



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

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ABSTRACT

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

1. Introduction

Parasites constitute a major part of biodiversity (Price, 1980; Dobson et al., 2008) and, consequently, an important component of global biomass (Kuris et al., 2008). Moreover, as trophic regulators (Dougherty et al., 2015) they play an important ecological role in Nature providing important ecosystem functions and services (Rubio-Godoy and Pérez-Ponce de León, 2023), are indicators of ecosystem quality (Lyubery and Smit, 2023), and have their own evolutionary value (Windsor, 1995). So, despite the fact that parasites may be confounded as pests (Pérez et al., 2006), they deserve to be conserved according to the World Conservation Strategy (IUCN, UNEP, IUCN UNEP WWF, 1980). Information on parasites may be used to highlight multiple threats to global biodiversity (Gagne et al., 2021). Parasites are part of the “hidden diversity” and most of them exert apparently negligible negative effects on their host, and, therefore, they may be considered as non-pathogenic (Rubio-Godoy and Pérez-Ponce de León, 2023). Recently, Kwak (2018) defined the term holistic conservation as a sub-field of conservation biology oriented to conserving threatened parasites with their hosts.

Parasitism involves exploiting small, discontinuous and ephemeral environments: for a parasite each host constitutes a patch of habitat within the matrix of an inhospitable environment. Therefore, colonizing new hosts may become very difficult and hazardous (Price, 1980; Combes, 2001). Some parasite species, particularly those host-specific,

may become more scarce and, therefore, more endangered than their hosts themselves (Pérez et al., 2013). But, if a co-extinction risk for both parasites and hosts exists (Rózsa, 1992; Stork and Lyal, 1993), when a hosts species is reintroduced in an area, following a local extinction, parasites may be co-reintroduced and co-recovered as well (Jørgensen, 2014; Pérez et al., 2023). Nevertheless, such parasite conservation success events are often unintentional (Gustafsson et al., 2021).

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

Both at global and local scale, parasites in general and lice in particular, are not usually included within the threatened invertebrate

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fauna (Whiteman and Parker, 2005; Barea-Azcón et al., 2008; Verdú and Galante, 2009). Out of the only 70 modern insect extinctions which have been documented (Dunn, 2005), at least 9 bird lice and 1 mammal louse (which are considered as extremely host-specific) became extinct (Koh et al., 2004). Recently, six lice species were listed as co-extinct, and 40–41 were recognized as co-endangered (Rózsa and Vas, 2014). At national level, 3 lice species became extinct, 4 were considered as critically endangered, and 8 as vulnerable in New Zealand (Buckley et al., 2012). Nevertheless, these numbers may be underestimated because a lack of data on the local status of a number of bird and mammal species and many host-lice assemblages as well, particularly regarding threatened and/or endemic host-species.

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

2. Material and methods

The conservation status of the Spanish birds and mammals was assessed according to the Red Book of Birds of Spain (Madroño et al., 2012) and to the Atlas and Red Book of terrestrial mammals of Spain (Palomo et al., 2007), which adopted the IUCN criteria (version 3.1: IUCN, 2001) (Tables 1–2). The global status of these species was updated through the IUCN Red List of Threatened Species (<https://www.iucnredlist.org/es>) and SEO BirdLife (<https://www.seo.org/>). Then, the lice species parasitizing each host species were obtained from Martín Mateo (2002; 2009), Pajot (2000) and Price et al. (2003). This information was completed through a search in the Web of Science (WOS) using as key words: “lice” + “parasitizing” + “host species” (latin name). Searches were made for each host species individually. The status assigned to a louse species was ultimately determined by the global (worldwide) status of it/s host/s. I followed criterium 6 of Kwak et al. (2020) for the assessment of the lice conservation status: a louse species has the same status of its threatened definitive host (if a monoxenic louse) or that of all of its threatened definitive hosts (if a polyxenic louse). Lice from hosts with deficient data about their conservation status in Spain were not included in the analysis.

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

3. Results

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

3.1. Bird lice

Two bird species became recently extinct globally (Madroño et al., 2002) and we have no knowledge about their lice fauna. Four other bird hosts became extinct regionally but these species are not globally

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

IUCN CATEGORY	NUMBER	PERCENTAGE
EX	2	0.3
RE	3	0.5
CR	11	1.8
EN	25	4.0
VU	43	6.9
NT	29	4.7
LC	484	77.8
DD	25	4.0
TOTAL	622	100

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

IUCN CATEGORY	NUMBER	PERCENTAGE
EX	0	0
RE	0	0
CR	2	1.3
EN	5	3.2
VU	14	8.9
NT	14	8.9
LC	105	66.5
DD	3	1.9
NE	15	9.5
TOTAL	158	100

threatened (“low concern”): the lanner falcon (*Falco biarmicus*), the white tailed eagle (*Haliaeetus albicilla*), the demoiselle crane (*Anthropoides virgo*) and the common Buttonquail (*Turnix sylvaticus*). The parasitic lice of these 4 birds were studied outside of Spain (Price et al., 2003). Thus, up to 7 lice species could have become extinct regionally (Table 3).

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

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

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

Twenty nine bird species are catalogued as NT in Spain. One of them, the Iberian grey shrike (*Lanius meridionalis*) is considered as VU worldwide, but this species was never studied for lice. Two of them, the Eurasian oystercatcher (*Haematopus ostralegus*) and the woodchat shrike (*Lanius senator*) are also NT globally. The last one harbours *Philopterus trigonophorus* (Ischnocera, Philopteridae), which has the same status worldwide The remaining NT Spanish birds are not threatened globally as they as catalogued as LC.

Table 3
Bird lice species presumably extinct in Spain.

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

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

SPECIES	SUBORDER, FAMILY	HOST/S	STATUS (REGIONAL/ WORLDWIDE)
<i>Aegypocetus perspicuous</i>	Ischnocera, Philopteridae	<i>Neophron percnopterus</i>	EN/EN
<i>Anatoecus regina</i>	Ischnocera, Philopteridae	<i>Tadorna ferruginea</i>	EN/LC
<i>Aquiligogus imperialis</i>	Amblycera, Menoponidae	<i>Aquila adalberti</i>	EN/VU
<i>Ardeicola stellaris</i>	Ischnocera, Philopteridae	<i>Botaurus stellaris</i>	EN/LC
<i>Ardeiphilus trochioxus</i>	Amblycera, Menoponidae	<i>Botaurus stellaris</i>	EN/LC
<i>Austromenopon echinatum</i>	Amblycera, Menoponidae	<i>Calonectris diomedea</i>	EN/LC
<i>Brueelia minor</i>	Ischnocera, Philopteridae	<i>Lanius minor</i>	CR/LC
<i>Colpocephalum imperialis</i>	Amblycera, Menoponidae	<i>Aquila adalberti</i>	EN/VU
<i>Craspedorrhynchus fraterculus</i>	Ischnocera, Philopteridae	<i>Aquila adalberti</i>	EN/VU
<i>Cummingsiella ovalis</i>	Ischnocera, Philopteridae	<i>Numenius arquata</i>	CR/NT
<i>Falcolipeurus frater</i>	Ischnocera, Philopteridae	<i>N. percnopterus</i> / <i>Gyps himalayensis</i>	EN/EN-NT
<i>Halipeurus abnormis</i>	Ischnocera, Philopteridae	<i>Calonectris diomedea</i>	EN/LC
<i>Neocolpocephalum percnopteri</i>	Amblycera, Menoponidae	<i>Neophron percnopterus</i>	EN/EN
<i>Otidocetus houbarae</i>	Ischnocera, Philopteridae	<i>Chlamydotis undulata</i>	EN/VU
<i>Quadraceps obliquus</i>	Ischnocera, Philopteridae	<i>Uria aalge</i> / <i>U. lomvia</i>	EN/LC-LC
<i>Saemundssonina (S.) calva</i>	Ischnocera, Philopteridae	<i>Uria aalge</i> / <i>U. lomvia</i>	EN/LC-LC

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

SPECIES	SUBORDER, FAMILY	HOST/S	STATUS (REGIONAL/ WORLDWIDE)
<i>Aquiligogus barbata</i>	Amblycera, Menoponidae	<i>Gypaetus barbatus</i>	VU/NT
<i>Degeeriella punctifer</i>	Ischnocera, Philopteridae	<i>Gypaetus barbatus</i>	VU/NT
<i>Falcolipeurus quadripunctatus</i>	Ischnocera, Philopteridae	<i>Gypaetus barbatus</i>	VU/NT
<i>Coloceras brittanicum</i>	Ischnocera, Philopteridae	<i>Streptopelia turtur</i>	VU/VU
<i>Hohortsiella streptopeliae</i>	Amblycera, Menoponidae	<i>Streptopelia turtur</i>	VU/VU
<i>Lunaceps haematopi</i>	Amblycera, Menoponidae	<i>Haematopus ostralegus</i>	VU/NT
<i>Quadraceps ornatus</i>	Ischnocera, Philopteridae	<i>Rissa brevirostris</i>	VU/VU

3.2. Mammalian lice

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

Five Spanish mammals are considered EN at regional level: three of them are bats (this group is not parasitized by Phthiraptera), and the lice of the European mink (*Mustela lutreola*), were never studied. The remaining one, the Iberian lynx (*Lynx pardinus*), which is also catalogued as EN at global level, is the host of *Felicola (Loricicola) isidoro*

(Trichodectera, Trichodectidae) (Pérez and Palma, 2001, Fig. 1), which can also be considered as EN.

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

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

4. Discussion

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

The status of threatened species may improve, particularly when recovery plans are applied (Bottrill et al., 2011). This is the case of the



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

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

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

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

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

5. Conclusions

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

Conflicts of interest

With regards to the submitted manuscript, I declare to have no conflict of interest.

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