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Andean condor nesting and behavior: A study of a free-living pair and chick as well as population behavior near Antisana Ecological Reserve, Ecuador

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Abstract

The behavior of the Andean condor (*Vultur gryphus*), especially nest behavior, is little known outside of captivity. More information on chick-parent interactions and parenting dynamics of successful condor pairs is needed in order to help create an effective conservation plan for a species in peril of extinction. Study of nest home used by a free-living pair of condors and home to a five-month old juvenile began on November 11, 2018 and continued through November 29, 2018. The nest is located in Antisanilla Biological Reserve and nearby Antisana Ecological Reserve. The chick was also tagged with numbers and a tracking device during the period of observation. Transects and stationary observations were also done at popular condor feeding sites nearby to gain other behavioral information about the condors of the region. Results confirmed a previous finding that males do more parenting than females. Differences in cliff behaviors were also observed between parents. The chick's daily behavior was recorded and a significant difference in level of activity was observed before and after the tagging event. The study finds proof of the necessity for protected areas such as Antisana and Antisanilla as well as the habitat loss caused by human development and provides insights for future Andean condor conservation efforts.

Resumen

El comportamiento del cóndor andino (*Vultur gryphus*), especialmente el comportamiento del nido, es poco conocido fuera del cautiverio. Para ayudar a crear un plan de conservación efectivo para una especie en peligro de extinción, se necesita más información sobre las interacciones de los padres con sus polluelos y la dinámica de crianza de los pares de cóndor exitosos. El estudio del hogar del nido a un par de cóndores de vida libre y un juvenil de cinco meses comenzó el 11 de noviembre de 2018 y continuó hasta el 29 de noviembre de 2018. El nido se encuentra en la Reserva Biológica Antisanilla y cerca de la Reserva Ecológica Antisana. El polluelo también fue etiquetado con números y un dispositivo de seguimiento durante el período de la observación. También se realizaron transectos y observaciones estacionarias en los sitios populares de alimentación de cóndor cercanos para obtener otra información sobre el comportamiento sobre los cóndores de la región. Los resultados confirmaron un hallazgo previo de que los machos hacen más crianza que las hembras. Las diferencias en comportamientos de los padres en el acantilado también fueron observadas. Se registró el comportamiento diario del polluelo y se observó una diferencia significativa en el nivel de actividad antes y después del evento de etiquetado. El estudio encuentra la prueba de la necesidad para las áreas protegidas tales como Antisana y Antisanilla, así como la pérdida de hábitat causada por el desarrollo humano. También proporciona información para los futuros esfuerzos de conservación del cóndor andino.

Introduction

The Andean condor (*Vultur gryphus*) is the largest flying bird in the world and an iconic bird in South America. The species range extends from Venezuela at the northern extreme, down to Bolivia, Chile, and Argentina, confined primarily to the Andean corridor (Herrmann and Costina 2000). Andean condors are a scavenging species of raptor (Falconiformes) and feed on carrion. While they originally fed primarily on native guanacos and rheas, their diet now consists almost entirely of exotic herbivores including sheep, cattle, horses and deer (Lambertucci et al. 2009). Andean condors are also one of the longest-lived birds in the world. This long life-cycle makes them even more vulnerable as a population because they cannot quickly reproduce. Andean condors are generally assumed to be monogamous (Pavez and Tala 1996), although until recent years, adult females have not been individually identified because of lack of differentiating characteristics other than feather patterns, so pairs have been identified by constant presence of the adult male. Females lay a single egg per reproductive season and pairs usually reproduce every 2-3 years, depending on conditions, resources, and location (Wallace and Temple 1987).

Little is still known about the behavior of the Andean condor in its natural habitat, particularly its nesting behavior. This is because most behavioral studies of the species have been performed with captive birds. A recent study (Lambertucci and Mastrantuoni 2008) found that in one pair of condors living in Argentina, the father spent significantly more time with the chick, interacted more, and brought more food than the mother condor. This is a-typical for bird family dynamics, where the mother usually cares for the chick more (Lambertucci and Mastrantuoni 2008). It has been suggested that females are less often seen feeding at carcasses because they spend more time around the nest (Ríos-Uzeda and Wallace 2007). However, if the behavior observed in Lambertucci and Mastrantuoni 2008 were further substantiated, it would beg for another explanation of female condor behavior. Due to a lack of in-depth or long-term behavioral analysis of the Andean condor in the wild, and especially in Ecuador, any behavioral data recorded would be potentially useful in better understanding juveniles, males, females, and group interactions and hierarchy.

Numbers along the Andean condor range have declined significantly in the last 200 years and the species is categorized throughout its range as Near Threatened (IUCN Red List). While higher numbers still exist in Patagonia, the numbers in the northern páramo of South America have dwindled severely. This has largely been as a result of increased agriculture at higher elevations in this area and a consequential habitat loss. The birds are also often hunted or poisoned by farmers, who may have a false belief that the scavengers actively kill livestock (Arnulphi et al. 2017). Further threats include competition with feral dogs. Many censuses of the species have been performed and disagree on exact number of condors existing in Ecuador (due to differences in geography and methods of surveys), but they generally find a number or roughly or just over 100 (Naveda-Rodríguez 2016). A not-yet published census performed in 2018 found over 200 individuals in Ecuador (S. Kohn, personal communication, 2018). The species not only has very few individuals in the region, but also an incredibly low genetic variability, reducing its viability even more (Hendrickson et al. 2003). With various levels and combinations of future and continuing threats factored in, some models predict an extinction

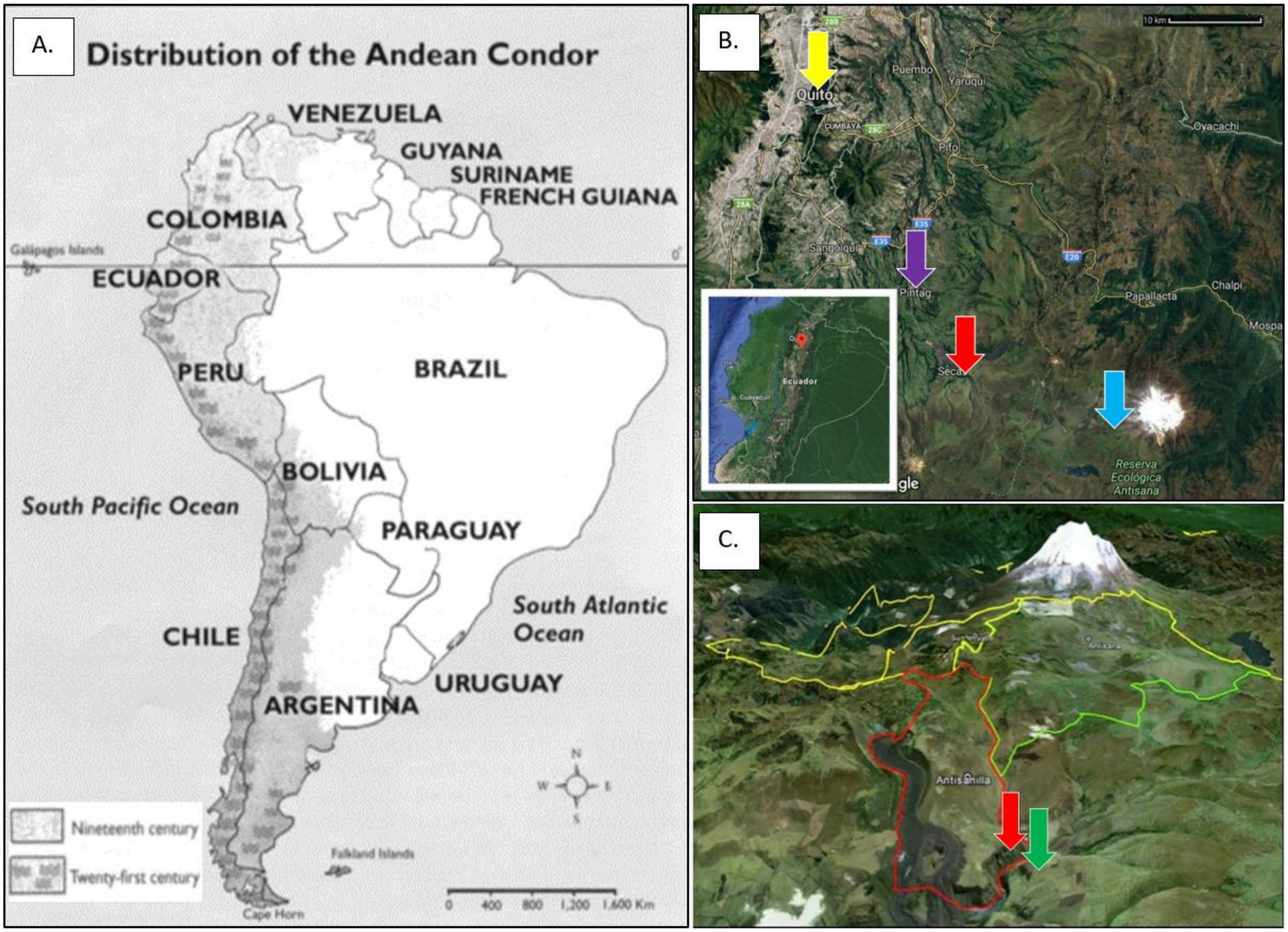

Figure 1: Helpful maps

A: Distribution of the Andean Condor. Modified from Hermann et al. (2010). B: Nest location within Ecuador. Yellow arrow represents downtown Quito, purple arrow represents Pintag, red arrow represents observed condor nest, and blue arrow represents Antisana Ecological Reserve. Created with Google Maps. C: Nest and lookout point. Red arrow represents observed condor nest, green arrow represents observation lookout point (Tambo Condor). Antisanilla (red geofence) and Antisana (green geofence) are also shown. Modified from (International Union for Conservation of Nature)

within the country in the next 60-100 years (Naveda-Rodríguez 2016). Other models show slightly more population stability. As a result, the species status within Ecuador is Critically Endangered.

Antisana Ecological Reserve (public) and Antisanilla Biological Reserve (private), located within the Ecuadorian provinces of Pichincha and Napo (Figure 1), as well as the surrounding area, is one of the most densely populated regions for condors in Ecuador. The area is in the Andean páramo, high grasslands which typically range in altitude from 3200-4000m above sea level (Lauer 1981). Its position near a major city in Quito (30 km from downtown), as well as the town of Pintag (11 km from downtown), puts it in a precarious position in terms of conservation and habitat loss but also provides an important case study for managing condor populations in populated areas and observation of behavior.

One pair of condors residing within Antisanilla Biological Reserve has laid an egg each of the last seven years, with six of these offspring successfully fledging. This makes it the most productive current Andean condor nest known throughout the species' range (S. Kohn, personal communication, 2018). All six chicks have been raised on the same cliff, and the observed chick was the third to be raised in its specific nest. These factors make the area, cliff, nest, and pair incredibly important to study to better understand optimal conditions for increased reproductive productivity and condor nest behavior. Nest behavior as well as general condor behavior in the surrounding area was studied for three weeks and the findings are described here.

Methods and Materials

The study took place in the Ecuadorian páramo near Antisana Ecological Reserve and Antisanilla Biological Reserve. Observation areas included one Andean condor nest cliff as well as ridges and pastures.

The primary aim of this study was observation of parent and chick nest behavior. An Andean Condor nest (Figure 2), home to an unnamed 5-month-old juvenile female and frequented by the adult parents, was observed between the dates of November 11 and November 29, 2018. Adult condors perched on nest cliff were assumed to be parents. This was a very reliable assumption because of the territoriality of condor pairs towards the nest region. In instances where an unrelated condor perched on the cliff, it was quickly harassed and chased away by a parent. This was observed on two occasions throughout the study, during which a juvenile condor was driven from its perch on the cliff, although presence of unrelated condors perched on the nest cliff was very rare.

Andean condors are the only species in the family Cathartidae to exhibit sexual dimorphism (del Hoyo et al. 1994). Adult males have a comb, or caruncle, on top of their heads which is absent in females. This dimorphism allowed for differentiation between male and female parents during nest visits. Condors were observed from a lookout point at Tambo Cóndor restaurant, roughly 500m from the nest. Observations were made for parts of or entire days and as weather permitted during the three weeks of observation. Thick fog often obscured the nest or entire cliff for portions of the day and these hours were not included in the data. Binoculars (10X42) and the naked eye were used to spot condors in the air, as well as black chested buzzard eagles which had a nest on the same cliff. A spotting scope with a maximum magnification of 60x was used to constantly watch the nest and the chick's behavior within it, as well as to observe adults when perched. A stopwatch was used to time all visits and a hand-held compass was used to estimate flight directions.

The chick was constantly observed during hours of observation and behavior was described and categorized into the following:

i. Displaying tag (any raising of a tagged wing in the direction of a parent)
ii. Flapping
iii. Inspecting (pecking at plants or rocks within nest)
iv. Jumping
v. Moving (changing physical perching or resting position within nest)
vi. Pecking tag (repeated head movement towards tag)

vii. Perching (standing still with head raised above chest height)
viii. Preening
ix. Resting (sitting or laying down with wings and head tucked in)
x. Ruffling (non-flapping wing movement)
xi. Running
xii. Spreading (full extension of wings, often including sunning)
xiii. Walking

Observation was separated into five-minute stretches and each stretch was assigned any actions which were observed during it. All categories except for resting were considered active actions.

For each five-minute period, weather was also noted objectively on a scale of 0-3, with zero meaning absence and three meaning heavy, for the categories of wind, clouds, and rain. Although wind was recorded, a wind speed gauge was not used, and any relative estimate was based on wind at the Tambo Cóndor lookout, rather than at the nest. There seemed to be a disparity in wind levels between the lookout and the nest and wind results were therefore not included in the final results. Presence and absence of direct sunlight in the nest was recorded. Temperature was not recorded because of a lack of access to the nest.

Adult behavior was split into nest visits and cliff visits. Nest visits included only perches within the confines of the nest. Perches anywhere else on the nest cliff were considered cliff visits. Each perching event was counted as one visit, and another visit was registered in instances when the adult left the cliff and returned to perch again. For cliff visits, duration, entrance direction, exit direction, time of day at start, distance from nest, presence or absence of spouse, weather conditions, and behavior were recorded. For nest visits, duration, entrance direction, exit direction, behavior, and time of day at start were recorded.

On November 26, 2018, the chick was removed from the nest and tagged by scientists from the Fundación Cóndor Andino Ecuador. This was the first tagging of a condor chick within the nest attempted in Ecuador. All observations continued for three days after the tagging event so that chick and parent behavior before and after tagging could be compared.

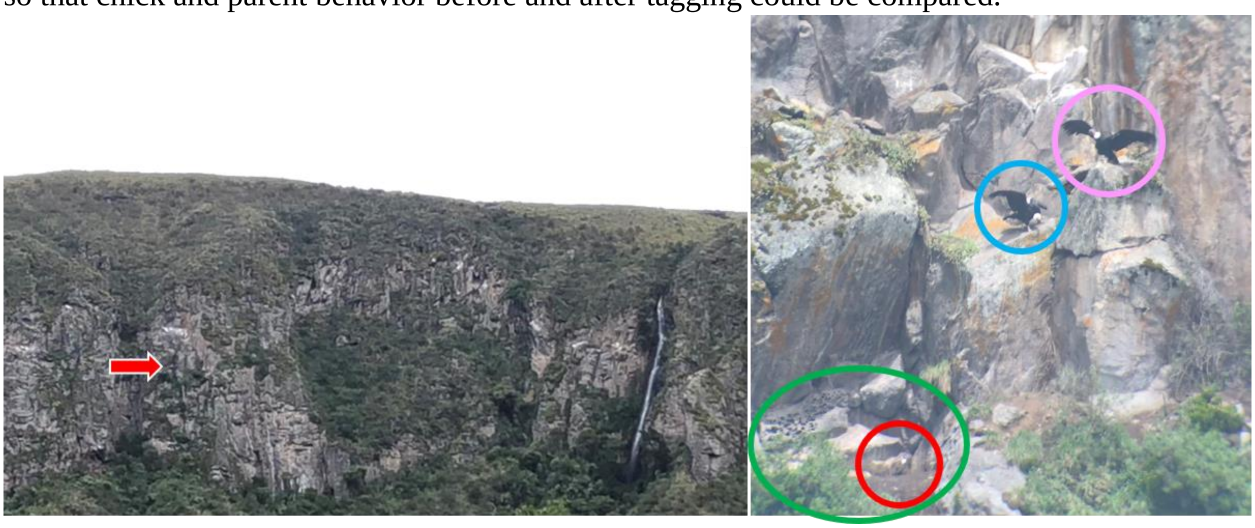

Figure 2: Observed nest

A: Nest cliff. Red arrow represents the nest. B: Family picture. Pink circle identifies female, blue circle identifies male, red circle identifies chick, green circle represents nest area.

A secondary focus of this study was feeding behavior and hierarchy within the condors around Antisana. This has been studied on numerous occasions with differing findings. Donázar and Feijoo (2000) found that within Andean condor roost sites, dominance was primarily determined by age and, within age groups, by sex. This differs from the hierarchy found within feeding groups by Donázar et al. (1999), which was primarily determined by sex and, within sex, by age groups. Two transects and four stationary periods of observation were performed on six separate days between the dates of November 14, 2018 and November 26, 2018. Condors were identified by gender and age but could not be individually identified (as was done in Méndez et al. 2018) due to a lack of photography equipment. Therefore, the possibility of double-counting individuals was not eliminated. For this reason, in addition to the small sample size and the very recent completion of a country-wide census, data was not used for census calculations, but for behavioral observation only. Gendering was done just like it was in gendering parents during nest observation, using the sexual dimorphism of the male's head comb to distinguish sex. Males are born with the head comb so this separation functions at any age. Within gender groups, age was determined by plumage. Birds were separated into juveniles, subadults, and adults. Juveniles were identified by the lack of the white collar which is present in sub-adults and adults. Subadults had developed nearly adult features, but still maintained some more brownish feathers. Their wing panels were also distinguishable from those of adults because they were not completely white. Adults had all black plumage, excepting the white feathers on top of their wings and their white collar. There is also a size difference between age groups which is often noticeable between adult and juvenile but was very difficult to distinguish between subadult and adult.

During stationary observations and transects, all observed condors were noted and aged and/or gendered in possible. If in flight, flight direction was noted as well. Weather was also recorded, using the same metrics as were used for nest observation.

The first period of stationary observation took place on November 14 and was performed from a ridge (S 00°29.377', W 078°16.842) looking into a cow pasture which is a common feeding ground for condors. On November 15, another period of stationary observation was performed from a lookout point on top of a small peak next to Laguna La Mica (0°31'56.5" S 78°13'11.2" W). On November 16, a fresh cow carcass was discovered in the same pasture (S 00°30.085', W 078°18.786) with actively feeding condors and another stationary observation was performed from the ridge directly above it. On November 17, this stationary observation was repeated. Following discovery of the carcass, due to high condor activity in the vicinity, two transects were performed along the horseshoe-shaped rim surrounding the pasture and carcass (Figure 12). The first was performed on November 20, beginning at the western leg of the horseshoe and totaling around 5 km. The second transect was performed no November 26, beginning at the eastern leg of the horseshoe and totaling around 6.5km.

Results

Nest observations

From November 11 to November 29, the nest was observed for a total of 85 h 48min, across 17 days. The times of observation are shown in Figure 3.

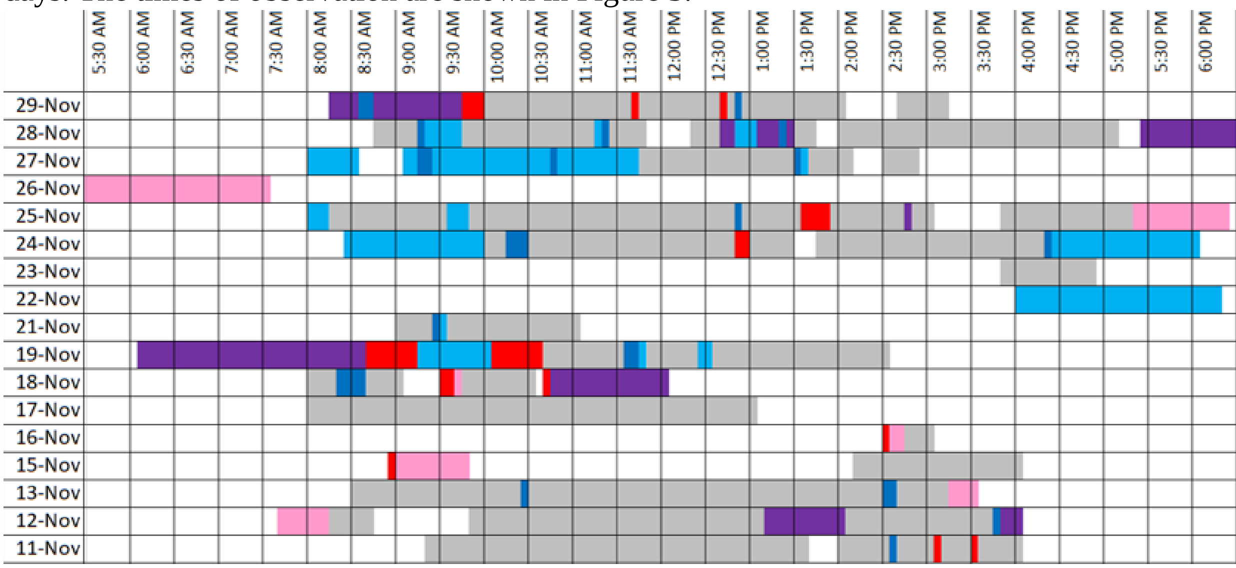

Figure 3: Daily cliff observations

Gray: total time under observation. Pink: Female perched on cliff. Red: Female in nest. Light blue: male perched on cliff. Dark blue: Male in nest. Purple: both male and female perched on cliff.

Parent behavior

Of confirmed entrances to the nest or cliff, the most common direction of entry was from the south. All entry flights came from the 135° comprised of S, SE, E, and NE (Figure 4A). Of confirmed exit flights from the nest or cliff, the most common direction of entry was from the

Figure 4A*: Flight directions inbound to cliff. (Arrow thickness proportional to number of confirmed flights in each direction).*

SW: 1, S: 8, SE: 15, E: 4, NE: 1)

(Image created with Google Maps)

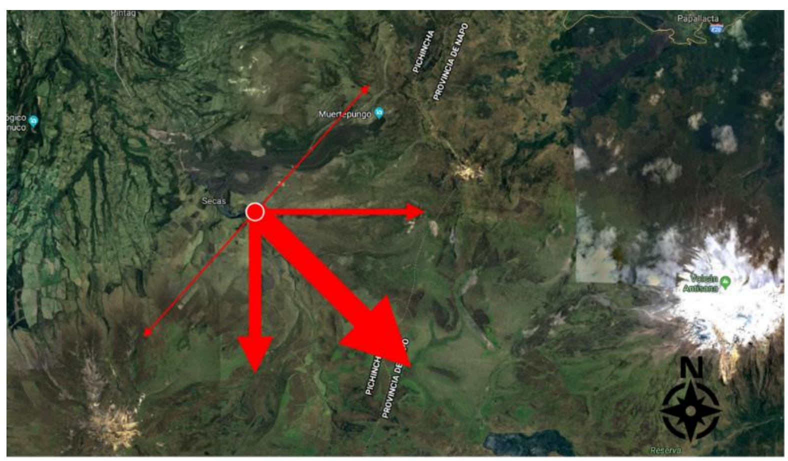

Figure 4B*: Flight directions away from cliff. (Arrow thickness proportional to number of confirmed flights in each direction).*

(S: 9, SE: 2, E: 1, NE: 3)

(Image created with Google Maps)

south east. All exit flights left in a direction within 180° comprised of SW, SE, E, and NE (Figure 4B).

Over the period of observation, the male visited the nest more often (19 visits) than the female (15 visits). Moreover, the male fed the chick more times (16) than the female (10). The female did however average longer per nest visit (9m 18s) than the male (5m 33s) and spent a longer combined time in the nest (140m 30s) than did the male (105m 30s). They both cleaned the chick the same number of times (5), suggesting that the female exhibits this behavior during a higher percentage of nest visits but with the same overall frequency as the male. Oher behaviors are detailed in Figure 5.

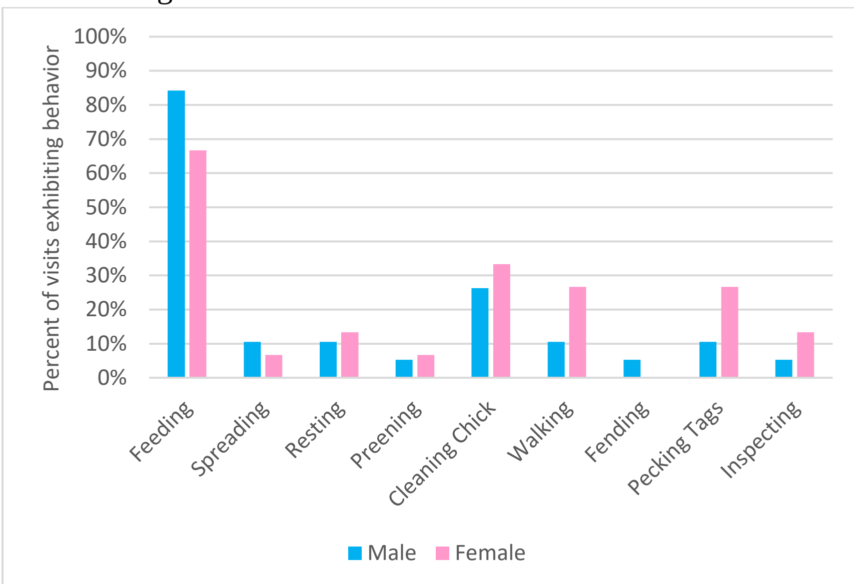

Figure 5: Nest visit behavior. *Percentage of nest visits during which parents exhibited certain behaviors. Blue bars represent male behaviors, pink bars represent female behavior.*

The parents mostly fed the chick once a day, with some exceptions. The female fed the chick more than once in a day on two occasions (two feedings in each instance), while the male fed the chick more than once in a day on three occasions, twice feeding the chick three times in the same day and once feeding it twice in the same day. Feedings all occurred between 8:00 and 16:00. The most frequent times for feeding however were between 8:00 and 13:00, with the hours of 9:00-10:00, 11:00-12:00, and 12:00-13:00 being particularly popular times (Figure 7). The most popular hour for the male to feed the chick was 11:00-12:00, while the most popular time for the female to feed the chick was 12:00-13:00. There was a very weak relationship (p-value 0.3432) between number of feedings per day by the male and female. Number of male feedings per date was plotted versus number of female feedings per date and fitted with a linear equation with an R^2 value of 0.0819 (Figure 6).

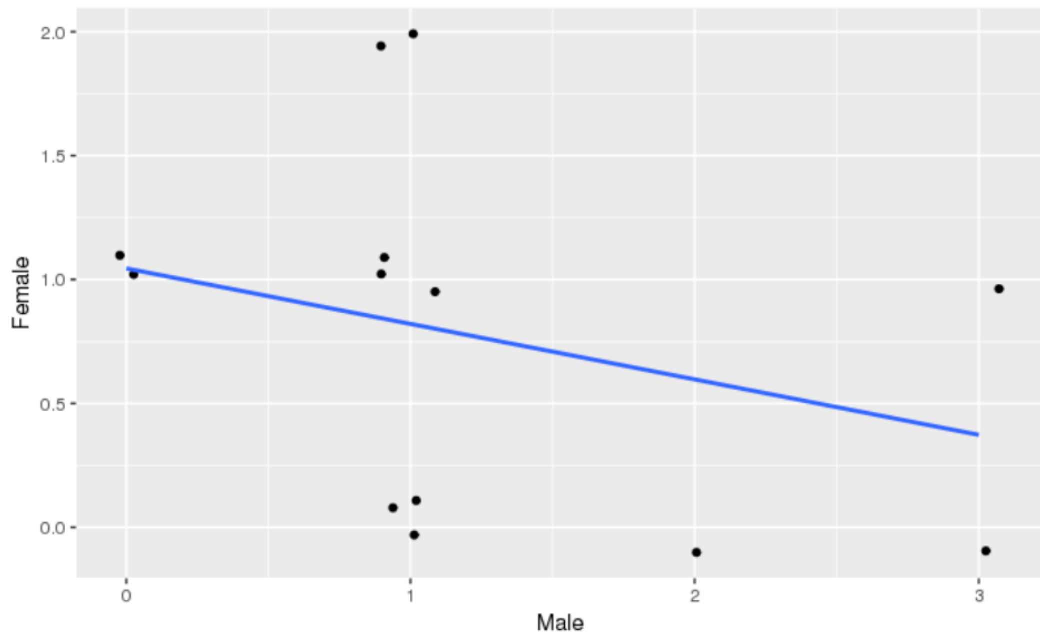

Figure 6: Number of male chick feedings per day vs number of female chick feedings per day*. Each data point represents one date of observation. Data points with identical coordinates are grouped around the coordinate.* R^2 *value: 0.0819, p-value: 0.3432*

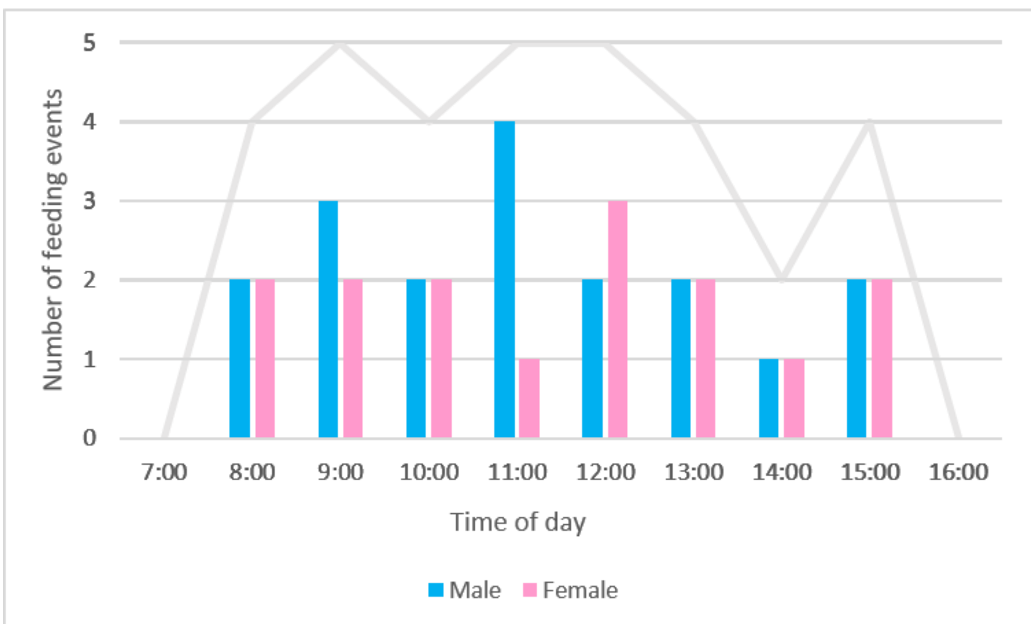

Figure 7: Feeding events by hour*. Blue bars represent male feeding events, pink bars represent female feeding events. Gray line represents the hourly sum of male and female feeding events.*

Male spent 1222 total minutes perched on the cliff throughout the study, while the female spent 781 minutes perched on the cliff. The male was perched on the cliff 1.56 times as long as the female. When combined with nest visits this drops slightly to 1.44 times as long as the female spent in the nest or elsewhere on the cliff.

During hours of observation when an adult was observed on the cliff, the male was alone 51% of the time, the female was alone 23% of the time, and the pair were both present 26% of the time. 46% of the male condor's cliff perches took place with the female present, while 45% of the female's cliff perches took place with the male present. These numbers are almost identical. This is slightly misleading however because each time an individual flew and returned to the cliff, it was counted as a new visit. During times when the male and female were both on the cliff, the male was typically more active. During these times, the female registered 10 separate events, much fewer than the male's 21 in that same time. Though the proportion of solo to accompanied visits was almost the same for both male and female, this was a factor of differing pair behavior during accompanied visits. If each visit event instead encompassed the entire duration of time spent at the cliff from arrival to departure, the ratio of solo to accompanied visits would be much higher for the male and lower for the female. When time of each perch is included, the male was alone for 66% of its time on the cliff, compared to the female who was perched alone for 47% of her time on the cliff.

The presence of at least one parent at the cliff at any given time of day can be modeled by the binomial equation $y = 0.0002x^2 - 0.0292x + 1.3889$, with an R^2 value of 0.8016 (Figure 8). Using this equation, the least likely time for a parent to be perched at the nest or cliff is at about 12:30.

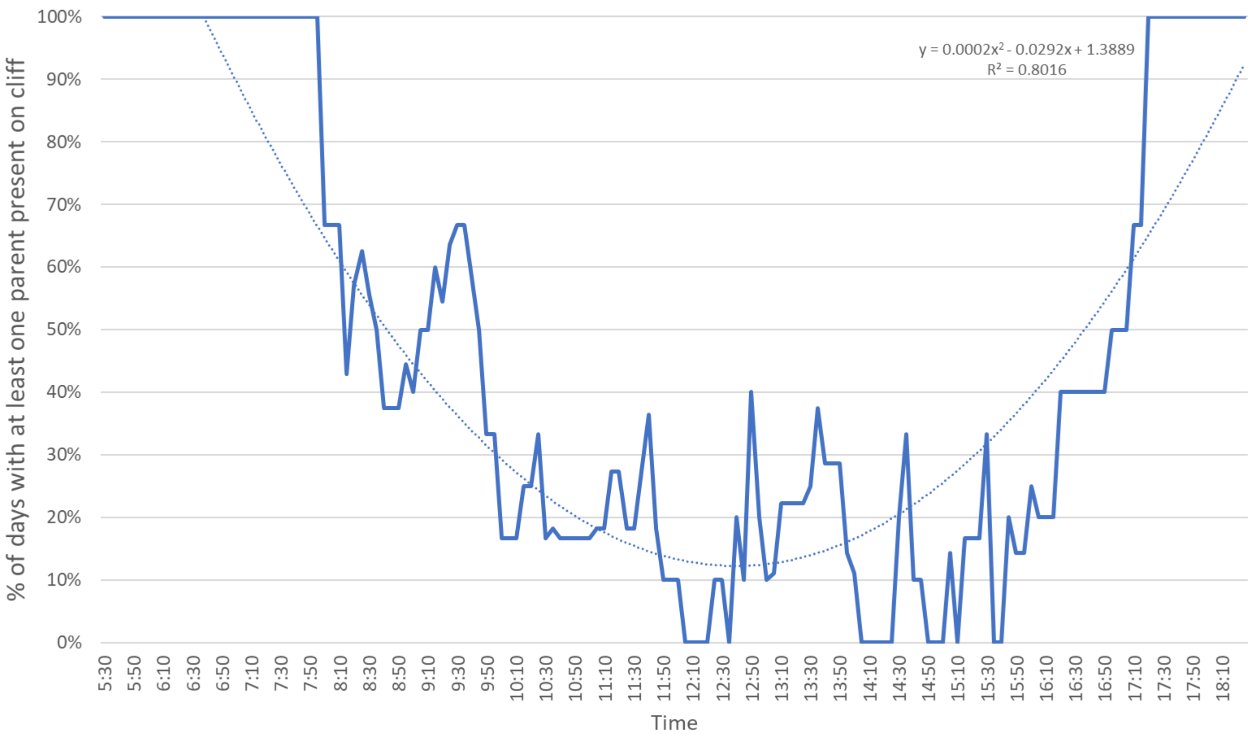

Figure 8: Daily parenting hours*. Graph shows percentage of total observed days with at least one parent present on the nest cliff at a given time. Binomial trendline:* $y = 0.0002x^2 - 0.0292x + 1.3889$, $R^2 = 0.8016$

Chick behavior

During nine days of observations, the chick's behavior was recorded every five minutes (Figure 9). 79% of these intervals were characterized only by resting. 21% of intervals contained some active action by the chick. “Moving” was the most common of these actions, followed by walking and ruffling. Although direct sunlight often coincided with initial chick movement, there were no significant results related to chick activity throughout direct sunlight periods. This was mostly because of a difficulty in accurately measuring whether there was direct sunlight. It is important to remember that all chick observations were made during its fifth month of age. Even within the three weeks of observation, the chick’s behavior changed slightly. It also took a major developmental step during this time, by successfully jumping to a higher-level rock within the nest for the first time. This shows the rapid development in condor chicks which is likely accompanied by a change in behavior throughout their nest-bound first months of life. This limits some of the possible generalization and application of results to condor chicks of similar age.

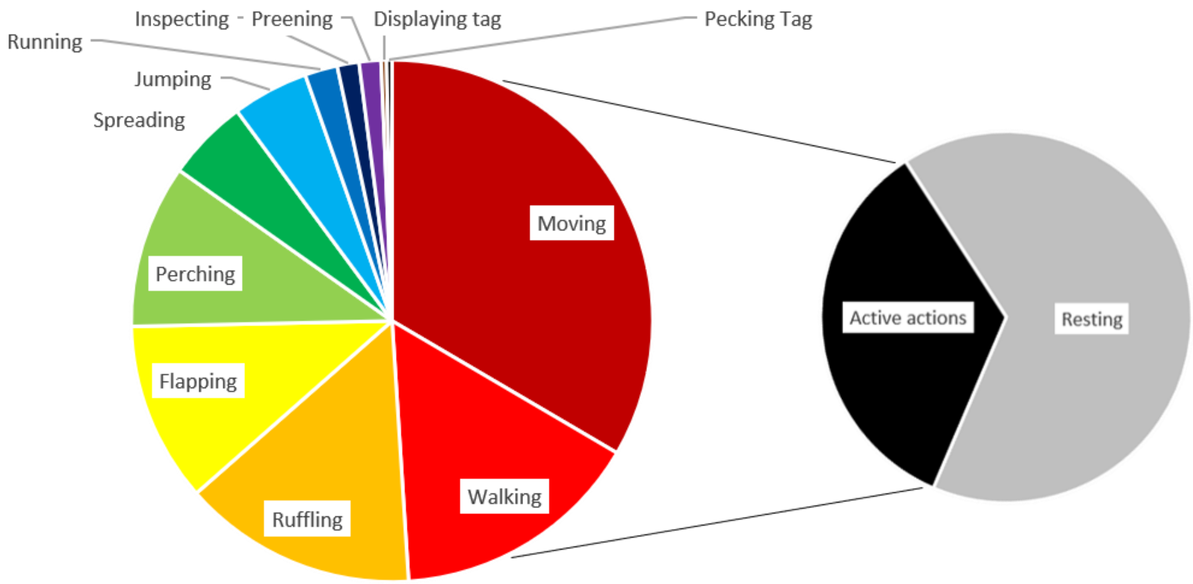

Figure 9: Chick nest behavior.

The chick was observed to be exclusively resting during 79% of five-minute intervals. All other actions were considered active actions, indicating chick activity. These include: moving (14%), walking (6%), ruffling (6%), flapping (5%), perching (4%), spreading (2%), jumping (2%), running (0.8%), inspecting (0.6%), preening (0.6%), displaying tag (0.1%), and pecking tag (0.1%). Displaying and pecking tag behaviors were only possible during the last three days of observation (once the chick had been tagged).

On November 26, the chick was tagged with the number 14 on both wings, as well as a tracking device on its right wing. At the beginning of the process, the female flew away and was not seen the rest of the time. The male arrived during the removal of the chick from the nest and was almost captured but escaped. The chick was relatively calm during the tagging process. Once re-released into the nest, the chick spent time very close to the edge of the nest but did not jump. Before tagging, the chick was on average noted to be participating in an active action during 14% of observed intervals. In the three days after tagging, the chick was on average noted to be participating in an active action during 35% of observed intervals. The chick’s levels of activity were significantly higher after than before tagging (t-test, p=.0277, JMP Pro 14) (Figure 10).

The chick was also noted to be dragging its right wing at times and to be having more difficulty flapping its wings, behavior not before observed. Both parents were disturbed by the tags and pecked or pulled at them, sometimes aggressively, until the chick walked away. It is unclear whether these responses harmed the chick although it was observed trying to run from parents during this behavior. The female was more affected, visiting the nest once to feed the chick on November 27 and then not returning to the nest until November 29. None of the female's three visits on the 29th involved feeding the chick, and the female's most common behavior was pecking at the chick's tags.

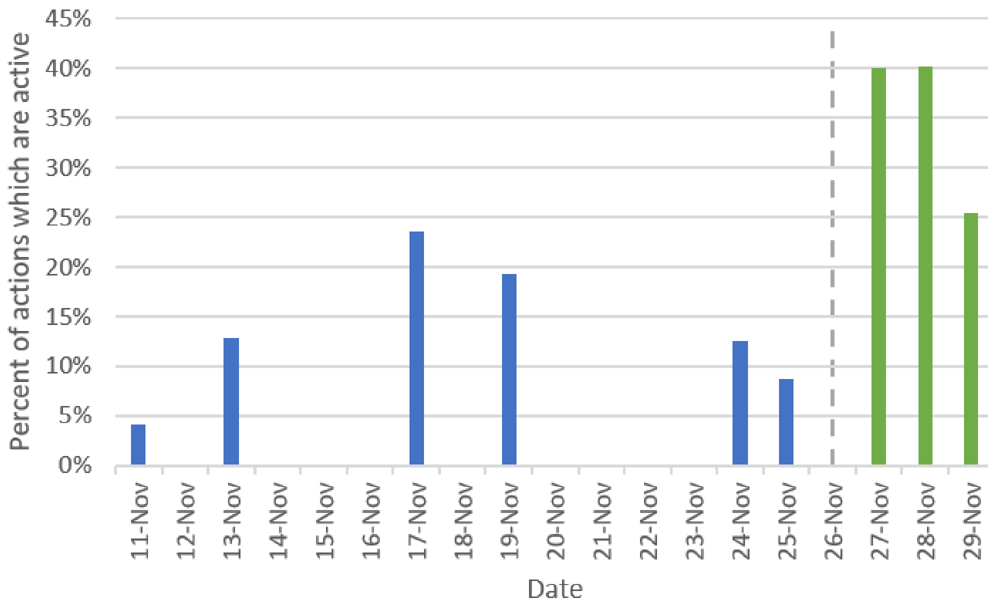

Figure 10: Active chick actions by date.

Percentage of five-minute periods of chick behavior characterized by actions other than only resting or being cleaned. Blue bars represent days before chick was tagged. Green bars represent days after chick was tagged. Dotted line represents tagging date.

Actions include: Displaying tag, Flapping, Inspecting, Jumping, Moving, Pecking tag, Perching, Preening, Ruffling, Running, Spreading, Walking

Field results

During the one day of constant carcass feeding observation, the following was observed. The initial feeding group was composed of 2 adult males (AM), 5 adult females (AF), 1 subadult male (SBM), 2 juvenile males (JM), and 2 juvenile females (JF). Four adults (2 AM, 2 AF) initially fed on the carcass, while the SBM, 2 JM's and 1 JF waited nearby. 3 AF's and 1 JF waited about 50m away on a hillside. 30 minutes after beginning, 2 AM's left feeding site. 2 JM's, 1 JF joined in feeding. AF's attempted to displace any juveniles which were feeding. One AF paused from feeding to clear the waiting juveniles further away from the carcass, only returning to the carcass when a third AF flew in and began to feed. When juveniles were feeding, JM's frequently displaced JF's. Birds were less likely to displace as duration they had been feeding increased.

In all field observations, weather played a large part in number of condors seen. When there was no precipitation or fog, an average of 2.29 condors were observed per hour. When there was precipitation or fog, an average of 0.22 condors were observed per hour.

Discussion

Parent behavior

Nest observations clearly show that both parents are involved in the raising of nestlings. This is not typically the case in birds, especially raptors, in which females are responsible from most of the parenting (Newton 1979). This study found however that the male plays a larger role in many parenting categories than the female, including number of nest visits, number of chick feedings, and total time on the nest cliff. The male also fed the chick more than once in a day on more occasions. This supports the finding in Lambertucci and Mastrantuoni (2008) that males were more likely to feed the chick multiple times per day and to exceed two feedings per day. The male was also far more active (flew and returned to the cliff) than the female during perches, often fending off black chested buzzard eagles. These findings suggest that male Andean condors play a greater role in parenting than do females in the fifth month of the nestling's life and possibly from birth until fledging.

Daily parental presence on the cliff rapidly decreased once the air was warm enough for the parents to fly and then increased again as expected at the end of the day. The time of least parent presence is just past 12:30 (Figure 8). This is also the height of chick feeding time, suggesting logically that the absence of parents at perches is due to their being out scavenging and only returning briefly to the nest to feed the chick, before once again searching for food. The most popular hour for the male to feed the chick was 11:00-12:00, while the most popular time for the female to feed the chick was 12:00-13:00. The later time of chick feeding in the case of the female is possibly a result of the dominance hierarchies at feeding sites. This would cause the female, a lower ranking individual, spend longer at feeding sites waiting until higher ranking individuals had left (Donázar et al. 1999). Another explanation of this disparity is a difference in trade-off calculations between the two sexes. Alarcón et al. (2017) found that in Andean condors, the sexual-size dimorphism impacts the calculus of each sex when balancing optimal feeding time and optimal wind and lift conditions. Males were more likely to prioritize wind conditions because of their heavier morphology and their dominance, which allows the adults to eat right away whenever they get to a carcass. Females, being lighter and less dominant than males, could greater afford to choose suboptimal wind and lift conditions because they have less sink than the males, and the incentive to get to a feeding site with little competition was much higher. While commuting statistics were not observed in this study, nest guarding statistics, any time a parent is perched at the nest cliff, were recorded, as well as incidences of feeding. From this data, commuting and foraging times can be inferred, as they are the two other known major behaviors of condors. Therefore, times directly after leaving the cliff those directly before returning can be assumed to be commuting times, while the rest of the time away from the nest is either commuting or foraging time. The return flight to the nest is the most energy-taxing commute for the Andean condor because it usually involves some powered flight to a high nest (McNamara & Houston 2008). The finding that the female returned to feed the chick later than the male is in keeping with Alarcón et al. (2017) because, if the male's typical return time is considered optimal wind and lift conditions, as it is incentivized to be based on the male's morphology and dominance, it suggests that the female is selecting sub-optimal return conditions. It could also be a result of a longer commute for the female. Donázar et al. (1999) suggests that hierarchically lower ranking individuals may expand their feeding range to include areas which are more energetically costly or more highly disturbed by humans. This could lead to less competition at feeding sites, as well as explain why some studies have found much greater male numbers at planted carcasses than females (Ríos-Uzeda & Wallace 2007).While the hypothesis that females were absent from feeding sites because of greater time spent parenting at the nest is unlikely in light of this study, as well as Lambertucci and Mastrantuoni (2008), the same phenomenon could be explained by the possibility that females are commuting and feeding for similar, or even longer periods of time, but to and at different, less favorable sites.

Looking at common perches can give further insight into the behavior of male versus female parents. Both parents most frequently visited a perch 2m from the nest. These visits were typically to briefly watch the chick and rest, frequently before or after visiting the nest. In terms of total time spent however, the favorite perches of the male and female were very different (Figure 13 & 14). The male spent by far the most time at a highly exposed perch, about 112m from the nest, which received sunlight during all hours of the day. This exposed him to increased harassment from black chested buzzard eagles. The preference for this perch likely parallels a pattern observed by Donázar, J. A., and Feijoo, J. E. (2002), whereby condors prefer roost spots which receive longer hours of direct sunlight in order to "maximize time available for foraging, plumage care, and maintenance, and to avoid cold stress" (Donázar & Feijoo 2002). This perch therefore fits very well with the rest of the male's observed behavior. The female, on the other hand, spent the most time perched about 12 m from the nest, in a highly protected and highly shaded nook in the cliff. While this again fits well with the observed lower activity of the female, it also begs the question of why she would not pick a sunnier perch. There was no observed evidence of displacement by the male which might exclude her from a perch receiving direct sun. This is especially interesting behavior, given that female Andean condors "experience higher physiological costs" than males (Gangoso et al. 2016).

Entrance and exit flight directions (Figures 4A & 4B) showed a clear pattern that the pair exclusively functioned within the 180-degree arc to the SE of the nest. This corresponds almost exactly with the region including Antisanilla Biological Reserve, Antisana Ecological Reserve, and Cotopaxi, another area of relatively high condor presence. This is also interesting because most commutes in this direction are increasing in altitude, making for a more difficult commute than is typical for condors which drop in elevation to feed (Alarcón et al. 2017). This pattern provides evidence of the complete habitat loss which has occurred in the other 180 degrees, which include the nearby town of Pintag and major city of Quito. In addition to direct habitat loss from human transformation, it is likely that the presence of roads in those directions, extending from populated areas, discourage the use of nearby land by condors (Speziale et al. 2008). It also shows that condors are having success within the mentioned reserves and that enough resources are available to this pair to make it the most productive currently known pair of Andean Condors.

In general, cliff observations were slightly hampered by decreased visibility late in the day as light became dimmer and a light fog often rolled over the cliff. This could have led to an undercounting of flying individuals which did not interact with the cliff or perched on the cliff without nest interaction. It is also possible that entrance and exit direction of condors flying later in the day was underrepresented because they were less likely to be identified while in flight. This error, however, would not have impacted nest visit or chick behavior data because a constantly monitored spotting scope was always watching the nest.

Chick behavior and tagging

The data collected on chick behavior establishes a baseline for how this chick and possibly other nestlings should behave under normal circumstances. Further, it is the first comparison of Andean condor chick behavior before and after an in-nest tagging event.

This was the sixth chick by this pair. Previous chicks had been left untagged in an effort to observe the pair without interference. Therefore, there were no compounding variables to account for. As stated in results, the chick's levels of activity were significantly higher after than before the tagging event. This behavior indicated that the chick was very uncomfortable with the tags. Due to the limited time frame of the study, it is unknown how long increased activity levels persisted in the chick's behavior and what effect the tags might have on its health in the long term. While the male exhibited less behavioral change, the event, as well as the tags on the chick did have a noticeable impact on both parents and led to fewer-than-typical feedings from the female in the aftermath. It is unknown whether this response would be typical in all Andean condors or whether it was pair-specific. There was no significant relationship found between number of feedings per day between parents. This suggests that if one parent stops feeding the nestling, the other is unlikely to compensate with more feedings. Therefore, if in-nest tagging events do uniformly lead to fewer feeding events from one or both parents, this may affect the health and growth of the chick. It is also unknown how long effects of in-nest tagging persist in parent behavior, and if the changed behavior would have any negative health impacts on the chick. Finally, it is unknown how an in-nest tagging event, as well as an unsuccessful capture attempt on the male in this specific case, might affect the future productivity of this pair or use of this nest.

Figure 11: Tagging of chick

Chick was removed from nest and brought to the top of nest cliff for examination, measurement, and tagging. Both wings were punctured to allow for tags on both, as well as a tracking device on the right wing. Chick was then lowered back into the nest.

Field Observations

All field observations were hampered by a small sample size. Nonetheless, they provide a complement to previous studies and raise questions about some previous findings. The feeding site behavior clearly pointed to dominance as determined by age group and, within age groups, by sex. This contradicts the findings of Donázar et al. (1999) and is the dominance hierarchy found in roost sites by Donázar and Feijoo (2000). The sample size is not large enough to make a claim about whether the condors of the Antisana region differ in feeding behavior from those observed in Donázar et al. (1999), from northern Argentina. It does, however, raise the question of whether the dominance hierarchy as determined by sex, and within sex, by age, is absolute, and if not, why it might differ from site to site or area to area.

Field observations further validated the finding that precipitation, as well as fog, has a grounding effect on condors (Lambertucci & Ruggiero 2013).

Conclusion

This study finds that the assumption made in Rios-Uzeda and Wallace (2007), that females were observed feeding at carcasses less frequently because they were spending time at nests, is flawed. Females contributed less time to parenting during the period of observation than did males. Instead, it is possible that females are feeding at different, less desirable sites, with higher human disturbance. If this explanation is true, it likely means that habitat loss and human presence even far from prime feeding sites can have a serious impact on condor populations because females and hierarchically lower ranking individuals are excluded from the prime sites. This should be considered when determining efficiency of protected areas and in future conservation efforts and likely calls for an expansion of protected areas. Additional studies specifically tracking female condor feeding habits, as well as overall behavior, are needed.

Findings add to the scarcity of knowledge of free-living Andean condor pairs and nest behavior although similar studies are still needed to create a fuller picture.

This study also uses flight directions entering and leaving a nest to determine what areas commuting and foraging is taking place in for a highly successful condor pair. These results provide evidence for the necessity of protected areas, as well as the habitat loss caused by roads and human presence. Findings may provide context for the spatial impact of population centers and roads on condor populations. Further studies are necessary to determine a strategy to preserve condor populations with this information in mind.

Change in nestling, as well as parent, behavior after an in-nest tagging event is detailed in this study. Significant changes in activity level were observed in the chick, as was abnormal parental behavior, as well as at least a temporary decline in feedings from the female. A longer study of nestling and parent behavior before and after an in-nest tagging event is needed to understand the longer-term consequences of this method on the chick's health, as well as the health and productivity of the parental pair.

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Appendix

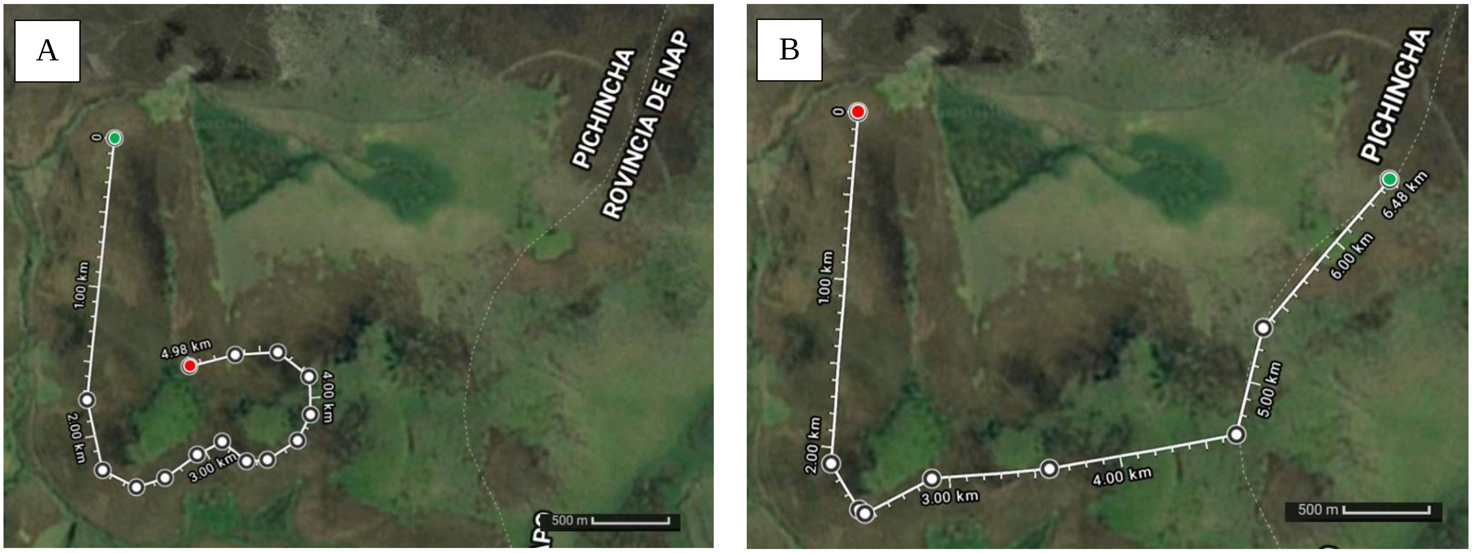

Figure 12: Transects

A: Transect 1 (November 20). B: Transect 2 (November 26). Green dot marks beginning of transect, red dot marks end of transect.

Created with Google Maps.

Favorite Perches	Male	Female
By # of visits	**6**	**5**
Distance from nest (m)	2	2
Early direct sun	No	No
Late direct sun	No	No
Description	Perch 2m to upper right of nest. Allows for chick observation and protection.	Perch 2m to upper right of nest. Allows for chick observation and protection.
By time spent (mins)	**277**	**243**
Distance from nest (m)	112	12
Early direct sun	Yes	No
Late direct sun	Yes	No
Description	Jut of rock coming off of nest cliff. Receives direct sunlight whenever sun is out.	Protected crevasse near nest, used as roosting place for nights

Figure 13: Favorite parent perches by number of visits and time spent

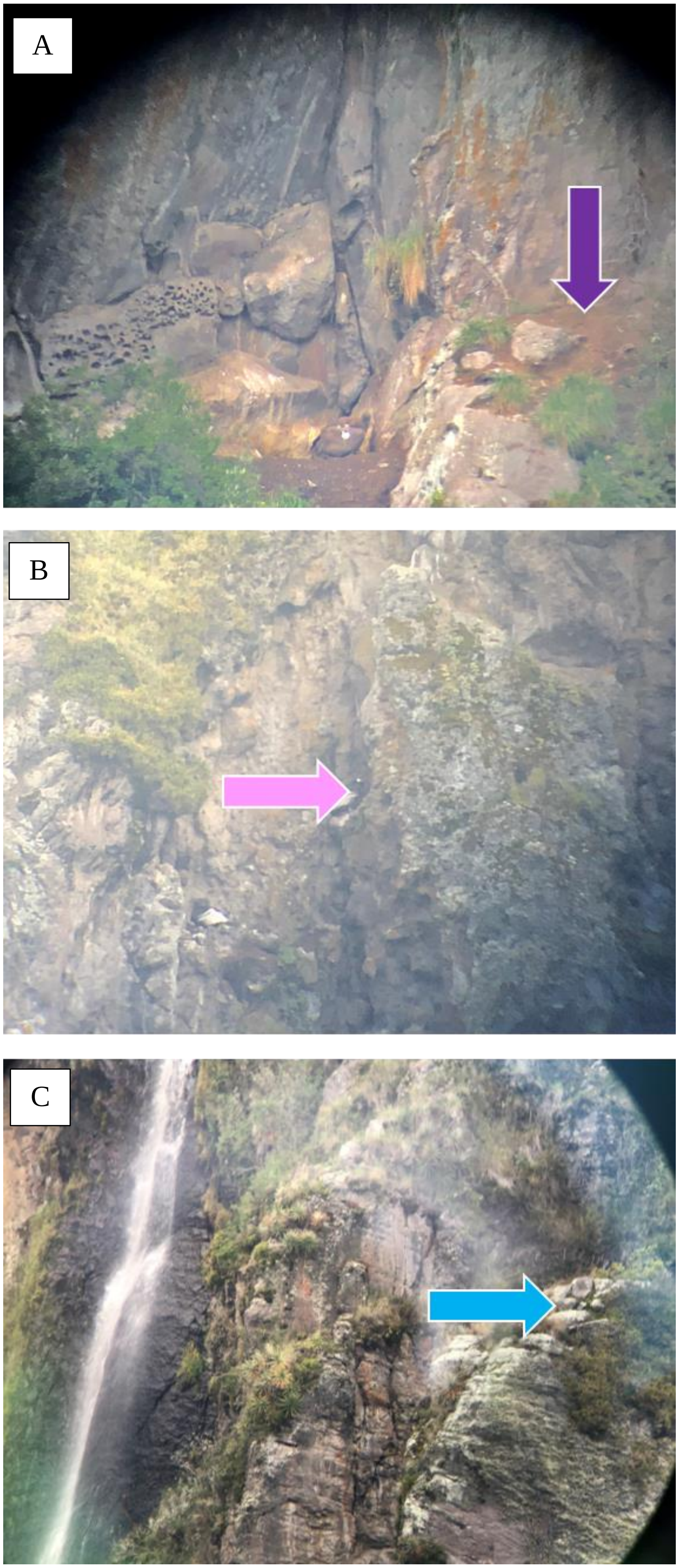

Figure 14: Favorite parent perches (pictures)

A: Male and female favorite perch site by number of visits. Purple arrow indicates perch site (2m to upper right of nest). Male visited six times, female visited five times throughout observations.

B: Female favorite perch site by time spent. Pink arrow indicates perch site (12m to left of nest). Perch is a protected crevasse near nest, used as roosting place for nights. Female spent a total of 243 minutes perched at this site.

C: Male favorite perch site by time spent. Blue arrow indicates perch site (112m to right of nest). Perch is a jut of rock coming off of nest cliff and receives direct sunlight whenever sun is out. Male spent a total of 243 minutes perched at this site.