

1 **How many threatened lice are there? An approximation to the red list of the**  
2 **Spanish Phthiraptera**

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9

10 **Abstract**

11 Although the idea of conserving parasites as part of biodiversity is not new, these in general and lice in  
12 particular, are not included in the threatened list of invertebrate fauna. Assuming that the conservation  
13 status of a lice species is similar to that of its host, the number of threatened lice within the Spanish  
14 entomofauna was estimated based on the known host-lice assemblages. The lice parasitizing many of the  
15 Spanish birds and mammals are unknown. Overall, I found 6 extinct (EX) species; 4 critically endangered  
16 (CR); 15 endangered (EN), 7 vulnerable (VU) and 1 species near threatened (NT), at regional level. Since  
17 the status of hosts varies through time and space, it, (together with those of their lice, must be periodically  
18 updated. In addition to a number of reasons that justify the conservation of parasites, lice deserve being  
19 conserved, particularly, because of their scientific value.

20

21 **Keywords:** birds, conservation, lice, mammals, Phthiraptera, Spain

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23 **1. Introduction**

24 Parasites constitute a major part of biodiversity (Price, 1980; Dobson et al., 2008) and, consequently, an  
25 important component of global biomass (Kuris et al., 2008). Moreover, as trophic regulators (Dougherty  
26 et al., 2015) they play an important ecological role in Nature providing important ecosystem functions

27 and services (Rubio-Godoy and Pérez-Ponce de León, 2023), are indicators of ecosystem quality  
28 (Lymbery and Smit, 2023), and have their own evolutionary value (Windsor, 1995). So, despite the fact  
29 that parasites may be confounded as pests (Pérez et al., 2006), they deserve to be conserved according to  
30 the World Conservation Strategy (IUCN, UNEP, WWF, 1980). Information on parasites may be used to  
31 highlight multiple threats to global biodiversity (Gagne et al., 2022). Parasites are part of the “hidden  
32 diversity” and most of them exert apparently negligible negative effects on their host, and, therefore, they  
33 may be considered as non-pathogenic (Rubio-Godoy and Pérez-Ponce de León, 2023). Recently, Kwak  
34 (2018) defined the term holistic conservation as a subfield of conservation biology oriented to conserving  
35 threatened parasites with their hosts.

36 Parasitism involves exploiting small, discontinuous and ephemeral environments: for a parasite each host  
37 constitutes a patch of habitat within the matrix of an inhospitable environment. Therefore, colonizing new  
38 hosts may become very difficult and hazardous (Price, 1980; Combes, 2001). Some parasite species,  
39 particularly those host-specific, may become more scarce and, therefore, more endangered than their  
40 hosts themselves (Pérez et al., 2013). But, if a co-extinction risk for both parasites and hosts exists  
41 (Rózsa, 1992; Stork and Lyal, 1993), when a hosts species is reintroduced in an area, following a local  
42 extinction, parasites may be co-reintroduced and co-recovered as well (Jørgensen, 2014; Pérez et al.,  
43 2023). Nevertheless, such parasite conservation success events are often unintentional (Gustafsson et al.,  
44 2021).

45 The sucking and chewing lice (Insecta: Phthiraptera) are hemimetabolous insects which spend their entire  
46 lives on the bodies of their hosts. Becoming accidentally dislodged from their hosts involves almost  
47 certainly death (Galloway, 2018). As host-specific parasites of birds and mammals, the host  
48 biogeographic history is to some extent a determinant of that of its lice (Lima et al., 2023). Moreover,  
49 genealogies and population genetics of lice may be used for elucidate the evolutionary and demographic  
50 history of their hosts (Whiteman and Parker, 2005). If, consequently, their conservation status depends  
51 largely on their habitat availability, that is, the conservation status of their hosts (Kwak et al., 2019), the  
52 host preening behaviour and molt, among other factors, may reduce their number and prevalence (Pérez et  
53 al., 1996; Galloway and Lamb, 2021; Bush and Clayton, 2023), exacerbating their extinction risk. Over  
54 5300 lice species have been described: 575 of Anoplura, 3 of Rhynchophthirina, 1525 of Amblycera,  
55 2830 of Ischnocera and 382 of Trichodectera (Price et al., 2003; Galloway, 2018; Dong, 2022).

56 Both at global and local scale, parasites in general and lice in particular, are not usually included within  
57 the threatened invertebrate fauna (Whiteman and Parker, 2005; Barea-Azcón et al., 2008; Verdú and  
58 Galante, 2009). Out of the only 70 modern insect extinctions which have been documented (Dunn, 2005),  
59 at least 9 bird lice and 1 mammal louse (which are considered as extremely host-specific) became extinct  
60 (Koh et al., 2004). Recently, six lice species were listed as co-extinct, and 40-41 were recognized as co-  
61 endangered (Rózsa and Vas, 2014). At national level, 3 lice species became extinct, 4 were considered as  
62 critically endangered, and 8 as vulnerable in New Zealand (Buckley et al., 2012). Nevertheless, these  
63 numbers may be underestimated because a lack of data on the local status of a number of bird and  
64 mammal species and many host-lice assemblages as well, particularly regarding threatened and/or  
65 endemic host-species.

66 The aim of this work is to estimate the number of threatened lice species in Spain, taking into account that  
67 this country harbours a large proportion of the European bird and mammal diversity.

68

## 69 **2. Material and methods**

70 The conservation status of the Spanish birds and mammals was assessed according to the Red Book of  
71 Birds of Spain (Madroño et al., 2012) and to the Atlas and Red Book of terrestrial mammals of Spain  
72 (Palomo et al., 2007), which adopted the IUCN criteria (version 3.1: IUCN, 2001) (Tables 1-2). The  
73 global status of these species was updated through the IUCN Red List of Threatened Species  
74 (<https://www.iucnredlist.org/es>) and SEO BirdLife (<https://www.seo.org/>). Then, the lice species  
75 parasitizing each host species were obtained from Martín Mateo (2002; 2009), Pajot (2000) and Price et  
76 al. (2003). This information was completed through a search in the Web of Science (WOS) using as key  
77 words: “lice” + “parasitizing” + “host species” (latin name).

78 Searches were made for each host species individually. The status assigned to a louse species was  
79 ultimately determined by the global (worldwide) status of it/s host/s. I followed criterium 6 of Kwak et al.  
80 (2020) for the assessment of the lice conservation status: a louse species has the same status of its  
81 threatened definitive host (if a monoxenic louse) or that of all of its threatened definitive hosts (if a  
82 polyxenic louse). Lice from hosts with deficient data about their conservation status in Spain were not  
83 included in the analysis.

84 The list of threatened lice is based on the morphospecies concept, taking into account that this approach  
85 presumably underestimates the number of the true biological species.

86

### 87 3. Results

88 In Spain 622 bird and 158 terrestrial mammal species can be found (Madroño et al., 2002; Palomo et al.,  
89 2007).

#### 90 3. 1. Bird lice

91 Two bird species became recently extinct globally (Madroño et al., 2002) and we have no knowledge  
92 about their lice fauna. Four other bird hosts became extinct regionally but these species are not globally  
93 threatened (“low concern”): the lanner falcon (*Falco biarmicus*), the white tailed eagle (*Haliaeetus*  
94 *albicilla*), the demoiselle crane (*Anthropoides virgo*) and the common Buttonquail (*Turnix sylvaticus*).  
95 The parasitic lice of these 4 birds were studied outside of Spain (Price et al., 2003). Thus, up to 7 lice  
96 species could have become extinct regionally (Table 3).

97 Eleven bird taxa are considered as “critically endangered” (CR) at regional level. Two CR birds at  
98 regional level are “near threatened” (NT) globally, the marbled duck (*Marmaronetta angustirostris*) and  
99 the Tenerife blue chaffinch (*Fringilla teydea*), but their ectoparasitic fauna is unknown. Other 7 CR bird  
100 species are abundant outside Spain: “low concern” (LC). But only two lice species, *Brueelia minor* and  
101 *Cummingsiella ovalis* (Ischnocera, Philopteridae) (Price et al., 2003) may be considered as CR regionally  
102 (Table 4).

103 Twenty five Spanish bird species are catalogued as “endangered” (EN). Fourteen lice species are  
104 catalogued as EN regionally (Martín Mateo, 2002; 2009; Price et al., 2003). Their hosts and the hosts  
105 status are included in Table 4.

106 Forty three bird species are catalogued “vulnerable” (VU) in Spain, which harbour up to 7 VU lice  
107 species regionally (Table 5).

108 Twenty nine bird species are catalogued as NT in Spain. One of them, the Iberian grey shrike (*Lanius*  
109 *meridionalis*) is considered as VU worldwide, but this species was never studied for lice. Two of them,  
110 the Eurasian oystercatcher (*Haematopus ostralegus*) and the woodchat shrike (*Lanius senator*) are also

111 NT globally. The last one harbours *Philopterus trigonophorus* (Ischnocera, Philopteridae), which has the  
112 same status worldwide. The remaining NT Spanish birds are not threatened globally as they are catalogued  
113 as LC.

### 114 3. 2. Mammalian lice

115 Two mammals are classified as CR: the Mediterranean monk seal (*Monachus monachus*), which is  
116 considered as EN worldwide and the brown bear (*Ursus arctos*), which is classified as LC globally. The  
117 former is the host of an EN lice species: *Lepidophthirus piriformis* (Anoplura, Echinophthiriidae) (Rozsa  
118 and Vas, 2014). *Trichodectes pinguis* (Trichodectera, Trichodectidae) (Price et al., 2003) would be  
119 considered as CR regionally.

120 Five Spanish mammals are considered EN at regional level: three of them are bats (this group is not  
121 parasitized by Phthiraptera), and the lice of the European mink (*Mustela lutreola*), were never studied.  
122 The remaining one, the Iberian lynx (*Lynx pardinus*), which is also catalogued as EN at global level, is  
123 the host of *Felicola (Loriscicola) isidoroi* (Trichodectera, Trichodectidae) (Pérez and Palma, 2001; Fig. 1),  
124 which can also be considered as EN.

125 The Spanish VU mammals (n=14) include 8 bat species, which are not parasitized by Phthiraptera; 3  
126 species catalogued as EN worldwide: the Pyrenean desman (*Galemys pyrenaicus*), the Canary shrew  
127 (*Crocidura canariensis*), and the European rabbit (*Oryctolagus cuniculus*), the last parasitized by  
128 *Haemodipsus venticosus* (Anoplura, Polyplacidae) (Smith, 2022). The ectoparasitofauna from the first  
129 two remains unknown. The remaining three ones, with global status ranging from VU to NT: the southern  
130 water vole (*Arvicola sapidus*), the broom hare (*Lepus castroviejoii*) and the Cabrera's vole (*Microtus*  
131 *cabrerae*), whose parasitic lice have not been studied elsewhere.

132 There are 14 mammal species in Spain catalogued as NT. Ten of them are bats (a group not parasitized by  
133 Phthiraptera), and the lice of remaining ones (n=4) (LC at global level) are unknown.

134

## 135 4. Discussion

136 The results obtained in this study suggest that the number of threatened lice species in Spain is  
137 underestimated, taking into account that most of the avian and mammalian lice assemblages still remain  
138 unknown.

139 The status of threatened species may improve, particularly when recovery plans are applied (Bottrill et al.,  
140 2011). This is the case of the Iberian lynx (*Lynx pardinus*), the host of *Felicola (Loriscicola) isidoro*,  
141 which formerly was considered one of the most threatened felids and recently has been classified as  
142 “endangered”, after several years with increasing numbers (<https://www.iucnredlist.org/es>). On the  
143 contrary, the deterioration of the environmental conditions, among other factors, may upgrade the status  
144 of a species to categories of higher threat (Pereira Paglia and Fonseca, 2009). We must take into account  
145 that many host species analysed in this study currently show decreasing population trends despite their  
146 current lower threat status. Therefore, the status of the bird and mammal hosts (together with that of their  
147 lice species) must be periodically updated, even in the case of common and abundant species.

148 Concerning lice species parasitizing multiple host species, it seems to be reasonable assigning them the  
149 status of their less threatened host or considering them as LC. On the other hand, the extinction of a host  
150 species not always implies the extinction of its lice. It was thought that *Columbicola extinctus*  
151 (Ischnocera, Philopteridae), became extinct together with its host, *Ectopistes migratorius*, which formerly  
152 was one of the most abundant bird in the world (Stork and Lyal, 1993). But this louse species did not  
153 become extinct, as it parasitizes other columbiform host: *Columba fasciata* (Clayton and Price, 1999).

154 Diverse reasons have been argued to promote conserving parasites, in general, and lice in particular  
155 (Windsor, 1985; Whiteman and Parker, 2005; Lymbery and Smit, 2023). With regards to lice, they  
156 deserve being conserved because of their scientific value (US Fish and Wildlife Service, 1973; Kellert,  
157 1985). If most of the host-lice assemblages remain unknown, we still know very little about the co-  
158 evolution patterns of lice and their hosts (Lyal, 1987), the co-infection processes between lice infesting  
159 the same host and between them and other ecto- and endoparasites (Fernández-Muñoz et al., 2023), the  
160 physiology of lice (Burgess, 2022), or their bacteriome, particularly that from sucking lice (Perotti et al.,  
161 2009), among other topics.

162 Including threatened Phthiraptera in future revisions of red lists of invertebrates may be a first step to  
163 draw the attention of the competent authorities and promote the conservation of these species and their  
164 respective hosts. Some measures, such as avoiding use of insecticides and/or mechanic extirpation of  
165 ectoparasites of animals captured and/or maintained in captivity (except in extreme clinical cases), and  
166 maintaining lice in vivo and in vitro (when possible) (Pérez et al., 2013) may be useful.

167

168 **5. Conclusions**

169 The conservation of parasites in general and lice in particular is still a neglected issue. The current  
170 biodiversity crisis may favour the extinction of a number of bird and mammalian species, with the  
171 extinction of their parasitic lice in parallel. Only in Spain, up to 69 lice species with some extent of threat  
172 have been identified.

173

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309 **Figure legends**

310 **Figure 1.** *Felicola (Loriscola) isidoroi*. Adult male, habitus. This is the holotype of the species and is  
311 deposited in the collection of the Museo Nacional de Ciencias Naturales (CSIC) in Madrid, Spain.  
312 Photography by Jean-Claude Stahl (Te Papa Tongarewa Museum, Wellington, New Zealand).

313

314 **Table 1.** The status of Spanish birds (modified from Madroño *et al.*, 2002). EX: extinct; RE: extinct at  
315 regional level (Spain); CR: critically endangered; EN: endangered; VU: vulnerable; NT: near  
316 threatened; LC: low concern; DD: defficient data.

317

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318	IUCN CATEGORY	NUMBER	PERCENTAGE
319	EX	2	0.3
320	RE	3	0.5
321	CR	11	1.8
322	EN	25	4.0
323	VU	43	6.9
324	NT	29	4.7
325	LC	484	77.8
326	DD	25	4.0
327	TOTAL	622	100

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328

329 **Table 2.** The status of Spanish terrestrial mammals (modified from Palomo *et al.*, 2007). EX: extinct; RE:  
330 extinct at regional level (Spain); CR: critically endangered; EN: endangered; VU: vulnerable; NT:  
331 near threatened; LC: low concern; DD: defficient data; NE: not evaluated.

332

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333	IUCN CATEGORY	NUMBER	PERCENTAGE
334	EX	0	0
335	RE	0	0
336	CR	2	1.3
337	EN	5	3.2
338	VU	14	8.9
339	NT	14	8.9
340	LC	105	66.5
341	DD	3	1.9
342	NE	15	9.5
343	TOTAL	158	100

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345

346 **Table 3.** Bird lice species presumably extinct in Spain.

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348	SPECIES	SUBORDER, FAMILY	HOST/S	STATUS (REGIONAL/WORLDWIDE)
349	<i>Heleonomus elbeli</i>	Amblycera, Menoponidae	<i>Anthropoides virgo</i>	EX / LC
350	<i>Heleonomus furgalai</i>	Amblycera, Menoponidae	<i>A. paradisea</i> / <i>A. virgo</i>	EX / VU-LC
351	<i>Craspedorrhynchus macrocephalus</i>	Ischnocera, Philopteridae	<i>Haliaeetus albicilla</i>	EX / LC
352	<i>Degeeriella discocephalus</i>	Ischnocera, Philopteridae	<i>H. albicilla</i> / <i>H. leucocephalus</i>	EX / LC-LC
353	<i>Esthiopterum elbeli</i>	Ischnocera, Philopteridae	<i>Anthropoides virgo</i>	EX / LC
354	<i>Falcolipeurus sulcifrons</i>	Ischnocera, Philopteridae	<i>H. albicilla</i> / <i>Nisaetus cirrhatus</i>	EX / LC-LC
355	<i>Turnicola nigrolineatus</i>	Ischnocera, Philopteridae	<i>Turnix sylvatica</i>	EX / LC

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357

358 **Table 4.** Bird lice species critically endangered or endangered in Spain.

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360	SPECIES	SUBORDER, FAMILY	HOST/S	STATUS (REGIONAL/WORLDWIDE)
361	<i>Aegypoeus perspicuus</i>	Ischnocera, Philopteridae	<i>Neophron percnopterus</i>	EN / EN
362	<i>Anatoecus regina</i>	Ischnocera, Philopteridae	<i>Tadorna ferruginea</i>	EN / LC
363	<i>Aquiligogus imperialis</i>	Amblycera, Menoponidae	<i>Aquila adalberti</i>	EN / VU
364	<i>Ardeicola stellaris</i>	Ischnocera, Philopteridae	<i>Botaurus stellaris</i>	EN / LC
365	<i>Ardeiphilus trochioxus</i>	Amblycera, Menoponidae	<i>Botaurus stellaris</i>	EN / LC
366	<i>Austromenopon echinatum</i>	Amblycera, Menoponidae	<i>Calonectris diomedea</i>	EN / LC
367	<i>Brueelia minor</i>	Ischnocera, Philopteridae	<i>Lanius minor</i>	CR / LC
368	<i>Colpocephalum imperialis</i>	Amblycera, Menoponidae	<i>Aquila adalberti</i>	EN / VU
369	<i>Craspedorrhynchus fraterculus</i>	Ischnocera, Philopteridae	<i>Aquila adalberti</i>	EN / VU
370	<i>Cummingsiella ovalis</i>	Ischnocera, Philopteridae	<i>Numenius arquata</i>	CR / NT
371	<i>Falcolipeurus frater</i>	Ischnocera, Philopteridae	<i>N. percnopterus</i> / <i>Gyps himalayensis</i>	EN / EN-NT
372	<i>Halipeurus abnormis</i>	Ischnocera, Philopteridae	<i>Calonectris diomedea</i>	EN / LC
373	<i>Neocolpocephalum percnopteri</i>	Amblycera, Menoponidae	<i>Neophron percnopterus</i>	EN / EN
374	<i>Otidoecus houbarae</i>	Ischnocera, Philopteridae	<i>Chlamydotis undulata</i>	EN / VU
375	<i>Quadriceps obliquus</i>	Ischnocera, Philopteridae	<i>Uria aalge</i> / <i>U. lomvia</i>	EN / LC-LC
376	<i>Saemundssonina (S.) calva</i>	Ischnocera, Philopteridae	<i>Uria aalge</i> / <i>U. lomvia</i>	EN / LC-LC

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378 **Table 5.** Bird lice species catalogued as vulnerable (VU) in Spain.

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380	SPECIES	SUBORDER, FAMILY	HOST/S	STATUS (REGIONAL/WORLDWIDE)
381	<i>Aquilogogus barbati</i>	Amblycera, Menoponidae	<i>Gypaetus barbatus</i>	VU / NT
382	<i>Degeeriella punctifer</i>	Ischnocera, Philopteridae	<i>Gypaetus barbatus</i>	VU / NT
383	<i>Falcolipeurus quadripunctatus</i>	Ischnocera, Philopteridae	<i>Gypaetus barbatus</i>	VU / NT
384	<i>Coloceras britannicum</i>	Ischnocera, Philopteridae	<i>Streptopelia turtur</i>	VU / VU
385	<i>Hohortsiella streptopeliae</i>	Amblycera, Menoponidae	<i>Streptopelia turtur</i>	VU / VU
386	<i>Lunaceps haematopi</i>	Amblycera, Menoponidae	<i>Haematopus ostralegus</i>	VU / NT
387	<i>Quadriceps ornatus</i>	Ischnocera, Philopteridae	<i>Rissa brevirostris</i>	VU / VU

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