog. Vegetation is more sparse and bushy, whereas at lower elevations, where clouds and fog are more prevalent, the forest is relatively taller and vegetation is considerably denser. It seems that Black-and-chestnut Eagles, despite their rarity, may be more flexible in their use of habitats over a large altitudinal gradient than other species of raptors. Despite that this species of eagle is typically classified as a dweller of mid-elevation cloud forests, it has been reported on a few occasions at elevations higher than 3000 m a.s.l. (Hilty & Brown 1986, Fjeldsa & Krabbe 1990, Marquez & Renjifo 2002). Although we observed Black-and-chestnut Eagles more frequently from 900 to 2500 m a.s.l., we also found a Black-and-chestnut Eagle at 3165 m a.s.l. which may contribute to the probability that this species would also live at higher elevations. Considering these reports, the remoteness and pristine state of higher-elevation montane forests, their usually limited access, and the scarce knowledge of these ecosystems, it may be that forests at higher altitudes are also used by this species of eagle more than commonly suspected.

In our study area, Black-and-chestnut Eagles were challenging to find because of the steep, rugged topography and the dense forest that they inhabit. Nevertheless, once daily activity patterns were identified and observed over a period of several days, their behavior became more predictable. For example, we were able to find eagles at about the same location and time of day on sequential days. As is the case with many other raptor species

(Brown & Amadon 1968), Black-and-chestnut Eagles seem to have some consistent habits. Even after identifying certain daily patterns, however, it was extremely hard to follow the eagles for extended periods and obtain more extensive behavioral data because of the limitations imposed by their inaccessible habitat. The eagles' cryptic plumage further limited our ability to follow their movements over and into the forest canopy.

We did not find a significant monthly variation in our ability to detect Black-and-chestnut Eagles. As in many other tropical habitats, the cloud forest that comprised our study area was not prone to extreme seasonal weather changes. It is therefore likely that the activity of Black-and-chestnut Eagles is not highly affected by seasonal climate. Furthermore, we found no difference in our ability to detect the activity of the eagles on warm vs cool days. Daily temperatures in cloud forest areas varied more through the course of a day than between months. It seems likely that Black-and-chestnut Eagles are adapted to these particular weather conditions and may be active through a large range of temperatures.

Lehmann (1959) reported that Black-and-chestnut Eagles hunted mostly domestic chickens, arboreal mammals (mostly squirrels) and birds. Marquez & Renjifo (2002) compiled occasional observations of prey items such as guans, woolly monkeys (*Lagothrix lagotricha*), and chickens. Despite the fact that arboreal mammals such as woolly monkeys and brown capuchin monkeys (*Cebus apella*) commonly occurred in the study area in loud and conspicuous troops, and also are favored prey of other large Neotropical forest raptors, we saw no evidence that Black-and-chestnut Eagles commonly hunt this prey item. We observed a Black-and-chestnut Eagle catching a woolly monkey only once. Like Lehman (1959), we found rodents to be the most commonly observed prey item. While chickens belonging to a few villagers were present in

the area and presumably available, we never observed Black-and-chestnut Eagles attempting to hunt them. It may be that the habitat in our study area still supports a healthy enough prey base that eagles did not need to resort to feeding on non-native prey. Alternatively, Black-and-chestnut Eagles may be able to take other readily available bird prey items such as parrots or pigeons (as we observed), and maybe even other birds such as guans, oropendolas or trogons that seem common in the area. However, we suspect that the primary reason why Black-and-chestnut Eagles did not target chickens in our study area may be related to their tendency for taking prey from the canopy, rather than from the ground. Additional observations on this species of eagle will allow us to characterize its diet and hunting strategies more appropriately.

Five nests have been previously reported for Black-and-chestnut Eagles, three in Colombia (Lehmann 1959, Strewe 1999, Marquez & Rengifo 2002), one in Venezuela, and one in Bolivia (Hilty & Brown 1986). Our observations of adult-young interactions suggest that immature birds, like those of other large tropical raptors, remain with their parents and continue to be fed for several months after they fledge. At least one of the immature birds we saw was in first-year plumage (i.e., based on the coloration of its body and wings, which had some white speckling). This individual was last seen with the adults in May, after which we believe it dispersed as adult courtship and mating behavior began with the onset of the breeding season. Breeding beginning around mid-May and a nesting period between July and the end of August would be consistent with the time of nesting reported from Bolivia (Hilty & Brown 1986).

Black-and-chestnut Eagles did not act aggressively when interacting with other raptor species, which suggests that habitat and resource partitioning, may be clearly defined

among the raptors in the area. We observed Black-and-chestnut Eagles flying together with similar-sized Solitary Eagles and using the same areas at the same time, suggesting that they are not direct competitors. Whereas we observed Solitary Eagles hunting almost exclusively on snakes, we never saw a snake attacked or carried by Black-and-chestnut Eagles, suggesting that the two species exhibit a certain degree of resource partitioning.

The conservation status of the Black-and-chestnut Eagle is known for only a few countries of South America, primarily those in which it is considered to be highly threatened in Argentina and Bolivia, and endangered in Colombia (Collar *et al.* 1994, Marquez & Renjifo 2002). One of the factors that may contribute to the future survival of this species in Peru is the relatively high level of conservation of the cloud forest of the southeastern region of the country. The difficult access to these areas, the control of the human activities in the area by park rangers, the active support of conservation organizations, the private ownership of protected land, and the reinforcement of the Peruvian legislation in Manu Biosphere Reserve, may be contributing to still maintain these vulnerable habitats. Thus, it is possible that these habitats can still sustain viable populations of Black-and-chestnut Eagles. Nevertheless, a better understanding of the factors affecting this species' distribution and abundance is needed before its conservation status in Peru can be determined.

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