Ectoparasitism of the feather chewing louse Colpocephalum trichosum on the Andean Condor Vultur grifys

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ABSTRACTS

Feather chewing lice are common and important ectoparasites of birds. Here we report for the first time the presence of the ectoparasite, Colpocephalum trichosum Harrison 1916 (Phthiraptera: Menoponidae) on the Andean condor Vultur grifys Linnaeus, 1758 from the North high Andes of Ecuador in Pichincha province. A total of 20 louse specimens were collected and analyzed from one free-living female juvenile host. Additionally, high resolution photographs of the louse are included, and a discussion on the potential implications of ectoparasites on the conservation of this threatened bird species is presented. Finally, we propose that further studies on Andean Condor ectoparasites should be focused on the potential causes and effects of these interactions.

RESUMEN

Los piojos de las plumas son ectoparásitos comunes e importantes de las aves. En este trabajo reportamos por primera vez la presencia del ectoparásito Colpocephalum trichosum en el cóndor andino Vultur grifys de los Andes altos del norte de Ecuador en la provincia de Pichincha. Se colectó y analizó un total de 20 muestras de piojos de un hospedador hembra juvenil de vida libre, se muestran fotografías de alta resolución del piojo y se presenta una discusión sobre las posibles implicaciones de los ectoparasitos en la conservación de esta especie de ave globalmente amenazada. Finalmente, proponemos que los estudios a futuro sobre los ectoparásitos del cóndor andino se centren en las causas y efectos potenciales de estas interacciones.

Introduction

Ectoparasites, such as lice, can significantly affect the survival of species [1,2]. Several studies have documented that ectoparasites negatively affect health, longevity, reproductive success, population dynamics and species interactions [3–5]. Nonetheless, interspecific interactions have also proven to be of importance in the evolution of the host and its parasites [6,7]. Additionally, there is evidence that both parasites and hosts have radiated and coevolved together [8,9] which can be evidenced by the significant congruence between the host and parasite phylogenetic trees [10]. Moreover, feather lice interactions have played a significant role in understanding evolution at a finer scale. For example, Johnson et al. [7] found a strong correlation between the morphology of ectoparasites and body microhabitat preferences on the host to avoid being preened off as a result of repeated adaptive divergence of microhabitat specialization.

Host–parasite networks are altered and threatened by global change [11]. For instance, co-extinction of parasites from their hosts has been well documented [12–14] with some of these as a result of conservation efforts to save their hosts [15–17]. One of the best-known examples is the extinction of the avian chewing louse, Colpocephalum californici Price & Beer, 1963 from the Critically Endangered Californian Condor Gymnogyps californianus (Shaw, 1797). It is thought that this conservation-induced extinction was probably caused by the veterinary delousing routines implemented during the captive breeding programs [14,17]. Currently, three species of bird lice of the genus Colpocephalum Nitzsch, 1818, C. davisoni (Price & Beer, 1965), C. eremite (Price & Beer, 1965), and C. satellitum (Eichler & Zlotoricka, 1963) are considered as critically co-endangered species [17]. Therefore, parasite conservation, which is generally overlooked [13,18], should be considered in any conservation program. However, any measure taken must be based on in depth knowledge of the causes that generated these interactions and the potential effects that these can have on the conservation of their hosts.

The Andean Condor Vultur grifys Linnaeus, 1758, is distributed along the Andean mountain ranges, preferring the paramo habitat areas [19]. The species is globally listed as Vulnerable by the IUCN [20] and as
Endangered in Ecuador [21]. Since 2012, one of the most important research and conservation programs for this species in Ecuador is carried out by Fundación Condor Andino (FCA) and The Peregrine Fund, investigating the natural history, ecology, population size, breeding biology, health assessment and movement patterns [19]. As part of this program, condors are captured and tagged with satellite transmitters, providing a unique opportunity to collect parasites and blood samples to assess body condition and overall health status. Data from these satellite tags has augmented our understanding of the species exponentially and has been used as a basis for the conduction of two national condor censuses [19], the last of which was carried out in 2018. Results from the census showed that there is a minimum population of 150 condors in the country [19]. Unfortunately, since then, around 20 wild condors have been killed, mostly due to poisoning and hunting events, leaving the species very close to local extinction [19].

Despite the fact that research on the Andean Condor in Ecuador has significantly increased in the last decades [19] there are still some gaps in the natural history, especially on interspecific interactions, such as the biological effects of native ectoparasites. Studies of ectoparasites of wild vultures are scarce [22], therefore, new studies that focus on documenting host-parasite interactions are very important to fill these gaps.

Here we report for the first time the ectoparasitism of Colpocephalum trichosum on the Andean Condor from the northern Andes of Ecuador in Pichincha province.

Materials and methods

Study area

The host was rescued in the locality of Chitachaca, Cayambe, Pichincha, Ecuador (−0.042130° S − 78.104946° W) at approximately 3000–3100 m a.s.l. (Figure 1). This locality is a transition zone between Andean scrubland and paramo. The specimen was rescued in close proximity to human activities such as livestock production, but more than five kilometers away from any town. According to the Ecuadorian Ministry of Agriculture this area belongs to the Páramo Herbazal ecosystem (HsSn02) [23], which is a dense plant formation dominated by grasses such as Calamagrostis intermedia (J. Presl Steud) and Stipa ichu (Ruiz & Pav.) Kunth 1829. Currently, this ecosystem is under pressure, mainly due to the agricultural frontier expansion, human induced fires, and cattle grazing, threatening the fauna and flora that inhabit this fragile ecosystem.

Lice collection

The host, a female juvenile (approx. 7 months old, weight 7.68 Kg) Andean Condor Vultur gryphus, was rescued on 28 June 2020, by community residents in Chitachaca, Cayambe, Pichincha. The female could not stand up or fly, therefore she was transferred to the TUERI Wildlife Hospital at the University San Francisco de Quito (USFQ) campus in Quito. Her initial clinical check-up revealed a grade IV claudication of the right tarsal limb, with moderate dehydration, body condition score of 2.5/5, and moderate presence of ectoparasites throughout the body. Body condition scores on birds are determined based

Figure 1. (a) Map showing collecting location in Ecuador where host was rescued. (b) female juvenile Andean condor host from which lice were collected (TUERI-USFQ wildlife hospital archive).
on the musculature, or lack of, around the keel ranging from 1 (cachectic) to 5 (morbidly obese) based on how convex or concave the musculature feels upon palpation [24]. Complementary examinations such as X-rays confirmed a fracture of the lateral condyle of the distal epiphysis of the right lower limb femur. Orthopedic surgery was performed to correct this fracture and she was kept in confinement the entire time. Post-surgical recuperation took place in TUERI Wildlife Hospital and the individual was discharged on 15 August 2020 and transferred to Quito Zoo in Guayllabamba, Cayambe. Upon arrival, veterinarians did a routine health check and took morphometric measurements that were documented as follows: Length (head to tail) 131 cm, head (from occipital bone to beak) 22.4 cm, crest length 7.2 cm, tarsal length 12 cm, tail length 42.6 cm, and wing length (shoulder to elbow) 40.5 cm. In her second post-surgical check-up on July 24th, blood samples were taken for analysis. During this checkup, a severe presence of lice was found (more than 100) on the feathers, keel and tarsus. Lice were collected in microtubes with 70% alcohol and labeled with the collection information. Samples, numbered from MZUA-EN47338 to MZUA-EN47341, were deposited at Museo de Zoologia de la Universidad del Azuay, in Cuenca, and were analyzed in this study.

**Taxonomic identification**

For the initial study, a Ken-A-Vision compound microscope, model No. 862494, with dual view head and floating stage, was used. For taxonomic identification, we examined each of the specimens in search of morphological diagnostic characters that determine the genus and used a dichotomous key for identification at the species level [25]. At first instance, the specimens were sent to an external laboratory in Quito (Villa Vet Small Animal Clinic) for microscopic identification of the species. Then, they were sent to the Entomology Laboratory at Universidad de Azuay in Cuenca for a more efficient microscopic study. Finally, our identification was confirmed by two experts in the field. Photos of the specimens were taken using a Canon 5D Mark III camera with a Canon MPE 65 mm lens, a Nikon 10x and a Nikon 20x microscope objective. Final images are composed of several individual photos combined through a focus stacking technique using Zerene Stacker Software. For morphological measurements, a stereomicroscope Nikon SMZ745T with MSHOT software was used. Final plates were assembled using Photoshop CS6.

**Results**

Twenty adult specimens, 6 males and 14 females of the feather chewing louse, *Colpocephalum trichosum* Harrison, 1916 (Phthiraptera: Menoponidae) were collected (Figure 2). The lice were removed from the tarsal limbs, wings, chest and abdominal area, including individuals which voluntarily left the body onto the examination table as a result of anesthesia.

The morphological characters were identified using a dichotomous key of lice [25], having taken into consideration female and male diagnostic characteristics. According to Price and Beer [25], the identification of

![Figure 2. Lice specimens founded and morphological characteristics used for identification defined by Price and Beer [25]. (a) Male dorsal and ventral view. (b) Female dorsal and ventral view. (c) Relationship between the length of the abdominal segments, male. (d) Distinctive head chaetotaxy, male. (Scale bar 1 mm for all images, panels A-D).](image-url)
louse species is done subjectively since the quantitative distinction between specimens is variable and cannot be done statistically for most morphological characters. The order was identified as Mallophaga due to the apparent mouthparts adapted for chewing with developed opposable mandibles, and the anterior head was broadly rounded [26]. On magnification 10X and 40X, further diagnostic characters were identified that were compatible with the genus Colopocephalum, maxillary palps were present and spines were absent on the forehead. Using [25], dichotomous key of species of Colopocephalum, the identification was narrowed down based on the following characteristics. The anus on the female was U-shaped and the abdominal tergites III–VIII were tripartite in all females. Along the head region, the mid-dorsal head setae were as long as the shortest post-ocular setae, and the individuals had between 4 and 6 head setae. Finally, abdominal segments I–II were longer than segment III and the lateral tergoventral setae of II–III were longer than the median ones. Similar characteristics were identified in males with sexual dimorphism present in the genital characteristics, being that the males had genital sclerite with pairs of latero-posterior pointed projections and the aedeagus was long with barbs anteriorly positioned. The head region observed in males was similar to female characteristics, nonetheless males displayed 20 or more mid-dorsal head setae (Figure 2).

Measurements of specimens (all measurements are in millimeters) were recorded as follows: Total length from head apex to tip of the last abdominal segment, male 1.34, female 1.55 (1.52–1.58 n = 3); preocular width, male 0.32, female 0.32 (0.30–0.35 n = 3); prothorax width, male 0.34, female 0.35 (0.33–0.37 n = 3); prothorax length, male 0.13, female 0.13 (0.12–0.13 n = 3); Abdomen length male 0.64, female 0.94 (0.92–0.96 n = 3); abdominal segments width, male I 0.49, II 0.53, III 0.53, IV 0.51, V 0.50, VI 0.47, VII 0.42, VIII 0.33 and IX 0.19, female I 0.37, II 0.34, III 0.34, IV 0.36, V 0.34, VI 0.31, VII 0.28, VIII 0.25 and IX 0.12.

Discussion

The genus Colopocephalum sensu lato, is a common and sometimes abundant chewing louse that consumes feathers and sometimes their hosts’ skin [27]. It has a broad avian host range with a widespread geographical distribution [10]. Host avian orders include: Accipitridiformes, Ciconiiformes, Columbiformes, Cuculiformes, Falconiformes, Galliformes, Gruiformes, Passeriformes, Pelecaniformes, Phoenicopteriformes, Piciformes, Psittaciformes and Strigiformes [3,10].

Colopocephalum is a diverse genus with more than 136 species [28,29] that can be identified by several external morphological characters on adults, mainly on the sternites, femora and head [10,25]. The species C. trichosum is an obligate wingless ectoparasite, identified by Price and Beer [25], characterized mainly by the distinctive head chaetotaxy and the relationship between the length of the abdominal segments (Figure 2). This is a highly specific ectoparasite of V. grypus [25,29] that has been previously reported in Brazil from a captive Andean Condor [30], in Peru [25], Bolivia [31], Chile cited by Mollericona et al. [31], and from Argentina [32]. Nonetheless, its presence in other Andean regions has not been documented.

The documentation of these commensals on birds of prey or carrion birds provides insight on the impacts ectoparasites can have on the health of the animals in captivity and in the wild. Ombagdu et al. [33] mention chewing lice causing pruritus and damaged feathers in birds but have no negative systemic effects since they are not hematophagous. Ectosymbiosis is mentioned by various authors suggesting that many ectoparasites, including lice, are often found throughout the birds’ lifetime. The consistent decline in bird populations suggests that ectosymbiotic populations will equally decrease and could even suggest extinction [22]. Nevertheless, there is little evidence to show the significance of the host-ectoparasite interaction.

The individual in this study did not show signs of interaction with the lice, feathers were not damaged and hematological exams showed no abnormalities. It is known that most birds with infestation of ectoparasites will not show clinical signs but may exhibit damaged feathers or self-mutilation [34]. Kushwaha [22] details various defense mechanisms against ectoparasites in vultures such as preening, sunning, and feathers containing melanin. Also, parasite transmission usually occurs by direct contact between individuals, however, vultures normally keep low population densities amongst each other. Ectoparasite density depends on body size of the host, where larger body size will manifest larger lice populations, providing a large and stable surface area for the lice to thrive on [22,35]. From the 16 Andean condors that Fundación Cóndor Andino have marked, six were rescued and have had some type of disease, all of them presented a moderate load of lice while the subadults and juveniles (two of them captured in the nest) presented minimum or no ectoparasite load. These findings suggest that there is a correlation between the health status of the individual and the presence of a higher load of ectoparasites. However, studies on raptors have shown that lice populations do not affect overall health of individuals, but they are reservoirs of infectious diseases among different species [34].

Continued studies in the dynamics of host-ectoparasite relationships will highlight the importance of the collection and preservation of ectoparasites. Consistent quantification and investigation of ectoparasites inhabiting rescued raptors could further elucidate relationships in age, sex, weight, health, reproductive habits, landscape integrity and resource
availability. Moreover, it is known that host traits such as: age, sex, weight, health, etc. are correlated with the presence, prevalence, intensity and effects of bird ectoparasites [36,37]. It is also well known that ecological factors such as landscape integrity (alteration, fragmentation and vegetation cover), resource availability, abundance and density of birds, their interaction, and contact with native fauna could affect the presence of ectoparasites [38,39]. In the future, incorporation and analyses of these traits from the Andean Condor and environmental characteristics could be useful to better understand the causes that generate and maintain these host-ectoparasite interactions and if these affect the presence, prevalence, infestation levels and potential health related effects of lice on the Andean condor.

Andean Condors are social animals and have been observed allopreening (mutual preening) in the wild (Vargas pers. Observations), it may well be that this social behavior is promoted by the presence of ectoparasites. This is a possibility because these two species, *C. trichosum* and *V. grifbus*, have coevolved together over an extended period of time, in which case, their conservation would be dependent on each other. Finally, co-extinction of parasites and their host species is common, thus actions that focus on the conservation goals of the Endangered population of Andean Condor in Ecuador [40] should also benefit the persistence of associated ectoparasites.

Studies on bird ectoparasites in Ecuador are generally scarce [27,41,42] and absent on the Andean Condor. Therefore, further research on this topic is necessary and given that previous reports including this one have come from rescued animals, information regarding host-ectoparasite interaction in *V. grifbus* can be further indulged with proper documentation on rescued animals and individuals in captivity.

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