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Chewing lice (Phtiraptera) on the Bonelli's Eagle *Aquila fasciata* in the Iberian Peninsula (Spain)

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Abstract Bonelli's Eagle is an endangered species with little information on its ectoparasites. We studied their chewing lice (Phthiraptera: Amblycera, Ischnocera) infestations by visually searching the plumage of 64 wild and captive specimens. Three different species were identified: *Degeeriella* sp., *Colpocephalum impressum* and *Laemobothrion maximum*. This is the first case of *Laemobothrion maximum* on Bonelli's Eagle described. We also observe its haematophagous behavior. Due to the low prevalence of infestations, no alterations in the host health are described.

Keywords: feather, ectoparasite, hematophagous, louse, raptor

Összefoglalás A héjasas egy veszélyeztetett faj, amelynek ektoparazitáiról kevés információ áll rendelkezésre. Tolltetű (Phthiraptera: Amblycera, Ischnocera) fertőzéseiket 64 vadon élő, illetve fogságban tartott példány tollazatának vizuális vizsgálatával tanulmányoztuk. Három fajt azonosítottunk: *Degeeriella* sp., *Colpocephalum impressum* és *Laemobothrion maximum*. Ez a *Laemobothrion maximum* általi fertőzés első ismert esete a héjasason. Megfigyeltük az említett faj vérfogyasztását is. A fertőzés alacsony prevalenciája miatt a vizsgált héjasasok egészségi állapotában nem történt változás.

Kulcsszavak: madártoll, ektoparazita, hematofág, tolltetű, ragadozó madarak

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Prevalence of parasites on a bird is conditioned by factors such as sex, age, sociability, mobility or its reproductive status and can have an impact on the physiological, physical and even immunological state of the host (Hamstra & Badyaev 2009, Owen *et al*. 2010, Doña *et al*. 2018, Talabante & Bernal 2022). In cases of seriously threatened birds, knowledge of their parasites can also provide information about their health status at a population level (Talabante *et al*. 2019). Therefore, knowledge of parasite-host relationships can be essential to determine different infective degrees or physiological deficits in their hosts. Despite this importance, little attention has been paid to parasite-host relationships for certain groups of birds.

One of the most diversified groups of parasites are chewing lice (Phthiraptera: Amblycera and Ischnocera suborders), which are mainly present in birds. Although they are considered parasites, numerous species can carry out a mutualistic relationship with their host (Martín-Mateo 2002). However, there are many species that interact with their hosts as parasites and can cause health problems to their hosts.

For our research we use the Bonelli's Eagle *(Aquila fasciata)* as a study model. Bonelli's Eagle is a large-sized eagle which inhabits mountainous areas across the Palearctic, Indo-Malayan and Afrotropical regions in arid and semi-humid habitats (Ferguson-Lees & Christie 2001). Their nests are placed on cliffs or in different tree species (Del Moral & Molina 2018). It is currently considered as endangered in Spain and as of Least Concern worldwide (Real Decreto 139/2011, BirdLife International 2019). It is a monogamous, territorial and solitary species, so the horizontal transmission of ectoparasites is likely to be less frequent than in more social raptors (Talabante & Bernal 2022). Studies on parasites and pathogens in Bonelli's Eagle are scarce and mainly focus on endoparasites (Real *et al*. 2000, Reche *et al*. 2003, Cabezón *et al*. 2011). According Pérez *et al*. (1996) and Martín-Mateo (2002), six lice species have been recorded globally on Bonelli's Eagle, Amblycera suborder: *Kurodaia fulvofasciata* Piaget 1880, *Colpocephalum impressum* Rudow 1866b and *Laemobothrion maximum* Scopoli 1763; Ischnocera suborder: *Degeeriella fulva* Giebel 1874, *D. regalis* Giebel 1866 and *Craspedorrhynchus fasciati* Gallego *et al*. (1987). In Spain, Gallego *et al.* (1987) cited the presence of *Cr. fasciati* in a review of this genus of lice. Cordero del Campillo *et al.* (1994) and Martín-Mateo (2009) cited the presence of *D. fulva* in their respective reviews. Finally, Pérez *et al*. (1996) published the occurrence of *D. regalis* and Martín-Mateo (2002) cited *Co. impressum* (under the synonime name *Aquilogogus impressus*).

Despite the degree of threat of the Bonelli's Eagle and the interest it has aroused in the community over these years, the study of its lice species remains insufficient. The purpose of this study is to review the lice present in the Bonelli's Eagle, providing new record of species not previously cited in Spain. In addition, the possible effect that the chewing lice species detected may have on this threatened species is indicated.

Lice were collected directly from the bird feathers in scientific bird ringing sessions or in wild specimens recently admitted to wildlife recovery centers, from 2022 to 2023, following the method visual examination of Martín-Mateo (1994) and Clayton & Drown (2001). Lice were stored in capped tubes containing 70% ethanol until their identification and were cleaned in 10% KOH, mounted in DMHF (Dimethyl hydantoin formaldehyde) on slides, and identified to species level under a light-microscope and stereo-microscope (Martín-Mateo 1994). The chewing lice species were identified according to Martín-Mateo (2002, 2009). Data on lice infestation on Bonelli's Eagles have been analyzed according to the methodology presented in Reiczigel *et al*. (2019). To avoid biases in these determinations all specimens were identified by the same researchers (CT and IB) and deposited in the authors' collections.

The chewing lice of a total of 64 Bonelli's Eagles have been studied: 42 wild specimens either nestling or adults and 22 captive individuals from recovery centers. Lice have been found in 7 Bonelli's Eagles, implying a prevalence of 10.93%. The presence of three lice has

Table 1. Prevalence of three chewing lice species detected on 64 Bonelli's Eagles from Spain. Confidence intervals (CI 95%) are calculated by Sterne's method (Reiczigel *et al.* 2019)
1. táblázat Három tolltetű faj prevalenciája 64 héjasason Spanyolországban. A konfidencia intervallumokat (CI 95%) Sterne módszerével számoltuk (Reiczigel *et al.* 2019)

Suborder	Species	Prevalence (%)	CI (95%) of prevalence	Mean intensity
Amblycera	*Laemobothrion (L.) maximum*	1.6	0.1–8.3	9.00
	Colpocephalum impressum	9.4	4.2–19.3	2.33
Ischnocera	*Degeeriella* sp.	3.1	0.6–10.7	1.50

been determined: *Laemobothrion (L.) maximum* (6 females and 3 males), *Colpocephalum impressum* (8 females and 6 males) and *Degeeriella* sp. Neumann 1906 (3 imaginal females). The prevalence and mean intensity of each species is shown in *Table 1*. Blood was detected in the digestive system in 2 females out of the 9 *L. maximum* specimen, which indicates hematophagous behavior *(Figure 1)*.

Hematophagy brings possible veterinary and conservation consequences since this host is a seriously threatened species. Although in most cases the presence of a small number of lice in birds do not produce symptoms, when the number of lice is very high, it can cause discomfort to the animal, affect the plumage quality, reduce its ability to reproduce and even affect its survival (Vysakh Mohan *et al*. 2001, Krone & Cooper 2002, Clayton *et al*. 2008).

Ontiveros *et al*. (2008a, 2008b) and Martínez *et al.* (2022) show a lower prevalence of ectoparasites in Bonelli's Eagles that incorporate pine branches in their nests, characterized

Figure 1. Females of *Laemobothrion (L.) maximum* with blood (dark red coloration) in the digestive system
1. ábra *Laemobothrion (L.) maximum* nőstények, emésztőrendszerükben vérrel (sötétvörös elszíneződés)

by a high level of aromatic compounds highly repellent for insects. These authors suggest a higher reproduction rate in couples that have a lower load of ectoparasites. However, the results of both studies focus on diptera and coleoptera, not considering lice species. Furthermore, Ontiveros *et al*. (2008b) suggest that the maintenance of alternative nests in raptors favors the reduction of ectoparasites, but this does not happen every year, so that the nests may be functioning as reservoirs for several seasons.

The presence of *D. fulva* has been previously reported by Cordero del Campillo *et al.* (1994). *D. fulva* is a louse present in other species of diurnal raptors, among others the Bonelli's Eagle (Martín-Mateo 2009). In our study, only females *Degeeriella* specimens were obtained, which has made species-level identification difficult. Although the chaetotaxy of the specimens studied suggests *D. fulva*, since it was not possible to study male genitalia, it prevents the reliable identification of the species. *Co. impressum* (syn. *Aquilogogus impressus* Martín-Mateo 2002) has also been cited in Golden Eagle *(Aquila chrysaetos)* (Martín-Mateo 2002). Both *Degeeriella* and *Colpocephalum* Rudow 1866 are considered common ectoparasites in large raptors. We could not detect *Cr. fasciati* in our sample, though it does appear in the review by Gallego *et al*. (1987).

Our results represent the first record of *L. maximum* in Bonelli's Eagle in Spain. Furthermore, the presence of specimens of *L. maximum* with hematophagous behavior has been described in our study, which is also the first described behavior of this type of ectoparasites on the Bonelli's Eagle.

The hematophagous behavior of lice in birds has been described in several species of Amblycera (Agarwal *et al.* 1983, Saxerna *et al*. 1985). Agarwal *et al*. (1983) describes hematophagy in *Menacanthus eurysternus* Burmeister, 1838 when feeding on the blood of growing feathers, even making injury in the skin of its host.

In diurnal raptors, hematophagous behavior has been indicated for certain species of the genus *Laemobothrion* Nitzsch 1818. This genus currently has four species that parasitize several species of Falconiformes and Accipitriformes, presenting a worldwide distribution. Three of the four species have been reported in diurnal raptors in Western Europe (Martín-Mateo 2002). All *Laemobothrion* species are large chewing lice and are considered to be primarily keratinophages. Regarding its oral morphology, Pérez *et al*. (1995) cites sharp structures close to the mandible in *L. maximum*, which is related to possible hematophagous behavior. The same authors indicate hematophagous behavior in this species on the Common Buzzard *(Buteo buteo)* (Pérez *et al*. 1994). Other authors have indicated a similar behavior in *Laemobothrion vulturis* Fabricius 1775 in Bearded Vulture *(Gypaetus barbatus)* (Złotorzycka & Danecki 1969, Srivastava 1974). Despite some evidence on the hematophagous behavior of *Laemobothrion* in diurnal raptors, the incidence of this behavior has been poorly studied. For our case study, the record of *L. maximum* is the first of the Bonelli's Eagle in Spain. Furthermore, it is the first documented case of hematophagous behavior in this species of raptor.

Heavy infestation with hematophagous lice has been related in some studies with alteration of fitness and hematological changes in wild and domestic birds. The principal findings that had been observed are related with lower rates of hemoglobin (Hb), total plasma protein, packed cell volume (PCV) or total erythrocytes (Al-Saffar & Al-Mawla

2008, Kloskowski *et al.* 2016, Al-Shaibani *et al.* 2018). In our study, no anomalous values have been found in the Hb value of the specimens with the presence of *L. maximum* with hematophagous behavior. Further studies in raptors are needed to analyze if the presence of those parasites is also related with analytical alterations and affection of the health status of the host.

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