ORNITOLOGÍA NEOTROPICAL
(2016) 27: 113–120

ORIGINAL ARTICLE

Sociedad de Ornitología Neotropical

DOMESTIC FOWL IN THE DIET OF THE BLACK-AND-CHESTNUT EAGLE (*SPIZAETUS ISIDORI*) IN THE EASTERN ANDES OF COLOMBIA: A POTENTIAL CONFLICT WITH HUMANS?

Santiago Zuluaga[1,2,3] & María Ángela Echeverry-Galvis[4]

[1]Fundación Proyecto Águila Crestada-Colombia (PAC-C) Calle 9 #1b-55bis Villamaría, Caldas, Colombia, 176007.

[2]Corporación Autónoma Regional del Guavio (CORPOGUAVIO) Carrera 7 #1A-52 Gachalá Cundinamarca, Colombia, 251250.

[3]Fundación para el Manejo y Conservación de los Ecosistemas Neotropicales Cra 32 #25ª-29 Bogotá D.C, Colombia, 111321.

[4]Departamento de Ecología y Territorio, Facultad de Estudios Ambientales y Rurales, Pontificia Universidad Javeriana, Transversal 4 #42-00, Piso 8 Bogotá, Colombia, 110231.

E-mail: Santiago Zuluaga · zuluagarapaces@gmail.com

ABSTRACT · Large birds of prey, such as the Black-and-chestnut Eagle (*Spizaetus isidori*), are among the most threatened species, due to their high habitat requirements as top predators. In order to develop effective conservation plans for this group, more detailed knowledge of the different aspects of their biology and interaction with human communities is required. We evaluated the nestling diet of the Black-and-chestnut Eagle for three breeding periods using three different methods in the rural area of Gachalá-Cundinamarca, on the eastern slope of the Eastern Cordillera of Colombia. In addition, we surveyed people living in the study area to assess the existence of potential eagle-human conflicts. Of the eight taxa recorded as prey, the Andean Guan (*Penelope montagnii*) was the most frequent (40%), while the House Chicken (*Gallus gallus*) contributed the greatest biomass (47%). Our surveys reveal an estimated yearly loss of one to two domestic fowl individuals per household, with 57% of owners surveyed claimed to have suffered losses. According to the survey results, inhabitants would prefer not to have the eagle breeding close to their houses (< 10 km), and would consider killing eagles if they preyed upon more than five domestic fowl individuals a year. To reduce the threat and the current human-eagle conflict in the area, it is important to consider "win-win" strategies, some of which are already being studied in the area, such as birdwatching initiatives.

RESUMEN · Depredación de aves de corral por el Águila Crestada (*Spizaetus isidori*): ¿un potencial conflicto con humanos?
Especies de grandes rapaces como el Águila Crestada (*Spizaetus isidori*), se encuentran dentro de las especies con mayores amenazas en términos poblacionales debido a los altos requerimientos de hábitat que presentan en su función de depredadores tope. Para elaborar planes efectivos de conservación en este grupo se requiere de un conocimiento más detallado de diferentes aspectos de su biología y de su interacción con las comunidades humanas. Por medio del seguimiento a dos nidos de una pareja reproductiva de Águila Crestada evaluamos la dieta aportada por los adultos al pichón, durante tres periodos reproductivos utilizando tres metodologías diferentes, en la zona rural del municipio de Gachalá-Cundinamarca, flanco oriental de la Cordillera Oriental de Colombia. Asimismo, realizamos encuestas a habitantes de la zona para evaluar el potencial conflicto reportado entre pobladores y águilas. De los ocho taxa que registramos como presas, la Pava Andina (*Penelope montagnii*) fue la presa más frecuente (40%), mientras que la Gallina (*Gallus gallus*) presento la mayor contribución de biomasa (47%). Cincuenta y siete por ciento de los encuestados dicen haber sufrido pérdidas anuales de gallinas, entre 1 y 2 por casa. Según la encuesta realizada, los residentes prefieren no tener la especie cerca de sus viviendas (< 10 km), y considerarían cazar las águilas si estas capturan más de 5 aves de corral al año. Con el ánimo de mitigar el conflicto que se presenta entre el águila y las personas, es importante considerar algunas opciones bajo un esquema de resolución beneficiosa para águilas y humanos, algunas de las cuales ya se están implementando en la zona, como el turismo de observación de aves.

KEY WORD: Andes · Black-and-Chestnut Eagle · Colombia · Diet · Domestic Fowl · Human Conflict · Persecution · *Spizaetus isidori*

Receipt 9 March 2016 · First decision 8 May 2016 · Acceptance 21 July 2016 · Online publication 27 July 2016

Communicated by Jean-Marc Thiollay

INTRODUCTION

The Black-and-chestnut Eagle (*Spizaetus isidori*) is a large forest raptor ranging from 63–74 cm in body length, with feathered legs and rounded wings (Córdoba-Córdoba et al. 2008). It lives in dense, undisturbed montane forest along mountain slopes and occurs in Venezuela, Ecuador, Peru, Bolivia, northern Argentina, and Colombia (Ferguson-Lees & Christie 2001), with the largest populations probably located in Colombia (Lehmann 1959, 1961). It is one of the least known Neotropical birds of prey (Valdez & Osborn 2004), and is considered to be very sensitive to habitat fragmentation and degradation, due to low population densities and large territory requirements (Thiollay 1991). This species is categorized worldwide as Endangered, with an estimated population size of between 250 and 999 individuals (BirdLife International 2015). Estimates from ecological niche models and habitat remnants suggest that, in Colombia, the population may range from 320 to 640 individuals in an estimated area of 16,000 km^2 (Echeverry-Galvis et al. 2014, Renjifo et al. 2014), which would represent more than half of the estimated global population. In the last decade, active nests of this species have only been found in Colombia, Ecuador, and Argentina (Olrog 1956, Strewe et al. 1999, Zuluaga 2012, Aráoz & Aveldaño 2013, Aráoz & Grande pers. comm., P Joost pers. comm.).

The diet of the Black-and-chestnut Eagle is not well studied. Current knowledge is mainly based on anecdotal observations from Colombia, Ecuador, and Peru, from where we know that it preys upon squirrels (*Sciurus* sp.), woolly monkeys (*Lagothrix lagotricha*), capuchin monkeys (*Cebus* sp.), coatis (*Nasuella* sp. and *Nasua* sp.), sloths (*Bradypus* sp. and *Choloepus* sp.), guans (*Chamaepetes* sp. and *Penelope* sp.), curassows (*Crax* sp.), and guacharacas or chachalacas (*Ortalis* sp.) (Lehmann 1959, 1961, Márquez & Renjifo 2002, Freile & Chaves 2004, Valdez & Osborn 2004). It also feeds on other birds of prey (Falconiformes) (Aráoz & Grande pers. comm.) and domestic fowl (*Gallus gallus*) (Lehmann 1959). Historically, predation on domestic fowl by the Black-and-chestnut Eagle has led to a conflict with rural communities (Lehmann 1959, Córdoba-Córdoba et al. 2008), resulting in illegal hunting (Córdoba-Córdoba et al. 2008, Zuluaga 2012, P Joost pers. comm.). Between 1950 and 1959, FC Lehmann obtained the first documented evidence of conflict between the Black-and-chestnut Eagle and rural communities in Colombia and South America (Lehmann 1959, 1961). Hunting to prevent livestock losses constitutes one of the main threats that this species and other large birds of prey face (Sarasola et al. 2010, Acevedo-Charry et al. 2015). As a result, Birdlife International has called for action in determining the hunting pressure on this species, as well as an evaluation of measures that could prevent or reduce this threat (Birdlife International 2015), while generating a better knowledge of this species' biology and habitat requirements.

The conflict, as defined by Redpath et al. (2013), between the eagle and humans can be understand in a two way competition, one for space and the other for food (Treves & Karanth 2003, Inskip & Zimmermann 2009, Carter et al. 2012). The conflict for space arises because this species needs high quality forest, which is being destroyed through human activities, while the conflict for food presents for the perception that the eagle is dangerous for their domestic fowl, mainly House Chickens, which they feed on and occasionally trade. The urgent implementation of conservation measures for the Black-and-chestnut Eagle is needed due to its population declines, low reproductive rate and large territory requirements (Thiollay 1991), as well as habitat loss and hunting pressure (Echeverry-Galvis et al. 2014). The present study aims to: 1) assess the diet of a breeding Black-and-chestnut Eagle pair; 2) determine the perception of the presence and the economic impact generated by domestic fowl predation by the eagle; 3) propose management actions to reduce potential eagle-human conflict in an area previously known to present such conflict.

METHODS

Study area. The study was conducted within the biological corridor "Farallones de Gachalá y Medina," in the department of Cundinamarca, Colombia. The area is located within the buffer zone of two protected areas: a national one, the Chingaza National Natural Park, and a regional one, the Tolima Regional Protective Forest Reserve (Figure 1). The area contains primary and secondary Andean forests, where the most representative tree species are Andean oak (*Quercus humboldtii*), trumpet tree (*Cecropia* sp.), figs (*Ficus* sp.), manzano (*Guarea kunthiana*), mano de oso (*Oreopanax bogotensis*), cassia (*Senna spectabilis*), chuwaca (*Prunus buxfolia*), alstonville (*Tibouchina lepidota)*, wax-tree (*Vismia guinensis*), and encenillo (*Weinmannia cochlearis*) (CORPOGUAVIO-ONF ANDINA 2014).

The two Black-and-chestnut Eagle nests studied were located in the rural area of Gachalá-Cundinamarca, on the eastern slope of the Eastern Cordillera of Colombia, within the jurisdiction of the Corporación Autónoma Regional del Guavio (CORPOGUAVIO) (Autonomous Regional Corporation of Guavio), at a forest remnant surrounded by pastures devoted to live-stock grazing (4°40'30''–4°39'30''N; 73°29'15''–73°28'15''W). We found the first nest (nest 1) on 6 April 2013. It was located on an emerging *Vochysia* sp. tree, 50 m high, at an altitude of 2038 m a.s.l. Due to strong winds in August 2013, the tree fell and the breeding pair built a second nest about 300 m from the original tree. We found the second nest (nest 2) with a nestling, on 14 March 2014; it was placed in an emerging *Ficus* sp. tree, 40 m high, at an altitude of 2080 m a.s.l. The exact hatching day of the nestlings was unknown, and we estimated their age based on plumage and size. In

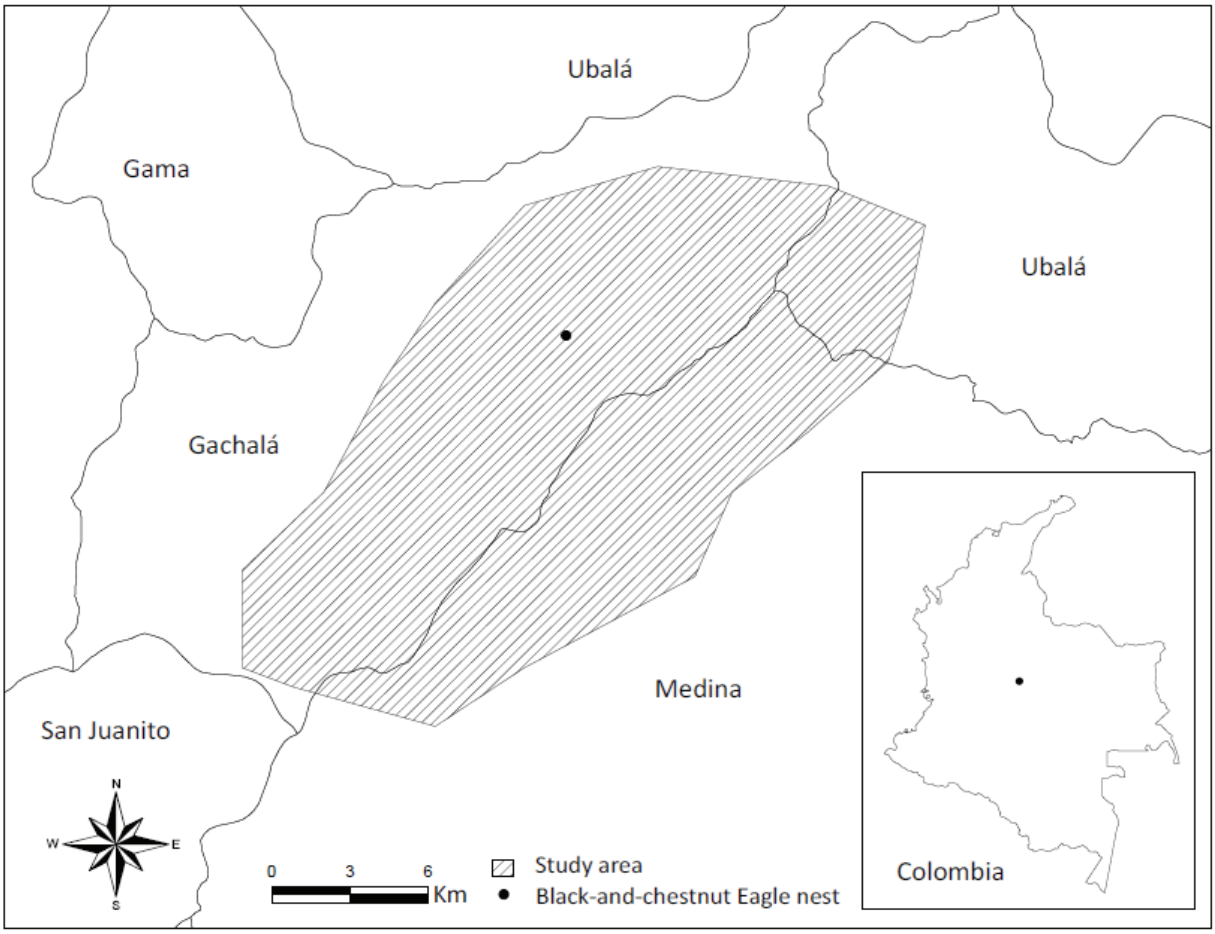

Figure 1. Study area in the biological corridor "Farallones de Gachalá y Medina", Guavio region, Cundinamarca, Colombia. The location of both Black-and-chestnut Eagle (*Spizaetus isidori*) nests is depicted by the black dot.

each breeding attempt and nest we followed, only one nestling was present.

Diet assessment. We collected prey remains from the two nests when the nestlings were between five and six months old, an age at which the young spend much of their time away from the nest. A climber collected prey remains from nest 1 on 27 July 2013, and from nest 2 on 24 July 2014 and 8 July 2015. We set up observation platforms on trees at a similar height as the nests and at a horizontal distance of approximately 50 meters in order to conduct direct observations of the eagles on the nest. We began observations of nest 2 in 14 March 2014 when the nestling was six weeks old, and monitoring took place two days per week for a total of 440 hours of observation during 22 weeks. The observations began between 07:00 and 08:00 h and ended between 17:00 and 18:00 h. During observations, we used binoculars (10x50), photographic cameras, and a monocular spotting scope (20–60x) to identify prey items brought to the nestling. We determined the sex of the parent bringing the prey to the nest by size, given that females are larger than males, as in other raptor species (Ferguson-Lees & Christie 2001). Additionally, when the nestling was around 48 ± 3 days old (March 30, 2015), we placed one camera trap (Bushnell trailcam) approximately 2 m above the nest. The Bushnell trailcam was programmed to record video footage during 10 seconds per hour (24 hours per day). We based prey identification on Hilty & Brown (1986) for birds and Eisenberg (1989) for mammals. In addition, we estimated body mass from literature (Emmons & Feer 1997, Dunning 2007, Tirira 2007), taking into account prey age class (juvenile or adult).

Human perception of eagle's presence and its impact on domestic fowl. To assess the perception of local inhabitants on the presence of the Black-and-chestnut Eagle and possible economic impact of the eagle in the region, we conducted interviews between April and May 2014 on a group of 18 rural communities in the study area (2,706 inhabitants). Interviewees were asked to identify the eagle from a series of illustrations of possible raptors in the area. These human communities are settled in areas surrounding the biological corridor and have a history of conflict with the Black-and-chestnut Eagle (Lehmann 1959, 1961; SZ pers. observ.). We estimated human population sample size based on Bernard's (2006) probabilistic sampling procedure with a confidence interval of 95%, considering that the study area rep-

resents an unequally distributed population (Bernard 2006). Based on such considerations, we randomly selected ten areas of different sizes from a rural information map of the study area provided by COR-POGUAVIO to carry out our surveys.

Data analysis. We calculated total prey biomass in the eagle's diet by multiplying the mean mass of each prey type (Emmons & Feer 1997, Dunning 2007, Tirira 2007) by the observed number of that prey. Prey occurrence, which represents the importance of a prey in the diet, was estimated as the frequency at which a species was brought to the nest. With this value, trophic niche amplitude was estimated using Levins' standardized index (Colwell & Futuyma 1971), based on the following formula: $Bsta = (B–1)/(n–1)$; where B is Levins' index $(B = 1/\sum Pj^2)$, Pj is the percentage of occurrence of each prey species, and n is the number of prey species. This index has a range between 0 (minimum niche amplitude and, consequently, maximum selectivity) and 1 (maximum niche amplitude, minimum selectivity) (Krebs 1999). Although Levin's niche breath is most commonly used in comparisons within studies, presenting this metric allows for comparisons with the dietary niche breadth of other species (Renton 2010).

Based on previous informal conversations with the local communities, we used two different estimates to evaluate the economic impact of the eagle in the rural community. First, families were categorized according to the number of domestic fowl owned, as: a) "small owner" with less than 12 domestic fowl; b) "medium owner" with 12–22 birds; and c) "large owner" with more than 22 domestic fowl, based to the minimum and maximum numbers reported. Likewise, a yearly average loss of domestic fowl by eagle predation was determined from interviews and normalized by the time of the owner's residency in the area, according to the owner's responses. The numbers of individuals lost to the eagle in each ownership category were compared with a Kruskal-Wallis test. We also assessed a possible correlation between the distance to the eagle's nest and the number of fowl lost per year with Spearman's correlation coefficient. Second, we inquired about the perception of the economic impact of domestic fowl loss on the family economy, based on five categories: "very severe impact" (where the family can lose all of their domestic fowl), "severe impact" (in which the family can lose a great part of their birds), "moderate impact" (the family is moderately affected), "slight impact" (the loss is recoverable), and lastly, "very slight impact" (where the loss is minimal). These categories were defined, based on the dialogues and specific language of the inhabitants in the area, given that they rarely quantify the impact of wildlife on their economic activities, making it difficult to specify monetary values.

The interview included the following questions in order to determine how local inhabitants perceived the impact, presence and proximity of the eagle: (1) What would be the minimum acceptable distance between your home and an eagle nest? Possible answers were: > 100 km, > 10 km, between 1 and 10 km, 1 km, and in the owner's backyard; (2) How many individual domestic fowl would you tolerate losing before hunting the eagle? Possible answers were: none, between one and five, up to 10, > 10, and > 50 fowl. Following Kansky et al. (2014), we defined tolerance as "the proportion of individuals who have a higher acceptance toward the species despite suffering damage." Considering the yearly average loss of domestic fowl and the distance between the eagle's nest and each house, we classified the possible answers in three types of tolerance categories: high, neutral and low. Neutral levels were those that included the average yearly losses recorded in the area. Given that in the area the average yearly loss was 1.3 fowl (see Results), people that answered that they would tolerate the loss of 1 to 5 fowl per year were included in the neutral category. People that would not tolerate any losses (category 'none' above) were considered as of low tolerance and those that tolerated losses of > 5 fowl per year as of high tolerance.

RESULTS

Diet. Using all methods, 84 prey items belonging to eight taxa were recorded being delivered by the Black-and-chestnut Eagle to the nest (Table 1). Of the total number of items, 38% could not be identified. Based on direct visual observations (21), the female brought 19% and the male 38%, while for the remaining 43% the sex of the parent could not be identified. The prey with the highest frequency of occurrence (40%) was the Andean Guan (*Penelope montagnii*), while the prey that contributed the greatest biomass (47%) was the House Chicken (*Gallus gallus*). All prey items were identified as adult individuals. We estimated the trophic niche amplitude at 0.38, with eight prey species, of which 50% were birds (Table 1). Birds contributed 73% of the total prey biomass when domestic birds were included, and 46% including only wild prey (Table 1).

Human perception of eagle's presence and economic impact. We conducted interviews with 95 inhabitants living in the area of the eagle's nest (average distance to nest: 6.8 km, range 4.1–18 km) of which 78% identified the eagle properly, while the rest identified a "large raptor." Of the total of surveyed households (95), 90% claimed to be House Chicken owners and 53% of them reported losses due to the Black-and-chestnut Eagle during the time they had been living in the area (average = 5 years, range 1–50 years). We found an average loss of 1.3 House Chicken individuals per year and farmer, from a reported total population of approximately 1800 domestic chickens (mainly hens) in around 8000 ha. No significant difference was found between the categories of the number of House Chicken owned and

Table 1. Frequency and biomass of prey delivered to a Black-and-chestnut Eagle (*Spizaetus isidori*) nest in the biological corridor "Farallones de Gachalá y Medina," Guavio region, Cundinamarca, Colombia, between 2013 and 2015. Values of % occurrence and biomass given in parentheses represent estimated contributions if domestic species are excluded from the diet. *Domestic species.

Species	Prey remains (2013–2015)	Direct observations (2014)	Video recordings (2015)	Occurrence (%)	Biomass (%)
Birds	25	10	2	71 (59)	73 (46)
*Gallus gallus**	5	7	2	27	47
*Meleagris gallopavo**	1	0	0	2	3
Herpetotheres cachinnans	1	0	0	2 (2)	1 (2)
Penelope montagnii	18	3	0	40 (57)	22 (44)
Mammals	3	11	1	29 (41)	27 (54)
Nasuella olivacea	3	1	0	8 (11)	8 (15)
Lagothrix lagotricha	0	1	0	2 (3)	10 (21)
Dasypus novemcinctus	0	1	0	2 (3)	4 (8)
Sciurus granatensis	0	8	1	17 (24)	5 (10)
Unidentified bird	5	0	3		
Unidentified mammal	1	0	2		
Unidentified prey	0	0	21		
Total	34	21	29		

the average yearly loss to eagle predation (Kruskal-Wallis H = 4.5, df = 2, $P = 0.11$, Table 2). There was no correlation between the distance to the nest and the number of House Chicken lost to eagle predation in the area (Spearman $r_s = 0.02$, $P = 0.58$). We found no correlation between the average number of House Chicken lost to eagle predation per year and the distance at which the owners would accept the eagle's nest to be located (Spearman $r_s = 0.15$, $P = 0.34$), or between the number of House Chicken that interviewees would be willing to sacrifice to the eagle and the distance at which they would accept the eagle's nest (Spearman $r_s < 0.01$, $P = 0.86$). Taking into account the total number of people surveyed, including those who currently do not own House Chicken but declare they would be interested in having House Chicken in the near future, 32% considered that the eagle has a "very severe" or "severe" economic impact. The remaining 20% considered that the eagle had a "moderate" impact, while 48% considered it had a "slight" or "very slight" impact. Of the interviewees, 48% had a low tolerance for accepting the eagle's presence-proximity, while 42% had a high tolerance to proximity. Regarding the acceptable number of domestic fowl lost to the eagles hunting, 48% of interviewees where classified as neutral tolerance, while 34% had an overall high tolerance.

DISCUSSION

Diet. The most important prey in terms of biomass for the breeding pair of the Black-and-chestnut Eagle studied was adult House Chicken, while the Andean Guan is the most frequent prey (Table 1). The occurrence of House Chicken in the diet of the Black-and-chestnut Eagle pair is similar to that documented by Aráoz & Grande (pers. comm.) for a nest found in northern Argentina, where domestic fowl represented 19% of prey items (N = 21) during the eagle's reproductive season. In the province of Imbabura, in Ecuador, domestic fowl consumption has also been reported as high (P Joost pers. comm.). Eagle consumption of domestic fowl around the world shows substantial differences. In Portugal, Bonelli's Eagle (*Aquila fasciata*) consumes a high percentage of domestic species, with an estimated 38% of prey biomass represented mainly by wild and messenger Rock Pigeons (*Columba livia*), domestic fowl, and turkey (*Meleagris gallopavo*) (Palma et al. 2006). In Argentina, the Crowned Eagle (*Harpyhaliaetus coronatus*) feeds on domestic goats (*Capra hircus*), which contribute 0.2% of the prey biomass (Sarasola et al. 2010), while in Brazilian Amazon; domestic species are absent in the diet of Harpy Eagle (*Harpia harpyja*) (Aguiar-Silva et al. 2014).

The inclusion of House Chicken in the Black-and-chestnut Eagle's diet could be related to prey availability in the landscape surrounding the nest's location. According to ecological niche models (Renjifo et al. 2014), the nests in this study were located in an area that is categorized as "less suitable" for the species. Given the current habitat loss of up to 60% of the original vegetation cover in medium and high mountain zones in Colombia (Etter et al. 2006), which would reduce the availability of native prey for the eagle, the frequency of eagle-human conflicts is expected to increase (Kenward 1999). Nests of this species studied in Ecuador and Argentina are also found at the limits between agricultural lands and native forest (Aráoz & Grande pers. comm., P Joost

Table 2. Average number of House Chicken lost to Black-and-chestnut Eagle (*Spizaetus isidori*) predation per year, according to the number of House Chicken owned in the biological corridor "Farallones de Gachalá y Medina," Guavio region, Cundinamarca, Colombia. Only owners with more than one House Chicken are included. Means (± SD) are given.

Category of ownership	n	Average total loss	Surveyed owners with loss of domestic fowl (%)	Average yearly loss
Small (< 12 fowl)	21	7.5 ± 2.5	42.9	0.9 ± 2.9
Medium (12–22 fowl)	34	16.7 ± 3.0	58.8	1.6 ± 2.5
Large (> 22 fowl)	32	34.3 ± 11.3	65.6	1.4 ± 2.4

pers. comm.), which could also represent less suitable areas. Thus, the high biomass of House Chicken in the eagle's diet could be explained by the overlap of rural communities and the eagle's habitat.

According to Moleón et al. (2009), landscape composition significantly affects the proportion of wild vs. domestic prey for Bonelli's Eagle in southern Spain. In addition, Palma et al. (2006) suggested that domestic prey abundance could be compensating for the lack of wild prey in Portugal. Similarly, Matchett & O'Gara (1987) considered that the possible increase in domestic sheep (*Ovis aries*) consumption by the Golden Eagle (*Aquila chrysaetos*) in Montana, USA, between 1974 and 1975, was induced by the decline in wild hare populations (*Lepus* spp.), as well as the relative inactivity of other prey species due to cold temperatures and high humidity. The increase of domestic prey in the eagle's diet could likewise be explained by a lower diversity of native prey in the study area due to proximity to human settlements and reduced amount of native forest cover, as proposed by Palma et al. (2006) in Portugal and Spain for Bonelli's Eagle, but this remains to be tested.

Birds were the most frequent prey for the Black-and-chestnut Eagle, despite the important contribution of squirrels (*Sciurus granatensis*) to the diet, which was high among the non-domestic prey. Aráoz & Grande (pers. comm.), in a preliminary monitoring of the Black-and-chestnut Eagle's diet in northern Argentina, did not record mammals among the prey given to a nestling between 12 and 16 weeks of age. For other large forest raptors, such as the Harpy Eagle (*Harpia harpyja*), canopy mammals are the main prey, although they occasionally prey upon terrestrial species as well (Aguiar-Silva et al. 2014, 2015). Additionally, there is a noteworthy presence of a smaller raptor in the diet of the pair we observed, a Laughing Falcon (*Herpetotheres cachinnans*), which raises the possibility of this eagle's role as a "super-predator" that controls meso-predators, similar to what has been observed in Argentina (Aráoz & Grande pers. comm.).

Human perception of eagle presence and economic impact. We found an ambiguous eagle-human conflict (*sensu* Redpath 2013) between acceptance of an eagle pair and concern regarding the economic consequences of this species' hunting habits. Most householders would prefer not to have an eagle nest close or in their vicinity, but seem to agree on a certain level of tolerable domestic fowl loss regardless of the actual nest's distance. According to the surveys conducted, more than half of the population recognizes the existence of a conflict with the eagles due to domestic fowl losses, similar to findings in other areas of Colombia (Córdoba-Córdoba et al. 2008). This contrasts with the findings of Holmern & Røskaft (2013), who reported that only 33% of the inhabitants in the outskirts of the Serengeti National Park (Tanzania) identified themselves as being affected by birds of prey, and rarely acted in retaliation.

Owners with a greater number of House Chicken reported a higher perceived frequency of eagle attacks (67%) which, however, was not significantly different from the other two categories (Table 2). This contrast with the findings of Moleón et al. (2009), who reported an increase in hunting activity by Bonelli's Eagle related to an increase in domestic prey density in southern Spain. Given that we did not assess prey density but only overall number, it remains to be tested whether there is a difference in prey intake based on density. Taking into account that no significant correlation was found between the number of House Chicken owned and the number lost to eagles, a reduction in fowl number does not seem to be a viable solution to reduce fowl predation by the eagles. Most surveyed inhabitants consider that the impact of House Chicken loss caused by the eagle is slight to very slight (48%), which agrees with a reported yearly loss of 1 to 2 domestic fowl (Table 2). Most inhabitants would allow the eagle to take up to five individuals of House Chicken attempting to hunt the eagles. This suggests that, although the eagles are considered a threat to their economy, they are not perceived as a determining element. Considering that one House Chicken costs around $8 USD, fowl predation by the eagles represents an average economic loss of around $10 USD per year and household (based on average yearly loss of 1.3 ind.). The general perception of House Chicken owners is that eagles nesting further away are less threatening to House Chicken, and they are more tolerant when the nest is far from human settlements. However, we found no correlation between the distance to the nest and the number of House Chicken taken.

To our knowledge, there is no information regarding whether prey consumed during the nestling or

juvenile period can change adult dietary preferences later on in life. However, it is worth considering that if juveniles are more commonly presented with domestic fowl over native prey, they could more actively seek such prey as adults, and come into more frequent contact with domestic fowl from the increasingly common human presence in rural areas. There have been increases in the reported losses of domestic fowl to eagle predation in the departments of Magdalena, Chocó, Norte de Santander, Cauca, Boyacá, Quindío, Meta, and Huila in Colombia (Córdoba-Córdoba et al. 2008, Zuluaga 2012, BirdLife International 2015), as well as in the province of Imbabura in Ecuador (P Joost pers. comm.) and the province of Salta in Argentina (Aráoz & Grande pers. comm.). While nature-human conflicts can rarely be completely resolved, they can be managed through possible win-win solutions, in which, by definition, both parties obtain a partial benefit (Redpath et al. 2013). For our study site, strategies that take into account habitat preferences for the eagle while maintaining and while securing income for the farmers, could lead to changes in the human perception and a lower threat; one option that could be examined might be ecotourism. However, given that our data are based on observations on one eagle pair in a relatively small area, broader regional and national scale studies should be conducted to determine the generality of our findings.

ACKNOWLEDGMENTS

We thank CORPOGUAVIO, especially O. Jiménez Díaz, M. Urquijo Collazos and M.A. Andrade, as well as all of the professionals from the projects: Biodiversity Management and Conservation, and Strengthening of Environmental Education. We also thank A. Contreras, G. Contreras, M. Romero, L. González, I. Garzón, F. Sáenz, A. Matiz, O. Jaudoin, and F.H. Aguiar-Silva for field support, L. F. Gómez for support during the community visits, and F. Aristizábal for aid with mapping. We also thank the landowners where the nests were located, E. Medina, F. E. Alvarado, B. Beltran, and the communities from the localities of the municipalities of Gachalá, Ubalá, and Medina. This project was developed under the special association agreement 422/2013, under the framework of the 2012-2015 Action Plan of CORPOGUAVIO. We thank the directors of Fundación NEOTROPICAL, F. Sáenz Jiménez and F. Cirí León. We also appreciate comments made by J.M. Thiollay, M. Jais, K. Delhey, and two anonymous reviewers that greatly improved the manuscript.

REFERENCES

Acevedo-Charry, O, E Matiz-González, K Pérez-Albarracín, S Rodríguez-González & CJ Valencia-Vera (2015) El Águila Arpía (*Harpia harpyja*) y el Águila Iguanera (*Spizaetus tyrannus*) en el ecotono entre los Andes y los llanos de la Orinoquia, Arauca, Colombia. *Spizaetus* 19: 2–11.

Aguiar-Silva, FH, TM Sanaiotti & BB Luz (2014). Food habits of the Harpy Eagle, a top predator from the Amazonian rainforest canopy. *Journal of Raptor Research* 48: 24–35.

Aguiar-Silva, FH, TG Junqueira, TM Sanaiotti, VY Guimaraes, PCV Mathias & CV Mendonça (2015) Resource availability and diet in Harpy Eagle breeding territories on the Xingu River, Brazilian Amazon. Brazilian Journal of Biology 75: 181–189.

Araóz, R & S Aveldaño (2013) Registro de ejemplares de Águila Poma (*Oroaetus isidori*) para el departamento La Candelaria, provincia de Salta, Argentina. *Nótulas Faunísticas* (*segunda serie*) 118: 1–4.

Bernard, HR (2006) Research methods in anthropology. Qualitative and quantitative approaches. 4th edition. Altamira Press, Oxford, UK.

Birdlife International (2015) Species factsheet: *Spizaetus isidori*. *In* IUCN red list of threatened species. Version 2015. Downloaded from http://www.birdlife.org on 16 March 2015.

Carter, N, SJ Riley & J Liu (2012) Utility of a psychological framework for carnivore conservation. *Oryx* 46: 525–535.

Colwell, RK & JD Futuyma (1971) On the measurement of niche breadth and overlap. *Ecology* 52: 567–576.

Córdoba-Córdoba, S, MA Echeverry-Galvis & F Estela (2008) Nuevos registros de distribución para el Águila Crestada (*Spizaetus isidori*) y el Águila Iguanera *(S. tyrannus*) para Colombia, con anotaciones para su identificación. *Ornitología Colombiana* 7: 66–74.

CORPOGUAVIO-ONF ANDINA (2014) *Plan de manejo ambiental reserva forestal protectora Tolima.* Corporación Autónoma Regional del Guavio, Cundinamarca, Colombia.

Dunning, JB (2007) *CRC Handbook of avian body masses.* 2nd ed. CRC Press Taylor and Francis Group, Florida, USA.

Echeverry-Galvis, MA, S Zuluaga & D Soler (2014) *Spizaetus isidori*. Pp 104–105 *in* Renjifo, LM, MF Gómez, J Velázquez-Tibatá, AM Amaya-Villarreal, GH Kattan, JD Amaya-Espinel & J Burbano-Girón (eds). *Libro rojo de aves de Colombia, Volumen I: Bosques húmedos de los Andes y la costa pacífica.* Editorial Pontificia Universidad Javeriana e Instituto Alexander von Humboldt, Bogotá D.C., Colombia.

Eisenberg, JF (1989) *Mammals of the Neotropics. The northern Neotropics: Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana.* Volume 1. Univ. of Chicago Press, Chicago, Illinois, USA.

Emmons, L & F Feer (1997) *Neotropical rainforest mammals: a field guide.* 2nd ed. Univ. of Chicago Press, Chicago, Illinois, USA.

Etter, A, C Mcalpine, K Wilson, S Phinn & HP Possingham (2006) Regional patterns of agricultural land use and deforestation in Colombia. *Agriculture Ecosystems & Environment* 114: 369–386.

Ferguson-Lees, J & D Christie (2001) *Raptors of the world.* Houghton Mifflin, Boston, Massachusetts, USA.

Freile, JF & JA Chaves (2004) Interesting distributional records and notes on the biology of bird species from a cloud forest reserve in north-west Ecuador. *Bulletin of the British Ornithologists' Club* 124: 6–15.

Hilty, SL & WL Brown (1986) *A guide to the birds of Colombia.* Princeton Univ. Press, Princeton, New Jersey, USA.

Holmern, T & E Røskaft (2013) The poultry thief: subsistence farmers' perceptions of depredation outside the Serengeti National Park, Tanzania. *African Journal of Ecology* 52: 334–342.

Inskip, C & A Zimmermann (2009) Human-felid conflict: a review of patterns and priorities worldwide. *Oryx* 43: 18–34.

Kansky, R M Kidd & AT Knight (2014) A meta-analysis of attitudes towards damage-causing mammalian wildlife. *Conservation Biology* 28: 924–938.

Kenward, RE (1999) Raptor predation problems and solutions. *Journal of Raptor Research* 33: 73–75.

Krebs, CJ (1999) *Ecological methodology.* 2nd ed. Benjamin Cummings, Menlo Park, California, USA.

Lehmann, FC (1959) Contribuciones al estudio de la fauna de Colombia XIV. Nuevas observaciones sobre *Oroaetus isidori* (Des murs). *Novedades Colombianas* 1: 169–195.

Lehmann, FC (1961) Notas generales. *Novedades Colombianas* 1: 523–526.

Márquez, C & LM Renjifo (2002) *Oroaetus isidori*. Pp: 89–90 *in* Renjifo, LM, AM Franco-Maya, JD Amaya-Espinel, G Kattan & B López-Lanus (eds). *Libro rojo de aves de Colombia*. Serie Libros rojos de especies amenazadas de Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt y Ministerio del Medio Ambiente, Bogotá D.C., Colombia.

Matchett, MR & BW O'gara (1987) Methods of controlling Golden Eagle depredation on domestic sheep in southwestern Montana. *Journal of Raptor Research* 21: 85–94.

Moleón, M, J Bautista, JA Sánchez-Zapata & JM Gil-Sánchez (2009) Diet of non-breeding Bonelli's Eagles *Hieraaetus fasciatus* at settlement areas of southern Spain. *Bird Study* 56: 142–146.

Olrog, CC (1956) Un águila nueva para la Argentina. *Hornero* 10: 172–173.

Palma, L, P Beja, M Pais, Da Cancela & L Fonseca (2006) Why do raptors take domestic prey? The case of Bonelli's Eagles and pigeons. *Journal of Applied Ecology* 43: 1075–1086.

Redpath, SM, J Young, A Evely, WM Adams, WJ Sutherland, A Whitehouse, A Amar, RA Lambert, JDC Linnell, A Watt & RJ Gutiérrez (2013) Understanding and managing conservation conflicts. *Trends in Ecology & Evolution* 28: 100–109.

Renjifo, LM, MF Gómez, J Velázquez-Tibatá, AM Amaya-Villarreal, GH Kattan, JD Amaya-Espinel & J Burbano-Girón (2014) *Libro rojo de aves de Colombia, Volumen I: Bosques húmedos de los Andes y la costa pacífica.* Editorial Pontificia Universidad Javeriana e Instituto Alexander von Humboldt, Bogotá D.C., Colombia.

Renton, K (2001) Lilac-crowned Parrot diet and food resource availability: resource tracking by a parrot seed predator. *The Condor* 103: 62–69.

Sarasola, JH, MÁ Santillán & MA Galmes (2010) Crowned Eagles rarely prey on livestock in central Argentina: persecution is not justified. *Endangered Species Research* 11: 207–213.

Strewe, R (1999) Notas sobre la distribución y anidación del Águila Poma, *Oroaetus isidori*, en Nariño. *BOLETIN SAO* 10: 45–52.

Thiollay, JM (1991) Altitudinal distribution and conservation of raptors in southwestern Colombia. *Journal of Raptor Research* 25: 1–8.

Tirira, DG (2007) *Guía de campo de los mamíferos del Ecuador.* 6th ed. Publicación especial sobre los mamíferos del Ecuador. Ediciones Murciélago Blanco, Quito, Ecuador.

Treves, A & KU Karanth (2003) Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology* 17: 1491–1499.

Valdez, U & S Osborn (2004) Observations on the ecology of the Black-and-chestnut Eagle (*Oroaetus isidori*) in a montane forest of southeastern Perú. *Ornitología Neotropical* 15: 31–40.

Zuluaga, S (2012) Estado del conocimiento actual del Águila Crestada de Montaña (*Spizaetus isidori*) en Colombia. *Spizaetus* 13: 9–14.