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Ellie Cohn  
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# Andean condor cliff and parental care behavior

A behavioral study of a chick and his free-living parents on the Peñón del Isco, Ecuador

Ellie Cohn



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## ABSTRACT

Andean condors (*Vultur gryphus*) are a Near Threatened species of New World Vulture found throughout the Andes region of South America. Their population has been significantly diminished in the country of Ecuador due to threats primarily related to habitat loss and persecution by humans. High chick and juvenile mortality also threaten populations and as a result, investigation of wild Andean condors' cliff behavior and parental care are necessary in order to develop informed and effective conservation management plans. A 22-day observational study was conducted, monitoring a known breeding pair of Andean condors and their approximately three-month-old male chick on the Peñón del Isco in the Antisanilla Biological Reserve. During the period of observation, the male and female condors and their chick were monitored, and their behaviors were tracked. Findings reveal that although the male and female parents spent a comparable amount of time present on the cliff where the nest is located, the male parent played a larger parental role. The male parent spent more time in the nest, brought food to the chick more often, and spent more time feeding the chick. Additional findings highlight the importance of the Peñón del Isco as a habitat for Andean condors. The objective of this study was to develop further observations on the behavior of Andean condor parents and chicks to contribute to scientific knowledge that will allow for the conservation of the species.

## RESUMEN

Los cóndores andinos (*Vultur gryphus*) son una especie casi amenazada de la familia Cathartidae que se encuentra a través de la región de los Andes de América del Sur. Su población ha disminuido significativamente en el país de Ecuador debido a amenazas relacionadas principalmente con la pérdida de hábitat y la persecución por humanos. La mortalidad alta de los polluelos y los juveniles también es una amenaza a la población y como resultado, es necesario investigar el comportamiento y el cuidado de los padres de los cóndores andinos silvestres para desarrollar planes de manejo de conservación informados y efectivos. Se realizó un estudio observacional de 22 días, monitoreando una pareja reproductora de cóndores andinos y su polluelo macho de aproximadamente tres meses de edad en el Peñón del Isco en la Reserva Biológica Antisanilla. Durante el período de observación, se monitorearon el macho, la hembra y su polluelo, y se rastreó su comportamiento. Los resultados revelan que, aunque los dos padres pasaron una cantidad de tiempo comparable presente en los acantilados donde se encuentra el nido, el padre desempeñó un papel parental más grande. El padre pasó más tiempo en el nido, trajo comida al polluelo con más frecuencia y pasó más tiempo alimentándolo. Resultados adicionales recalcan la importancia del Peñón del Isco como hábitat para los cóndores andinos. El objetivo de este estudio fue desarrollar nuevas observaciones sobre el comportamiento de los padres y polluelos del cóndor andino para contribuir al conocimiento científico que permitirá la conservación de la especie.

## ACKNOWLEDGEMENTS

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## INTRODUCTION

The Andean condor (*Vultur gryphus*) is the largest New World vulture and has been found historically throughout the Andes mountains of South America in a region ranging from northern Venezuela to southern Argentina and Chile (Herrmann, Costina, & Costina, 2010). Andean condors are known for their impressive 3-meter wingspan (Vargas et al., 2018a). Their feathers are black with the exception of large white patches on their wings and a white collar. A sexually dimorphic species, male condors have a large comb on their head which allows for the differentiation of males and females (Herrmann, Costina, & Costina, 2010). Andean condors are scavengers and as a result their diet consists of carrion (Vargas et al., 2018a). In Ecuador, their diet primarily consists of domesticated bighorn cattle (Vargas et al., 2017). As scavengers, the Andean condor plays a key role in the páramo ecosystem, providing ecological services that include waste recycling, sanitary services, and indirect control of mammalian disease vectors (Sekercioglu, 2006).

Due to its small, declining global population, the International Union for Conservation of Nature (IUCN) has classified the Andean condor as Near Threatened (BirdLife International, 2019). Although larger populations exist in the Patagonia region of southern South America, the population of Andean condors in Ecuador has diminished significantly (Vargas et al., 2018a). A 2018 census of Andean condors in Ecuador counted a total of 150 condors and created a population estimate of only 140 to 270 individuals (Vargas et al., 2018b). In addition to having an extremely small population size, Andean condors have extremely low genetic diversity which puts the population at an increased risk of population decline (Hendrickson et al., 2003).

Population decline has been primarily caused by habitat loss as increased agricultural activity has reduced habitat in the areas inhabited by condors (Vargas et al., 2018a). Although they are a cultural symbol in much of South America, they are hunted and poisoned by farmers due to the false belief that they are a threat to livestock (Lambertucci & Speziale 2009). A decrease in habitat and in food available within protected areas causes increased human-condor interactions which furthers these false beliefs (Vargas et al., 2018a). Andean condors are also unintentionally poisoned by carrion meant to target other species. Other causes of population decline include loss of food sources due to competition with feral dogs and lead toxicity due to ingestion of contaminated carrion (Ogada, Keesing, & Virani, 2012; Wiemeyer, 2017).

Andean condors additionally possess a number of biological characteristics that make their populations especially vulnerable to these threats. Andean condors can have long lifespans (individuals may live as long as 80 years) and do not begin reproducing until the age of seven or eight (Vargas et al., 2018a). Adult breeding pairs tend to only lay eggs every two to three years, they only raise a single offspring in each brood, and chicks are dependent on their parents for as many as 15 months (Vargas et al., 2018a). Breeding pairs are monogamous and individuals typically do not find a new mate in the event of the death of their original mate (V. Ushiña, personal communication, November 10, 2019). These factors result in a species that reproduces relatively slowly which puts them at an increased risk of population decline as it is more difficult for the population to recover from threats.

The Antisanilla Biological Reserve is a reserve privately owned by the Jocotoco Foundation (Fundación Jocotoco Ecuador, n.d.). The reserve is located in the Pichincha province of Ecuador, approximately 35 km southeast of Quito and 10.5 km southeast of Pintag. The border of the Antisana Ecological Reserve is located approximately 10.5 km to the east. The Antisanilla Biological Reserve covers an area of 4,500 hectares and is at an elevation of 3300 - 4600 meters above sea level (Fundación Jocotoco Ecuador, n.d.). The area immediately

surrounding the Antisanilla Biological Reserve is dominated by agricultural fields and livestock pastures, which both provide condors with possible sources of food while also threatening their protection. Up to 40 Andean condors have been registered within the Antisanilla Biological Reserve and thus it is an important habitat for these birds (Fundación Jocotoco Ecuador, n.d.). The Antisanilla Biological Reserve provides the condors with valuable perching sites, water sources, food resources, and nest sites.

One known breeding pair of Andean condors has laid an egg in the Antisanilla Reserve every year for the past eight years (V. Ushiña, personal communication, November 10, 2019). All eggs have been laid and all chicks have been raised on the cliffs within the Antisanilla Reserve known as the Peñón del Isco. The most recent egg laid by this breeding pair successfully hatched in the summer of 2019. Based on sexually dimorphic characteristics, the chick was identified as a male. This chick is the first to occupy the current nest site. Previous chicks have occupied nest sites closer to the northwest end of the Peñón del Isco (V. Ushiña, personal communication, November 10, 2019). The current nest site is located at the southeast end of the cliffs in a large crevice as seen in Figure 1. To the right of the nest is rock and to the left of the nest is an area of vegetation.



*Figure 1.* Location of the current nest site within the Peñón del Isco at two different magnifications. The nest is located at the southeast end of the cliffs and is set into a crevice in the rockface.

The number of Andean condors in Ecuador that are juveniles or subadults is estimated to be less than 25% of the total population (Vargas et al., 2018b). This suggests low reproductive success or low survival of hatchlings and juveniles. Older studies have also confirmed that younger individuals, including hatchlings and juveniles, have higher mortality rates than older individuals in the same populations (Temple & Wallace, 1989). Despite the concern for their population size and reproductive success, investigation into the reproduction and nesting behavior of Andean condors in Ecuador has been limited, however a few studies provide insight into possible trends of behavior. A 2008 study focused on the nesting behavior of a pair of Andean condors over a 28-month period in Argentina (Lambertucci & Mastrantuoni). During the nesting period, Lambertucci and Mastrantuoni found that both the male and female parent brought food to the nestling, while the male parent visited the nest more often, stayed in the nest for longer periods of time, and brought food more frequently than the female parent. Additional

unpublished studies on the known breeding pair in the Antisanilla Biological Reserve confirm the findings of Lambertucci and Mastrantuoni. A 2018 study by Handler and a 2019 study by Chalekian focused on a chick born to the known breeding pair in the summer of 2018. Both studies found that the male parent spent more time at the nest site and more time engaging in parental care. Handler also confirmed that the male parent made more visits to the nest and fed the chick on more occasions. Given that all three of these studies focused on only a single male and female parent and their offspring, more information on nesting behavior and parental care of Andean condors is needed to best inform conservation efforts.

Further investigation into the nesting behavior and parental care of Andean condors is necessary to better understand the best conservation strategies to protect the species from extinction. A 22-day observational study of the known breeding pair in the Antisanilla Biological Reserve and their most recent chick was conducted. The focus of these observations was on adult cliff behavior, parental care, and nest behavior in families of adult and chick Andean condors. Overall this research has the intended goal of contributing to the base of knowledge on Andean condors to aid in the creation of conservation management plans and help prevent further population decline.

## MATERIALS AND METHODS

This study was based on the behavioral observations of an Andean condor family on the Peñón del Isco in the Antisanilla Biological Reserve. The family consists of a male and female parent and their three-month-old, male chick. The Andean condor chick and his parents were observed for 22 consecutive days between November 11th, 2019 and December 2nd, 2019. Observation occurred between the hours of 6:00 and 18:00. Observation typically occurred from 6:00-8:00, 9:00-13:00, and from 14:30-18:00. However, due to weather conditions and other factors related to the accessibility of the observation point, the actual hours of observation each day varied. Additional observation occurred on some days from 8:00-9:00 and 13:00-14:30 to ensure that data was collected throughout the whole window of observation.



Figure 2. Maps of the region surrounding the area of observation. A: Map including the locations of Pintag, the Antisanilla Biological Reserve (private reserve), and the Antisana Reserve (public reserve). The red box is area included in map B. B: Map including the Mirador Isco (site of observation) and the location of the nest on the Peñón del Isco. Created with Google Earth.

Observation occurred from the Mirador Isco, a lookout point within the Antisanilla Biological Reserve located southwest from the Peñón del Isco by approximately 500 meters (Figure 2). This site was selected because it offered the best view of the nest and the perches of the male and female parent condors. Condors, as well as birds of other species, were spotted using the naked eye and binoculars (8x26). Parental activity in the nest and on the cliffs and chick activity in the nest was monitored using a telescope with a 60x magnification. A watch was used to keep time.

Observation was divided into one-minute-long observation periods. During each minute, the presence or absence of the female parent and male parents was recorded, and if present, their location was noted. The male and female parent were identified based on the presence or absence of a comb on the top of their head. When present, the adult's behavior was monitored and any behaviors that occurred during each observation period were identified and recorded. Parental behaviors were divided into four categories: parental care, mating behavior, territorial behavior, and other. The fourth category, other, was characterized by independent actions such as resting or self-preening. Observed parental behaviors included:

- i. Parental Care
  - a. Feeding Chick
  - b. Watching Chick
  - c. Preening Chick
- ii. Mating Behavior
  - a. Spreading Wings
  - b. Rubbing Necks
  - c. Watching Partner
- iii. Territorial Behavior
  - a. Cliff Protection from other condors
  - b. Cliff Protection from other bird species
- iv. Other
  - a. Flying
  - b. Perching (standing still with head raised above chest height)
  - c. Resting (standing still with head below chest height)
  - d. Moving
  - e. Walking
  - f. Self-Preening
  - g. Flapping Wings
  - h. Bathing
  - i. Pecking Ground
  - j. Looking Around

In addition to tracking behavior on the cliff, the direction of the arrival or departure of the condors was observed to gain a better sense of how the surrounding area was utilized by the Andean condors in the Antisanilla Biological Reserve. If the arrival or departure of an individual occurred during the observation period, the direction of flight was determined and recorded. The approximate direction of flight was determined using a compass.

Because of the constant presence of the chick, his behavior was monitored and recorded during each observation period. Behaviors of the chick fell into the following categories:

- i. Moving (changing physical position within nest)
- ii. Walking

- iii. Flapping Wings
- iv. Self-Preening
- v. Being Preened by Parent
- vi. Feeding (being fed by parent)
- vii. Perching (standing still with head raised above chest height)
- viii. Resting (standing still with head below chest height)

In addition to the observation and characterization of chick and adult behavior during each minute-long observation period, other factors were observed and recorded. First, the weather was recorded. Recordings were made for the presence of rain, clouds, and wind on a scale of 0 to 3, 0 indicating the complete absence of the factor and 3 indicating a heavy presence. It should be noted that weather observations were made based on the conditions at the point of observation, the Mirador Isco, as the exact conditions at the cliffs and nest could not be assessed. Additionally, during each observation period, separate tallies were kept of the number of Andean condors (not part of the family being observed) and the number of birds of other species present on or above the Peñón del Isco. To analyze the presence of condors and birds of other species present, after the numbers of condors and other birds were separately tallied during each minute-long observation period, the tallies for each minute were added across the hour to generate a total number of birds tallied per hour. This was averaged across the 22 days of observation to generate an average number of birds present per hour. It should be noted that the same bird may have been tallied across multiple minutes.

Data analysis focused on comparisons of the frequency of behaviors exhibited as well as comparisons of the amount of time spent performing different behaviors. Behaviors of the male and female parent were analyzed by comparing the total frequency of behaviors. To determine if there was a significant difference between the parental care behaviors of the two parents, chi-square goodness of fit tests were performed for frequency of visits to the nest, total time spent at the nest, frequency of feedings, and total time spent feeding. The equation for this test is:

$$X^2 = \sum \frac{(O - E)^2}{E}$$

where O is the observed frequency of behavior and E is the expected frequency of behavior. The chi-square goodness of fit tests were performed using the null hypothesis that there was no difference between the behavior of the male and female parent, and therefore, the observed frequencies should be equal. Analysis also looked at trends of activity of the parents, chick, and birds of other species based off of average activity at each hour of the day.

## RESULTS

Between November 11th, 2019 and December 2nd, 2019, observation occurred for a total of 168 hours and 4 minutes. Observation ranged from 4.25-9.25 hours per day with a median observation time of 7.75 hours per day.

### *Cliff Usage*

Both the male and female parents were present on the Peñón del Isco for a portion of every day of observation. The male parent was present at the cliffs or nest for a total of 3,145 minutes, or 52 hours and 25 minutes. He was present for an average of 142.95 minutes each day. The female parent was present at the cliffs or nest for a total of 3,194 minutes or 53 hours and 14

minutes. She was present for an average of 145.18 minutes each day. The chick was present for the entire duration of observation.

Of their time spent present on the cliff, the male and female parents spent 775 minutes and 1021 minutes perched, respectively. They both visited 22 different perches throughout the observation period, although the 22 perches visited were not identical for the two individuals. The male parent perched a total of 56 times while the female parent perched a total of 77 times. The four most popular perches were identified, see Figure 3. Perch preference was analyzed both based on the time spent on each perch and the frequency of visits to each perch. For the male parent, the most popular perches based on total time spent on the perch were: C (317 total minutes), D (180 total minutes), and A (49 total minutes). For the male parent, the most popular perches based on total number of visits were: C (10 visits), D (6 visits), and A (5 visits). For the female parent, the most popular perches based on total time spent on the perch were: A (196 total minutes), D (133 total minute), and B (131 total minutes). For the female parent, the most popular perches based on total number of visits were: A (12 visits), D (9 visits), and C (7 visits). The three perches where the male and female parent spent the most time represented 70.45% and 45.05% of their total time perching respectively. The three perches that the male and female visited the greatest number of times represented 37.5% and 36.36% of their total visits. The Andean condors observed were more likely to be perched than flying during periods of hail or heavy rain



*Figure 3.* Approximate locations of the male and female parents' preferred perches on the Peñón del Isco. Perches A, B, C, and D were among the most visited perches by the male and female parent, as well as the perches that the two individuals spent the most time at. The red square represents the nest location.

Perch A was positioned furthest to the northwest. Both the male and female condor were most often observed at this perch in the evening or early morning hours of observation and it was thus assessed to be a site also used for roosting. It was common for both parents to rest at this site. Perch B was located to the southeast of Perch A and was immediately to the right of the waterfall present at the Peñón del Isco. This perch was the most common perch visited by the parent condors after bathing. Perch C was located on the southeast end of the Peñón del Isco, northwest from the nest. This perch was in the sunlight on clear days and was covered in vegetation. Perch D was immediately to the left of the nest and was also covered in vegetation. This perch was most often visited right before or right after visiting the nest.

In addition to perching behavior, both parents were observed on the cliffs exhibiting a wide variety of other behaviors. Besides perching, the three most common behaviors by frequency for both the male parent and the female parent were flying, resting, and self-preening.

Other independent behaviors constituted a much smaller portion of the observed actions. Behaviors are detailed in Table 1.

Table 1 – Percentages of Most Common Behaviors Based on Behavior Frequency

	Perching	Flying	Resting	Self-Preening	Other*
Male Parent	37.79%	20.89%	6.45%	29.76%	5.11%
Female Parent	47.46%	19.80%	6.41%	21.49%	4.84%

\*Behaviors classified as other: Moving, Walking, Spreading Wings, Flapping Wings, Bathing (in waterfalls to clean feathers), Pecking Ground, Watching Their Partner, Rubbing Necks, and Looking Around.

Neither mating nor territorial behaviors were highly prevalent. Mating behaviors were observed between the male and female parents on three different days throughout the period of observation. Mating behaviors observed were watching their partner, spreading their wings, and rubbing necks. All three of these behaviors were exhibited on all three days. Each of the parents exhibited territorial behaviors once. The female parent was observed chasing a black-chested buzzard-eagle away from the nest area. The male parent was observed chasing a second adult male Andean condor above the Peñón del Isco.

During observation, an Andean condor was observed arriving to and departing from the Peñón del Isco on 76 occasions. These condors included both the male and female parent as well as other adult, subadult, and juvenile condors of both sexes. Of these arrivals, the three most popular directions of flight were north (23 individuals), southeast (23 individuals), and northwest (10 individuals). Andean condors were observed departing from the Peñón del Isco 132 times. The three most common directions of departure flight were northeast (46 individuals), north (44 individuals), and east (42 individuals). The respective percentages of the three most common directions of arrival and departure are seen in Figure 4.

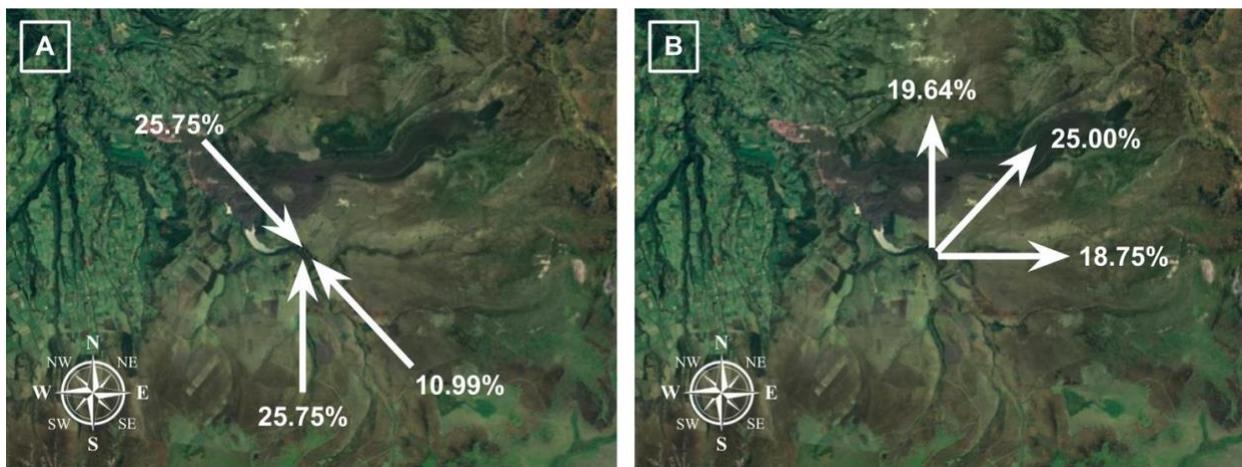


Figure 4. Arrival and departure flight directions of Andean condors to the Peñón del Isco. All arrows center on the Peñón del Isco within the Antisanilla Reserve. Map A demonstrates the arrival directions, the most common directions being north, southeast, and northwest. Map B demonstrates the departure directions, the most common directions being northeast, north, and east. Percentages reflect the number of flights that arrived or departed in the given direction. Created with Google Earth.

In addition to the presence of Andean condors, the Peñón del Isco is a habitat for many other species of birds. Aside from Andean condors, the species of birds most commonly spotted from the Mirador Isco were the black-chested buzzard-eagle (*Geranoaetus melanoleucus*), the carunculated caracara (*Phalacrocorax carunculatus*), and the variable hawk (*Geranoaetus polyosoma*). The black-chested buzzard-eagles were observed to also have nests on the Peñón del Isco. The average sum of the number of Andean condors was highest in the early morning hours (6:00-9:00), decreased throughout the midmorning and afternoon (9:00-15:00), and rose again towards the late afternoon and early evening (15:00-18:00), as seen in Figure 5. The average sum of the number of birds of other species followed a similar trend throughout the day, however, the sum was higher in the late afternoon and early evening (15:00-18:00) than in the early morning hours (6:00-9:00). The average sum of the number of Andean condors was always higher than the sum of the number of other birds present.

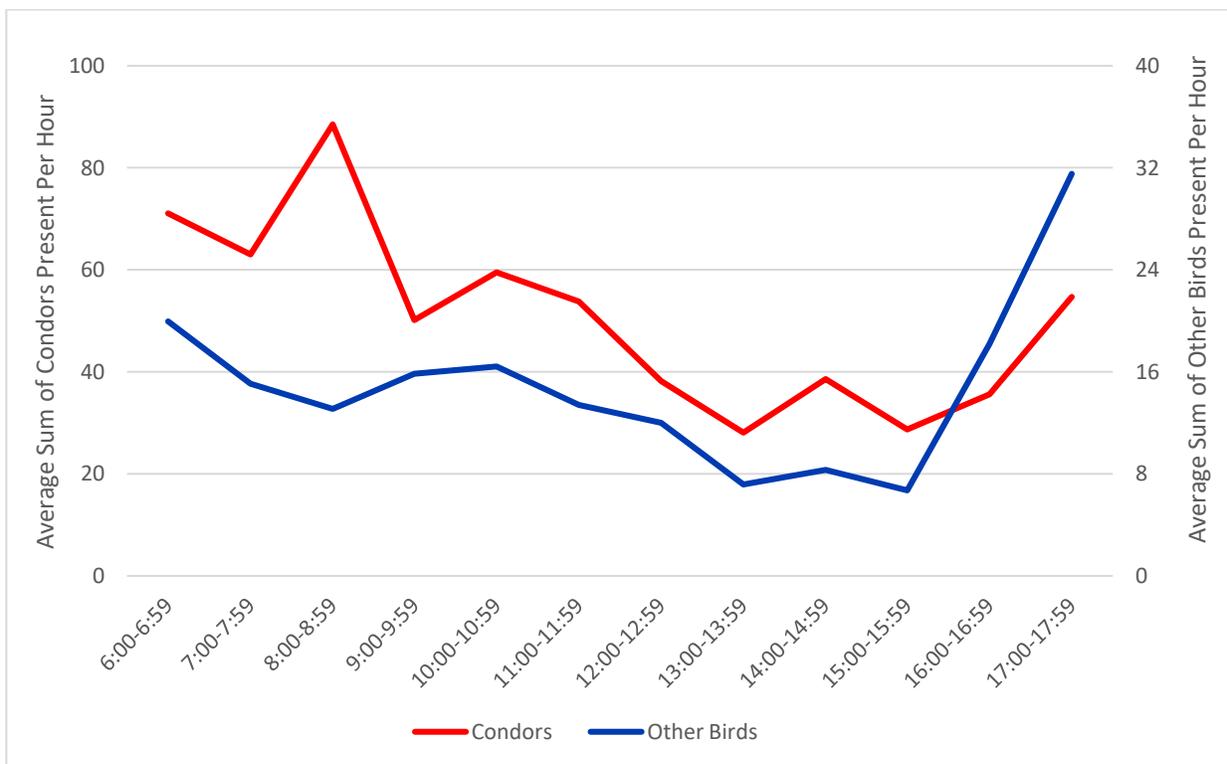


Figure 5. Average sum of the number of Andean condors and birds of other species tallied during each hour of observation. Average sum generated by adding the number of birds tallied during each minute-long observation period for each hour and taking the average across the 22 days of observation.

### Parental Care and Chick Behavior

Both the male and female parent played a role in parental care. Both were observed visiting the nest, feeding the chick, and preening the chick on multiple occasions. The male parent visited the nest a total of 45 times, which is more than the number of visits made by the female parent, who visited the nest a total of 28 times. The male parent was observed visiting the nest 21 out of the 22 days of observation and visited an average of 2.05 times per day ( $\sigma = 1.05$  visits). The male parent spent a total of 507 minutes at the nest and his average time spent at the nest per visit was 13.45 minutes ( $\sigma = 11.94$  minutes). The female parent was observed visiting the nest 20 out of the 22 days of observation and visited an average of 1.27 times per day ( $\sigma =$

0.70 visits). The female parent spent a total of 390 minutes at the nest and her average time spent at the nest per visit was 11.52 minutes ( $\sigma = 13.26$  minutes). Overall, the male spent significantly more visits to the nest ( $X_2 = 3.9589$ ,  $P < 0.05$ ) and spent significantly more time present at the nest ( $X_2 = 15.2609$ ,  $P < 0.01$ ).

Most visits to the nest were made between the hours of 10:00 and 13:00 (Figure 6). During the 22 days of observation, the female parent made no visits to the nest before 10:00 and only visited during six out of the 12 hours of the day. During the 22 days of observation, the male parent visited the nest 10 out of the 12 hours of the day. It should be noted that not all hours of the day were observed each day. Therefore, it is likely that parents fed the chick outside of the hours of observation. Additionally, each hour of the day was not observed the same number of times, however, comparison may be made between the number of visits made by the two parents during the hours observed.

The male parent played a larger role in feeding the chick than the female parent. He made more visits to the nest to feed, spent longer feeding on average per day, and spent longer feeding on average per visit. Of the 45 visits made to the nest by the male parent, he fed the chick during 41 of the visits. The female parent fed the chick during 27 out of her 28 visits made to the nest. The male spent a total of 235 minutes feeding the chick during observation. He fed the chick for an average of 10.68 minutes per day ( $\sigma = 7.66$  minutes) and spent an average of 5.72 minutes ( $\sigma = 3.96$  minutes) feeding the chick per visit in which feeding occurred. The female parent spent a total of 123 minutes feeding the chick during observation. She fed the chick for an average of 5.59 minutes per day ( $\sigma = 3.12$  minutes) and spent an average of 4.56 minutes ( $\sigma = 3.12$  minutes) feeding the chick per visit in which feeding occurred. The male spent more total time feeding the chick on 15 out of the 22 days of observation (Figure 7). Overall, the male fed the chick more times ( $X_2 = 2.8824$ ,  $P < 0.10$ ) and spent significantly more time feeding the chick ( $X_2 = 35.03911$ ,  $P < 0.01$ ).

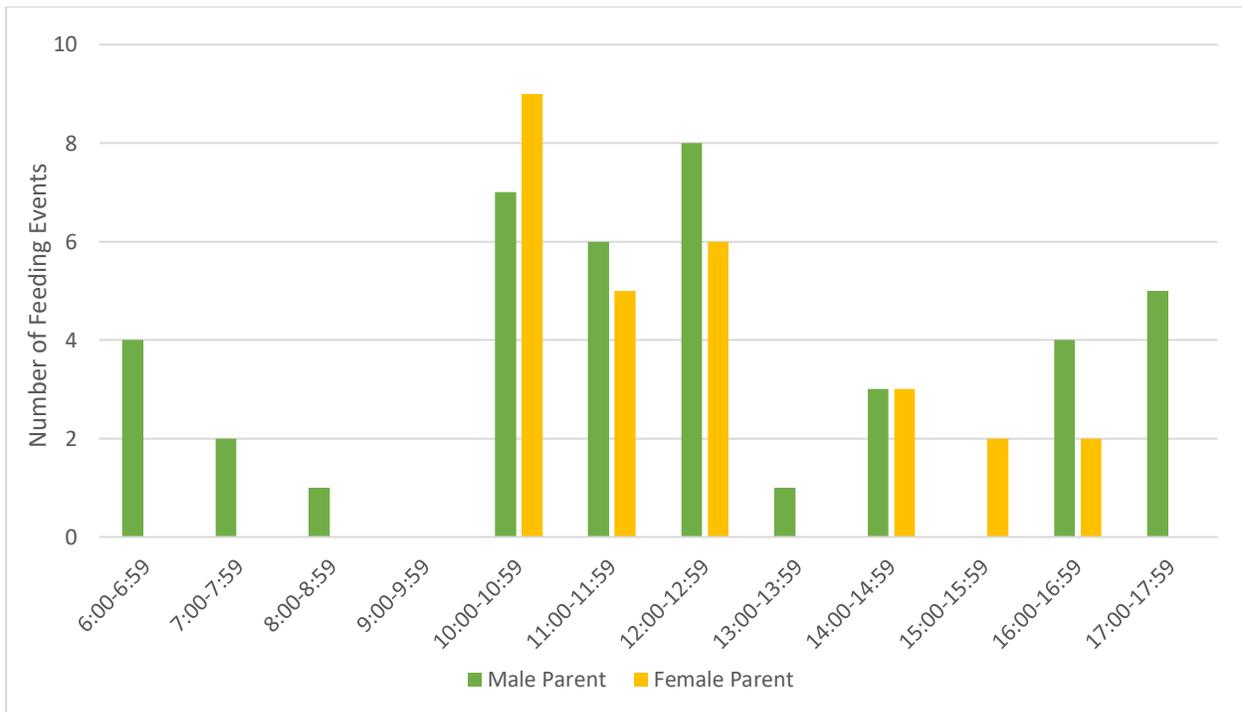


Figure 6. Number of feedings performed by each parent by hour of the day across the period of observation.

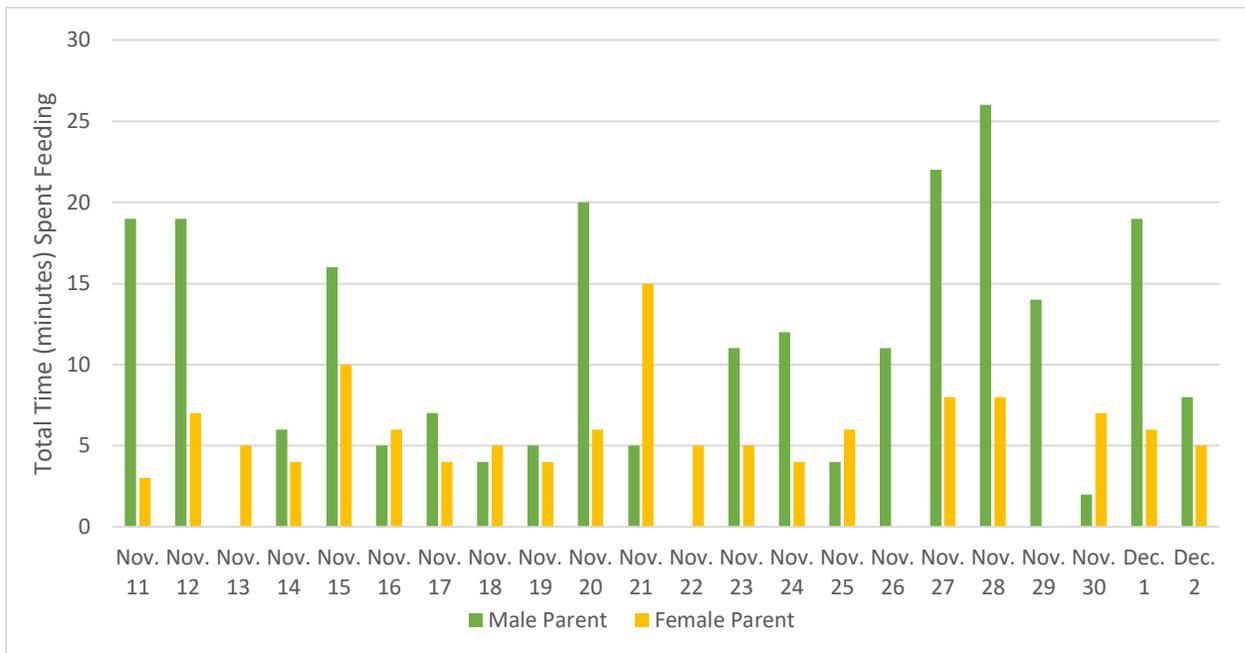


Figure 7. Total time spent by parents feeding the chick on each day of observation. Total time spent feeding may represent 0-4 feedings by either parent.

In addition to nest visits and feeding behaviors, both parents additionally exhibited other parental behaviors such as watching the chick and preening the chick. Both of these behaviors were noted on their frequency rather than the time spent completing the action. The male parent watched the chick 8 times and preened the chick 24 times. The female parent watched the chick 4 times and preened the chick 27 times.

The chick was present in the nest for the entire period of observation. However, due to the chick’s coloration, the positioning of the nest, and the light available, he was not visible during every hour of observation. As a result of these factors, the chick was only visible for 58% of the total observation time, or approximately 97.8 hours. Behavioral data could only be collected during periods when the chick was visible. During this period of time, seven different behaviors were observed as highlighted in Table 2.

Table 2 – Percentages of Observable Chick Behavior by Frequency of Behavior

Percent of Observed Behaviors	
Resting	38.32%
Moving	36.92%
Walking	16.59%
Feeding	9.50%
Flapping Wings	6.39%
Getting Preened	5.14%
Self-Preening	2.73%

Of the behaviors exhibited, 61.68% of the behaviors were active behaviors, or any behavior other than resting. Using these active behaviors, the chick's overall activity was assessed based on his average active minutes during each hour of the day (Figure 8). His average activity was highest in the middle of the day (between the hours of 11:00 and 13:00).

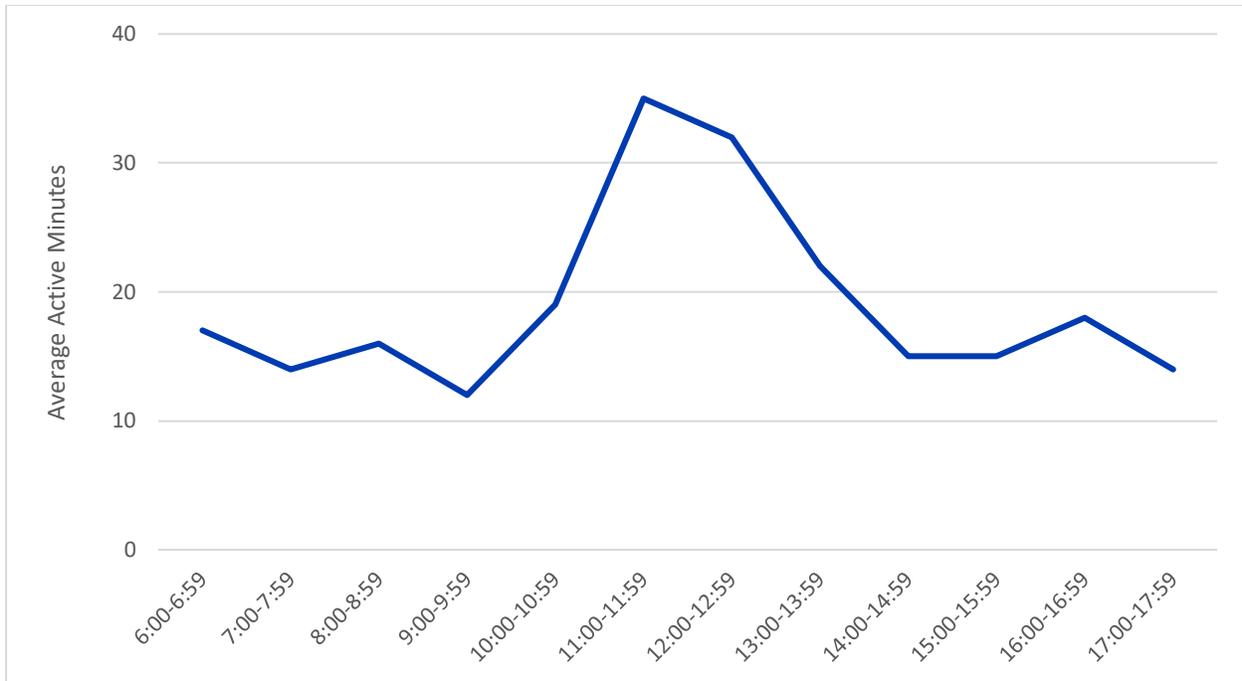


Figure 8. Average active minutes of chick per hour.

## DISCUSSION

### *Cliff Usage*

The male and female parents spent a very similar amount of time present on the cliff, their total times present only varying by 49 minutes. Other studies on the presence of male and female Andean condor parents suggest differing conclusions on which sex tends to be more present at nest sites. Ríos-Uzeda and Wallace (2007) report that female Andean condors in Bolivia may spend less time at feeding sites because they spend more time at nests with young. In contrast, Lambertucci and Mastrantuoni (2008) reported that an individual male Andean condor in Argentina spent more time present than the female parent, possibly due to territorial reasons, as the male parent may not have to travel as far to obtain food. Unpublished studies performed in the Antisanilla Biological Reserve suggest similar findings to that of Lambertucci and Mastrantuoni, demonstrating that the male parent was present significantly more than the female parent (Chalekian, 2018; Handler, 2019). The present study was affected by dense cloud coverage that completely obscured the view of the Peñón del Isco, often for hours at a time and most often in the late afternoon and evening. This was the largest limitation of the study, as observation could not occur during these periods. As a result, all hours of the day were not observed an even number of times and the total time present for the two individuals is a representation of the periods observed, rather than of the 22-day period as a whole. Had there been a more even distribution of observation hours or a larger number of observation hours completed, one of the parents may have revealed themselves to be present more than the other.

Other factors that may have influenced the presence of the male and female parent at the Peñón del Isco during the period of observation are the presence of food, the location of food, and the weather.

An important topic of consideration is the location of the nest site used, as well as why a new nest was built for this chick. All of the previous seven chicks have been raised on the Peñón del Isco and the previous three chicks were all raised in the same nest (Handler, 2018; V. Ushiña, personal communication, November 10, 2019). One hypothesis as to why a new nest site was selected was in avoidance of predators. A number of species that would consume Andean condor eggs or chicks, such as the spectacled bear (*Tremarctos ornatus*), are known to be present within the Antisanilla Biological Reserve and on the Peñón del Isco (Fundación Jocotoco Ecuador, n.d.). It is possible that the parents assessed the previous nest site to be too accessible to predators and therefore created a new nest site to protect their egg and offspring. Another hypothesis as to why a pair would choose a new nest site is to avoid the accumulation of parasites (Newton, 1979). By laying the egg in a new nest site, parents protect their young from a possible source of harm. California condors (*Gymnogyps californianus*) are a second type of New World vulture that belongs to the same family as the Andean condor and live in the western United States and Mexico. A study examining these condors found that most breeding pairs switched their nest sites after nesting failures (Snyder, Ramey, & Sibley 1986). Given that there had been one nesting failure to this breeding pair in the last two years, it is plausible that this encouraged the move (V. Ushiña, personal communication, November 10, 2019). The most recently used nest site is located at a distance from previous nest sites that is much greater than the distance between previous nest sites. It is located at the southeast end of the Peñón del Isco, while previous nest sites have been located more towards the center, close to the waterfall. This seems to suggest that the first hypothesis played a large role in the movement decision as the second two hypotheses would not suggest such a drastic relocation, whereas the threat of predation in the general vicinity of previous nest sites may cause the parents to move a further distance to protect their offspring.

In addition to the selection of nest location, there are a number of factors that may influence the perch preference of the male and female parent. The most common perch used for roosting overnight, Perch A, was the least accessible of the four most commonly used perches. In their assessment of roosting sites of Chilean Andean condors, Herrmann, Costina, and Costina reported that when selecting places to roost, observed condors chose inaccessible rock ledges or cliff faces (2010). These points serve as protection from external threats such as predation (Donázar & Feijóo, 2002; Herrmann, Costina, & Costina, 2010). Perch A was also well shielded from the wind and rain, thus protecting the condors from the elements while perching or roosting. Perches B and C were less protected and thus more commonly visited during the daytime. Due to Perch B's close proximity to the waterfall where the male and female condor bathed, Perch B was a common sunning spot following their bathing. Andean condors do not have waterproof feathers and thus must spend a considerable amount of time self-preening and sunning after bathing, upwards of two to three hours (Gailey & Bolwig, 1973). Perch C also received direct sunlight during the daytime on clear days and was thus also a common spot for self-preening and sunning. Lastly, Perch D was most likely chosen due to its proximity to the nest. As stated, this perch was most commonly visited immediately before or immediately after visiting the nest, and thus was a common spot for the parents to watch the chick from outside of the nest area. Andean condors have been observed to have a greater number of perches in the spring and summer than in the autumn and winter (Donázar & Feijóo, 2002; Herrmann, Costina,

& Costina, 2010). Given that the present study was conducted in the autumn and winter, this may suggest why the male and female parents respectively spent 70.45% and 45.05% of their total time perching at the three perches where they spent the most time, rather than dividing their time among a greater number of perches. However, due to Ecuador's equatorial climate, Andean condors in Ecuador are less likely to have their behaviors shaped by the time of year (Vargas et al., 2018a). Further research should compare the number of perches visited by Andean condors in Ecuador at different points of the year.

In addition to the reported behaviors, there were behaviors that have been observed among Andean condors that were possible but not observed during this investigation. It was possible that feeding behaviors would be observed among adults on the Peñón del Isco (V. Ushiña, personal communication, November 10, 2019). However, based on the availability of food in this location during the observation period, adults were not observed consuming food at any point. In contrast to Andean condors found in the Patagonia region of South America who reproduce between October and March, Andean condors in Ecuador have been known to be reproductively active throughout the year due to Ecuador's equatorial climate (Vargas et al., 2018a). As a result, mating behaviors such as gathering nest materials, chewing dirt, and copulation were also possible but not observed (Gailey & Bolwig, 1973; Chalekian, 2019). Territorial behavior was seen only a limited number of times. Lambertucci and Mastrantuoni (2008) reported that territorial behaviors, including flying towards and pursuing other birds, were mainly observed during the period of incubation and the first two months after the chick had hatched. Based on this and the knowledge that the observed chick at the Peñón del Isco is approximately three months old, it may explain why limited territorial behaviors were observed.

The directions of flight arrivals and departure give a sense of the land usage of the Andean condors. The Antisana Ecological Reserve, which is a common place for condor sightings and for the condors to feed, is located to the east of the Peñón del Isco (Ministerio de Ambiente, n.d.). 18.75% of flights departed to the east and 10.99% of flights arrived from the southeast, indicating that these flights may have been going to or coming from the Antisana Reserve. With the exception of the 25.75% of flights that arrived from the northwest, flights generally tended to avoid the area to the west of the Antisana Reserve. This area is more populated and has high human activity, such as in the town of Pintag. Speziale, Lambertucci, and Olsson (2008) demonstrate that condors prefer feeding sites further from roads and other areas of human activity. This provides reasoning as to why more flights departed in the northern, eastern, and northeastern directions from the Peñón del Isco as the area to the west is more heavily populated by humans and condors may have been searching for food in less disturbed areas. A number of other areas where condors have been commonly reported are also in the direction of common condor flight routes: the Cotopaxi National Park, the Cajas National Park, and the Cotacachi Cayapas Ecological Reserve (Ministerio de Ambiente, n.d.; Vargas et al., 2018b). All of these sites are ideal for condors due to their food potential and lower human disturbance, suggesting why flights might frequent these directions. Lastly, it should be noted that the discrepancy in the number of individuals arriving and departing can be explained by the presence of individuals on the Peñón del Isco when observation began and the fact that condors tended to depart at higher altitudes than they arrived, making discernment of departure directions easier.

The presence of Andean condors as well as birds of other species was highest in the morning hours and evening hours. One possible reason for the decrease in activity during the middle of the day is the idea that this portion of the day was spent finding food (Vargas et al., 2018a). Given that most feedings also occurred midday, it is plausible that fewer birds were

present because more birds were scavenging or hunting for food. Additionally, the most common time of the day for bad weather was the early afternoon. Cliffs, such as the Peñón del Isco, play an important role in the protection of condors from weather (Donázar & Feijóo, 2002; Lambertucci & Ruggiero 2013). During periods of heavy precipitation, the number of condors present was less likely to change as condors present at the Peñón del Isco were more likely to be perched on the cliffs rather than flying. There was also a decrease in the number of new condor sightings, as it was uncommon for condors to fly into the area during periods of heavy rain. Because all vultures, including Andean condors, locate carrion using their eyesight, they are less likely to be hunting and more likely to be perched during periods of poor weather and visibility (Ogada, Keesing, & Virani, 2012). Heavy rain and hail most often occurred in the afternoon hours (between 14:00-16:30). This correlates to the hours of decreased activity among both the Andean condors and birds of other species, suggesting that the weather conditions may have had an effect on the overall activity of the birds present.

### *Parental Care and Chick Behavior*

Although the two observed parents spent a comparable amount of time present at the Peñón del Isco, this study revealed the father to be the principal caregiver. He spent more time present at the nest, made more visits to the nest, fed the chick more times, and spent more time feeding the chick. Observations of the male parent as the principal parent are supported by other studies in the Antisanilla Reserve, studies in other parts of Ecuador, and a study conducted in Argentina (Chalekian, 2019; Handler, 2018; INEFAN, 1997; Lambertucci & Mastrantuoni, 2008). Lambertucci and Mastrantuoni (2008) monitored a breeding pair in Argentina for 28 months and found that the male brought food, fed the chick, and interacted with the chick significantly more than the female. The male performed 65% of the feedings, in contrast to the 22% performed by the female and 13% by a parent who could not be identified (Lambertucci & Mastrantuoni, 2008). Comparably, the male condor observed in the present study performed 60% of the observed feedings. A number of hypotheses as to why the male parent plays a larger role in providing food to the chick have been suggested, most of which are related to the social hierarchies of Andean condors. Based on the social hierarchies that exist between individuals in a group of condors as well as between the male and female in a breeding pair, it may be easier for males to obtain food and they may be able to obtain more food without traveling as far as individuals who are lower in the social hierarchy (Donázar et al., 1999). If females have to travel further to get food, they have less time to spend feeding the chick or performing other parental care behaviors. Although the observed male and female parents spent almost the same amount of time present on the cliff, it still may be possible that the female had to travel farther to get food, as the times between visits to the cliff were not analyzed.

Feeding time peaked for both the male and female parent midday, between the hours of 10:00 and 13:00. Lambertucci and Mastrantuoni (2008) observed that 84% of feedings of a chick in Argentina occurred between 11:00 and 18:00, however they do not propose a reason as to why most feedings occurred in this window. Alarcón et al. (2017) propose that due to the large size of Andean condors, who can weigh up to 15 kg, condors are forced to balance the food availability and wind resources. Carcasses tend to be more available in the early mornings whereas the updrafts that condors depend on to fly are strongest in the afternoon (Alarcón et al., 2017). A balance between these two factors may suggest that a midday feeding maximizes food availability and wind presence.

The chick, who has not yet left the nest and thus whose behavior would be less impacted by wind presence, was most active in the middle of the day, between the hours of 11:00 and 13:00. These hours overlap with the hours in which most feedings occurred, 10:00-12:00. This suggests that the increase in chick activity corresponds to the presence of either parent. The chick's overall activity seemed to follow a similar trend as the feeding schedule: decreasing throughout the early to mid-morning, peaking mid-day, and declining in the afternoon and evening. The chick's behaviors observed while the parents were present tended to be larger and more noticeable. Feeding was often accompanied by wing flapping or moving back and forth quickly. It is possible that the presence of either parent not only increased activity of the chick but made the chick more visible, thus increasing the number of observed active minutes. Based on the shape of the nest, it was possible for the chick to move into positions in which he was not visible from the Mirador Isco. However, in the presence of the parents, the chick was more likely to be in a position in which he was visible. It is predicted that a majority of the behavior that occurred during the periods in which the chick was not visible was resting behavior. Therefore, it is estimated that non-active behaviors (resting) are underestimated in this study and active behaviors (moving, walking, flapping wings, etc.) are overestimated.

## CONCLUSION

The purpose of this study was to gather observational data on the behavior of Andean condors at the Peñón del Isco within the Antisanilla Biological Reserve. By focusing these observations on the cliff behavior, parental care, and nest behavior, the goal of this study was to contribute to the knowledge of Andean condors. Given the high hatchling and juvenile mortality of Andean condors and the overall population decline, developing a larger knowledge base is an important step in aiding creation of conservation management plans and helping to prevent species extinction.

Findings reveal that although the male and female parents were present on the Peñón del Isco for a similar amount of time, the male parent spent more time performing parent care behaviors. He fed the chick more often and spent longer feeding the chick on average. Chick feedings and chick activity both peaked midday, while adult activity was highest in the mornings and evenings. The male and female adult both showed preference for four main perches which were likely chosen for their protection from rain and wind, the presence of direct sunlight on clear days, or their proximity to the nest. Flight direction data showed a preference for the region to the east of the Peñón del Isco, a region that was less developed and with more protected areas. Observed behaviors including perching, resting, moving, feeding, and self-preening were monitored for both the male and female parents as well as for the chick and these frequencies of behavior may be used as a baseline for behavior of Andean condors in the future.

The findings on parental care highlight the role that each parent plays in the upbringing of the hatchling. Given the role that both parents play in parental care, protection of both sexes at all life stages must be a top priority. Findings also raise further questions about nest selection and nest re-use which require further investigation. Further research should focus on the behaviors associated with nest movement, such as what kind of disturbances cause nest relocation, reasons why particular sites are chosen over others, and the duration of nest re-use. The findings on cliff behavior of the parents as well as the other Andean condors highlight the importance of the Peñón del Isco and the Antisanilla Biological Reserve as sites for conservation. The condors present demonstrated the importance of this site in terms of the resources it provides (food resources, water resources, perching and roosting sites, nest sites) as well as its proximity to

other important areas nearby. Continued protection of this site and the surrounding areas is necessary for the protection of this species.

These findings also highlight the importance of further research related to Andean condor behavior. Given that previous research on Andean condor behavior has focused on condors in captivity, more studies are needed that analyze the behavior of free individuals. High hatchling and juvenile mortality of Andean condors also suggests future research should continue to focus on parental and nesting behavior given that no concrete hypotheses exist to explain this trend. Studies should work to expand the sample size of families observed in order to develop conclusions on the species as a whole, rather than on particular breeding pairs. Studies should continue to be conducted within the Antisanilla Biological Reserve, as well as at other locations, and more long-term studies should be conducted. Studies of these areas will contribute to the understanding of parenting dynamics, population demographics, and typical behavior, and thus contribute to protecting the Andean condor from extinction.

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# APPENDIX

Table 1 – Hours of Data Observation Between November 11<sup>th</sup> and December 2<sup>nd</sup>

	Nov. 11th	Nov. 12th	Nov. 13th	Nov. 14th	Nov. 15th	Nov. 16th	Nov. 17th	Nov. 18th	Nov. 19th	Nov. 20th	Nov. 21st	Nov. 22nd	Nov. 23rd	Nov. 24th	Nov. 25th	Nov. 26th	Nov. 27th	Nov. 28th	Nov. 29th	Nov. 30th	Dec. 1st	Dec. 2nd	
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18:15																							
18:30																							
<b>Total Hours</b>	4.3	9.5	4.8	6.8	9	8.5	7.3	8.5	7	9.5	6	4.5	9	9.3	9	9	9.3	7.5	8	6	7	8.5	