Short Communication

# Co-extinct and critically co-endangered species of parasitic lice, and conservation-induced extinction: should lice be reintroduced to their hosts?

Lajos Rózsa and Zoltán Vas

**Abstract** The co-extinction of parasitic taxa and their host species is considered a common phenomenon in the current global extinction crisis. However, information about the conservation status of parasitic taxa is scarce. We present a global list of co-extinct and critically co-endangered parasitic lice (Phthiraptera), based on published data on their host-specificity and their hosts' conservation status according to the IUCN Red List. We list six co-extinct and 40 (possibly 41) critically co-endangered species. Additionally, we recognize 2–4 species that went extinct as a result of conservation efforts to save their hosts. Conservationists should consider preserving host-specific lice as part of their efforts to save species.

**Keywords** Conservation-induced extinction, critically co-endangered, co-extinction, lice, parasites, Phthiraptera

Gompper & Williams (1998) proposed that a species of Trichodectid louse specific to the black-footed ferret *Mustela nigripes* had gone extinct during a captive-breeding programme to save the host, and consequently this parasite has become an iconic species that exemplifies the need for parasite conservation. However, the claim that this louse is a separate species from the weasel louse *Neotrichodectes minutus* (Emerson, 1964) has never been confirmed. Thus parasite conservationists' iconic species has never been described as a species.

In another erroneous example of co-extinction the louse *Columbicola extinctus* was believed to have gone extinct together with its only known host species, the passenger pigeon *Ectopistes migratorius*, until genetic analysis showed that the louse was conspecific with those parasitizing an extant species of pigeon (Clayton & Price, 1999). Moreover, *Campanulotes defectus*, once also thought to be specific to the passenger pigeon, was shown to be a misidentification of an extant louse species (Price et al., 2000) hosted by the common bronzewing *Phaps chalcoptera*.

Lajos Rózsa (Corresponding author) MTA-ELTE-MTM Ecology Research Group, Budapest, Pázmány Str. 1/c, H-1117 Hungary
E-mail lajos.rozsa@gmail.com

Zoltán Vas Hungarian Natural History Museum, Budapest, Hungary

*Received 21 September 2012. Revision requested 28 November 2012. Accepted 2 April 2013. First published online 22 August 2014.*

These problems highlight the need to develop reliable taxonomical knowledge about threatened and extinct parasites. Although the co-extinction of host-specific dependent taxa (mutualists and parasites) and their hosts is known to be a feature of the ongoing wave of global extinctions (Stork & Lyal, 1993; Koh et al., 2004; Dunn et al., 2009), the magnitude of this threat is difficult to assess. Published lists of threatened animal parasites only cover ixodid ticks (Durden & Keirans, 1996; Mihalca et al., 2011), oestrid flies (Colwell et al., 2009), helminths of Brazilian vertebrates (Muñiz-Pereira et al., 2009) and New Zealand mites and lice (Buckley et al., 2012). Our aim here is to provide a critical overview of the conservation status of parasitic lice.

Firstly, we document the louse species that are known or suspected to have gone extinct in conservation efforts to save the host species. Secondly, we define lice specific to Critically Endangered hosts as critically co-endangered parasites. We list critically co-endangered and co-extinct species on the basis of known host associations (Durden & Musser, 1994; Price et al., 2003; Mey, 2004, 2005, 2010; Stephenson et al., 2008) and whether the host is categorized as Extinct, Extinct in the Wild, or Critically Endangered on the IUCN Red List (IUCN, 2011). We do not list lice specific to Endangered or Vulnerable hosts because of the reduced threat of conservation-induced extinction in their case.

During the captive-breeding and release programme to save the California condor *Gymnogyps californianus* the louse *Colpocephalum californici*, which was specific to this host, went extinct, probably as a result of veterinary delousing routines (Dunn, 2009).

Similarly, *Rallicola (Aptericola) pilgrimi* went extinct when its host, the little spotted kiwi *Apteryx owenii*, was translocated to predator-free islands to ensure its survival (Buckley et al., 2012).

We have no information about the fate of *Rallicola (Rallicola) guami*, a louse species known only from the Guam rail *Gallirallus owstoni*. Given that this host is extinct in the wild and only captive-bred stocks exist, it is likely that the parasite is extinct.

The status of *Linognathus petasmatus* is unknown, given the uncertainties about its host specificity. It may have been specific to the scimitar-horned oryx *Oryx dammah* and gone extinct as a result of conservation efforts to save this

TABLE 1 Species of lice that exclusively parasitize(d) Critically Endangered or Extinct birds or mammals, with their host species and conservation status.

| Louse species | Host species [host family] | Status of louse* |
|---|---|---|
| **Amblycera: Boopidae** | | |
| *Paraheterodoxus calcaratus* Kéler, 1971 | Woylie or brush-tailed bettong *Bettongia penicillata* [Potoroidae] | Critically co-endangered |
| **Amblycera: Menoponidae** | | |
| *Austromenopon confine* (Blagoveshtchensky, 1948) | Slender-billed curlew *Numenius tenuirostris* [Scolopacidae] | Critically co-endangered |
| *Austromenopon gregariae* Timmermann 1954 | Sociable lapwing *Vanellus gregarius* [Charadriidae] | Critically co-endangered |
| *Chapinia hoplai* Elbel 1967 | Sulu hornbill *Anthracoceros montani* [Bucerotidae] | Critically co-endangered |
| *Colpocephalum californici* Price & Beer 1963 | California condor *Gymnogyps californianus* [Accipitridae] | Conservation-induced extinction |
| *Colpocephalum davisoni* Price & Beer, 1965 | White-shouldered ibis *Pseudibis davisoni* [Threskiornithidae] | Critically co-endangered |
| *Colpocephalum eremitae* Price & Beer, 1965 | Northern bald ibis *Geronticus eremita* [Threskiornithidae] | Critically co-endangered |
| *Colpocephalum satellitum* (Eichler & Zlotorzicka, 1963) | White-rumped vulture *Gyps bengalensis* [Accipitridae] | Critically co-endangered |
| *Franciscoloa (Franciscoloa) thompsoni* Price & Beer, 1966 | Philippine cockatoo *Cacatua haematuropygia* [Cacatuidae] | Critically co-endangered |
| *Longimenopon dominicanum* (Kellogg & Mann, 1912) | Guadalupe storm-petrel *Oceanodroma macrodactyla* [Hydrobatidae] | Critically co-endangered |
| *Menacanthus annuliventer* Hopkins 1950 | Blue-billed curassow *Crax alberti* [Cracidae] | Critically co-endangered |
| *Myrsidea bakeri* Carriker, 1949 | Mariana crow *Corvus kubaryi* [Corvidae] | Critically co-endangered |
| *Myrsidea teraokai* Uchida, 1918 | Pohnpei starling *Aplonis pelzelni* [Sturnidae] | Critically co-endangered |
| *Plegadiphilus geronticus* Ledger, 1971 | Northern bald ibis *Geronticus eremita* [Threskiornithidae] | Critically co-endangered |
| *Psittacobrosus bechsteini* Mey, 2005 | Cuban red macaw *Ara tricolor* [Psittacidae] | Co-extinct |
| **Amblycera: Trimenoponidae** | | |
| *Philandesia chinchillae* (Werneck, 1935) | Long-tailed chinchilla *Chinchilla lanigera* [Chinchillidae] | Critically co-endangered |
| *Philandesia mazzai* (Werneck, 1933) | Long-tailed chinchilla *Chinchilla lanigera* [Chinchillidae] | Critically co-endangered |
| **Ischnocera: Philopteridae** | | |
| *Acutifrons caracarensis* (Kellogg & Mann, 1912) | Guadalupe caracara *Caracara lutosa* [Falconidae] | Co-extinct |
| *Ardeicola burmanus* Hajela & Tandan, 1970 | White-shouldered ibis *Pseudibis davisoni* [Threskiornithidae] | Critically co-endangered |
| *Ardeicola exilis* (Neumann, 1913) | Northern bald ibis *Geronticus eremita* [Threskiornithidae] | Critically co-endangered |
| *Chelopistes craxae* (Carriker, 1945) | Blue-billed curassow *Crax alberti* [Cracidae] | Critically co-endangered |
| *Coloceras hemiphagae* (Tenderio, 1972) | Norfolk Island pigeon *Hemiphaga novaeseelandiae spadicea* [Columbidae] | Co-extinct |
| *Coloceras restinctus* (Tenderio, 1972) | Norfolk Island pigeon *Hemiphaga novaeseelandiae spadicea* [Columbidae] | Co-extinct |
| *Craspedorrhynchus intermedius* (Piaget, 1880) | Madagascar fish-eagle *Haliaeetus vociferoides* [Accipitridae] | Critically co-endangered |
| *Cummingsiella breviclypeata* Blagoveshtchensky, 1948 | Slender-billed curlew *Numenius tenuirostris* [Scolopacidae] | Critically co-endangered |
| *Docophoroides levequei* Timmermann, 1963 | Waved albatross *Phoebastria irrorata* [Diomedeidae] | Critically co-endangered |
| *Falcolipeurus hopkinsi* Tandan, 1952 | Red-headed vulture *Sarcogyps calvus* [Accipitridae] | Critically co-endangered |
| *Falcolipeurus longiphallus* Zlotorzicka, 1963 | White-rumped vulture *Gyps bengalensis* [Accipitridae] | Critically co-endangered |
| *Ibidoecus vicinus* (Neumann, 1922) | Northern bald ibis *Geronticus eremita* [Threskiornithidae] | Critically co-endangered |
| *Neopsittaconirmus capreolus* (Gervais 1844) | Yellow-crested cockatoo *Cacatua sulphurea* [Cacatuidae] | Critically co-endangered |
| *Neopsittaconirmus emersoni* Guimarães, 1974 | Philippine cockatoo *Cacatua haematuropygia* [Cacatuidae] | Critically co-endangered |
| *Oxylipeurus craxae* Carriker 1944 | Blue-billed curassow *Crax alberti* [Cracidae] | Critically co-endangered |
| *Perineus oblongus* Kéler, 1957 | Waved albatross *Phoebastria irrorata* [Diomedeidae] | Critically co-endangered |
| *Philopteroides xenicus* Mey, 2004 | Bushwren *Xenicus longipes* [Acanthisittidae] | Co-extinct |
| *Philopterus acrocephalus* Carriker, 1949 | Nightingale reed-warbler *Acrocephalus luscinius* [Acrocephalidae] | Critically co-endangered |

Table 1 (*Cont.*)

| Louse species | Host species [host family] | Status of louse* |
|---|---|---|
| *Psittoecus hoogstraali* Guimarães, 1974 | Philippine cockatoo *Cacatua haematuropygia* [Cacatuidae] | Critically co-endangered |
| *Rallicola (Aptericola) pilgrimi* Clay, 1972 | Little spotted kiwi *Apteryx owenii* [Apterygidae] | Conservation-induced extinction |
| *Rallicola (Huiacola) extinctus* (Mey, 1990) | Huia *Heteralocha acutirostris* [Callaeidae] | Co-extinct |
| *Rallicola (Rallicola) guami* Carriker, 1949 | Guam rail *Gallirallus owstoni* [Rallidae] | Conservation-induced extinction (?) |
| *Rallicola (Rallicola) insulana* (Carriker, 1949) | Mariana crow *Corvus kubaryi* [Corvidae] | Critically co-endangered |
| *Rallicola (Rallicola) piageti* Clay, 1953 | New Caledonian rail *Gallirallus lafresnayanus* [Rallidae] | Critically co-endangered |
| *Saemundssonia (Saemundssonia) fusca* (Giebel, 1874) | Siberian crane *Grus leucogeranus* [Gruidae] | Critically co-endangered |
| *Sturnidoecus stresemanni* Mey, 1989 | Bali starling *Leucopsar rothschildi* [Sturnidae] | Critically co-endangered |
| **Ischnocera: Trichodectidae** | | |
| *Felicola (Lorisicola) isidoroi* Pérez & Palma, 2001 | Iberian lynx *Lynx pardinus* [Felidae] | Critically co-endangered |
| *Tricholipeurus pakenhami* Werneck, 1947 | Aders' duiker *Cephalophus adersi* [Bovidae] | Critically co-endangered |
| **Anoplura: Echinophthiriidae** | | |
| *Lepidophthirus piriformis* Blagoveshtchensky, 1966 | Mediterranean monk seal *Monachus monachus* [Phocidae] | Critically co-endangered |
| **Anoplura: Haematopinidae** | | |
| *Hematopinus oliveri* Mishra & Singh, 1978 | Pygmy hog *Porcula salvania* [Suidae] | Critically co-endangered |
| **Anoplura: Linognathidae** | | |
| *Linognathus petasmatus* Ferris, 1951 | *Addax *Addax nasomaculatus* [Bovidae] | Critically co-endangered (?) |
| *Linognathus petasmatus* Ferris, 1951 | *Scimitar-horned oryx *Oryx dammah* [Bovidae] | Conservation-induced extinction (?) |
| **Anoplura: Pedicinidae** | | |
| *Pedicinus (Neopedicinus) curtipenitus* Mey, 2010 | Grey-shanked douc langur *Pygathrix cinerea* [Cercopithecidae] | Critically co-endangered |
| **Anoplura: Pthiridae** | | |
| *Pthirus gorillae* Ewing, 1927 | Lowland gorilla *Gorilla gorilla* [Hominidae] | Critically co-endangered |

*Based on IUCN status of host species

host in captivity or it may be specific to the addax *Addax nasomaculatus* and critically co-endangered.

The IUCN Red List (IUCN, 2011) includes only one Critically Endangered species of lice and the criteria for selecting this particular species are not known. We considerably expand this list by naming six co-extinct and 40 (possibly 41) critically co-endangered species of parasitic lice (Table 1), based on the IUCN Red List status of host species.

There are several reasons why conservationists should care about threatened parasites. They not only constitute a large proportion of global biodiversity but also exert selective pressures to increase host diversity (Rózsa, 1992), and therefore harbouring a unique parasitic fauna can increase the conservation value of the host (Pérez & Palma, 2001). Furthermore, parasites carry phylogenetic and population genetic information about the evolutionary past of their hosts (Whiteman & Parker, 2005; Johnson et al., 2006). On the other hand, the preservation of parasite species that pose considerable medical or veterinary threats would not be widely accepted.

Not all parasites are equally important. For example, the critically co-endangered gorilla louse *Pthirus gorillae* is of particular value because it is closely related to the human pubic louse *Pthirus pubis* (Reed et al., 2007) thus its loss would deprive us of a unique possibility to study the evolution and ecology of a human pathogen.

In several cases the IUCN categorization of birds or mammals as Critically Endangered appears to be an understatement. Hosts such as the Jamaica petrel *Pterodroma caribbaea*, New Caledonian rail *Gallirallus lafresnayanus* and Guadalupe storm-petrel *Oceanodroma macrodactyla* probably went globally extinct long ago. Consequently our list probably underestimates the number of co-extinct and critically co-endangered species. Further sources of uncertainty are the arbitrary nature of the species concept in the case of lice (Mey, 2003) and the limited information available regarding host specificity (Moir et al., 2010, 2011).

Conservationists should consider preserving host-specific lice as part of their efforts to save birds or mammals ex situ. An obvious method is to establish in vitro cultures, which are relatively easy and cheap to maintain (Saxena & Agarwal, 1983). This would open the possibility for reintroduction of infested hosts. The potential costs and benefits of reintroducing infested vs non-infested animals are open to debate. As far as we are aware no practical work has been carried out to conserve any species of louse.

## References


Buckley, T.R., Palma, R.L., Johns, P.M., Gleeson, D.M., Heath, A.C.G., Hitchmough, R.A. & Stringer, I.A.N. (2012) The conservation status of small or less well known groups of New Zealand terrestrial invertebrates. *New Zealand Entomologist*, 35, 137–143.

Clayton, D.H. & Price, R.D. (1999) Taxonomy of New World *Columbicola* (Phthiraptera: Philopteridae) from the Columbiformes (Aves), with descriptions of five new species. *Annals of the Entomological Society of America*, 92, 675–685.

Colwell, D.D., Otranto, D. & Stevens, J.R. (2009) Oestrid flies: eradication and extinction versus biodiversity. *Trends in Parasitology*, 25, 500–504.

Dunn, R.R. (2009) Coextinction: anecdotes, models, and speculation. In *Holocene Extinctions* (ed. S.T. Turvey), pp. 167–180. Oxford University Press, Oxford, UK.

Dunn, R.R., Harris, N.C., Colwell, R.K., Koh, L.P. & Sodhi, N.S. (2009) The sixth mass coextinction: are most endangered species parasites and mutualists? *Proceedings of the Royal Society B: Biological Sciences*, 276, 3037–3045.

Durden, L.A. & Keirans, J.E. (1996) Host–parasite coextinction and the plight of tick conservation. *American Entomologist*, 42, 87–91.

Durden, L.A. & Musser, G.G. (1994) The sucking lice (Insecta, Anoplura) of the world: a taxonomic checklist with records of mammalian hosts and geographical distributions. *Bulletin of the American Museum of Natural History*, 218, 1–90.

Emerson, K.C. (1964) *Checklist of the Mallophaga of North America (north of Mexico). Part I. Suborder Ischnocera*. Deseret Test Center, Dugway, USA.

Gompper, M.E. & Williams, E.S. (1998) Parasite conservation and the black-footed ferret recovery program. *Conservation Biology*, 12, 730–732.

IUCN (2011) *The IUCN Red List of Threatened Species v. 2011.2*. Http://www.iucnredlist.org [accessed 10 January 2012].

Johnson, K.P., Kennedy, M. & McCracken, K.G. (2006) Reinterpreting the origins of flamingo lice: cospeciation or host switching? *Biology Letters*, 2, 275–278.

Koh, L.P., Dunn, R.D., Sodhi, N.S., Colwell, R.K., Proctor, H.C. & Smith, V.S. (2004) Species co-extinctions and the biodiversity crisis. *Science*, 305, 1632–1634.

Mey, E. (2003) On the development of animal louse systematics (Insecta, Phthiraptera) up to the present day. *Rudolstädter Naturhistorische Schriften*, 11, 115–134.

Mey, E. (2004) Zur taxonomie, verbreitung und parasitophyletischer evidenz des *Philopterus*-komplexes (Insecta, Phthiraptera, Ischnocera). *Ornithologischer Anzeiger*, 43, 149–203.

Mey, E. (2005) *Psittacobrosus bechsteini*: a new extinct chewing louse (Insecta, Phthiraptera, Amblycera) off the Cuban Macaw *Ara tricolor* (Psittaciiformes), with an annotated review of fossil and recently extinct animal lice. *Anzeiger des Vereins Thüringer Ornithologen*, 5, 201–217.

Mey, E. (2010) The *Pedicinus* species (Insecta, Phthiraptera, Anoplura, Pedicinidae) on douc langurs (*Pygathrix* spp.). *Vietnamese Journal of Primatology*, 4, 57–68.

Mihalca, A.D., Gherman, C.M. & Cozma, V. (2011) Coendangered hard-ticks: threatened or threatening? *Parasites & Vectors*, 4, 71.

Moir, M.L., Vesk, P.A., Brennan, K.E.C., Keith, D.A., Hughes, L. & McCarthy, M.A. (2010) Current constraints and future directions in estimating coextinction. *Conservation Biology*, 24, 682–690.

Moir, M.L., Vesk, P.A., Brennan, K.E.C., Keith, D.A., McCarthy, M.A. & Hughes, L. (2011) Identifying and managing threatened invertebrates through assessment of coextinction risk. *Conservation Biology*, 25, 787–796.

Muñiz-Pereira, L.C., Vieira, F.M. & Luque, J.L. (2009) Checklist of helminth parasites of threatened vertebrate species from Brazil. *Zootaxa*, 2123, 1–45.

Pérez, J.M. & Palma, R.L. (2001) A new species of *Felicola* (Phthiraptera: Trichodectidae) from the endangered Iberian lynx: another reason to ensure its survival. *Biodiversity and Conservation*, 10, 929–937.

Price, R.D., Clayton, D.H. & Adams, R.J. (2000) Pigeon lice down under: taxonomy of Australian *Campanulotes* (Phthiraptera: Philopteridae), with a description of *C. durdeni* n. sp. *Journal of Parasitology*, 86, 948–950.

Price, R.D., Hellenthal, R.A., Palma, R.L., Johnson, K.P. & Clayton, D.H. (2003) *The Chewing Lice: World Checklist and Biological Overview*. Illinois Natural History Survey, Champaign, USA.

Reed, D.L., Light, J.E., Allen, J.M. & Kirchman, J.J. (2007) Pair of lice lost or parasites regained: the evolutionary history of anthropoid primate lice. *BMC Biology*, 5, 7.

Rózsa, L. (1992) Endangered parasite species. *International Journal for Parasitology*, 22, 265–266.

Saxena, A.K. & Agarwal, G.P. (1983) Review article: in vitro rearing of Mallophaga. *Angewandte Parasitologie*, 24, 178–86.

Stephenson, B.M., Gaskin, C.P., Griffiths, R., Jamieson, H., Baird, K.A., Palma, R.L. & Imber, M.J. (2008) The New Zealand storm-petrel (*Pealeornis maoriana* Mathews, 1932): first live capture and species assessment of an enigmatic seabird. *Notornis*, 55, 191–206.

Stork, N.E. & Lyal, C.H.C. (1993) Extinction or 'co-extinction' rates? *Nature*, 366, 307.

Whiteman, N.K. & Parker, P.G. (2005) Using parasites to infer host population history: a new rationale for parasite conservation. *Animal Conservation*, 8, 175–181.


## Biographical sketches

Lajos Rózsa's primary research interest is the interaction between animals (including humans) and their pathogens. Zoltán Vas is studying the interaction between birds and their parasites, with a particular emphasis on evolution, ecology and conservation.