A report of infection in the crested ibis *Nipponia nippon* with feather mites in current Japan

Tsukasa WAKI¹, Satoshi SHIMANO²*

¹Faculty of Science, Toho University, 2-2-1 Miyama, Funabashi, Chiba 274-8510, Japan
²Science Research Center, Hosei University, 2-17-1 Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan

(Received 13 November 2019; Accepted 4 March 2020)

**Key words:** crested ibis, Compressalges nipponiae, Freyanopterolichus nipponiae, feather mite, infection

**INTRODUCTION**

The crested ibis *Nipponia nippon* Temminck, 1835 (Pelecaniformes, Threskiornithidae) is a wetland bird with a wide distribution throughout the Far East (Li et al., 2009). However, most native populations of this species have declined, mainly because of hunting activities and environmental destruction, except for a small area in China (Li et al., 2009). In Japan, the crested ibis was categorized as “Extinct in the wild (EW)” on the Red List of the Ministry of the Environment, Japan (Ministry of the Environment, 2002), when their wild population vanished. “Midori” and “Kin”, the last two reared individuals in the Sado Japanese crested ibis conservation center in Japan, died in 1995 and 2003, respectively, resulting in the complete extinction of Japanese individuals (Nishiumi, 2009; Yamagishi, 2009).

Since 1999, seven individuals were transported from Yang Xian, Shaanxi Province, China (Lan et al., 2019), in order to breed and re-introduce the crested ibis in Japan, because the Chinese population was thought to be closely related to the Japanese population based on the similarity of mitochondrial DNA (Yamamoto, 2007). The transported Chinese individuals were bred in cages on Sado Island, Japan, for reproduction. Since 2008, 327 individuals of the crested ibis, which were offspring of the Chinese individuals, were released on a natural field on Sado Island, which they colonized to maintain their population. Therefore, the crested ibis is currently categorized as “Critically Endangered (CR)” on the Red List in Japan (Ministry of the Environment, Japan, 2019a, 2019b).

Feather mites of the superfamilies Analgoidea Trouessart and Mégnin, 1884, Freyanoidae Koch, 1844, and Pterolichoidea Trouessart and Mégnin, 1884 are known bird parasites, which are thought to inhabit the flight feathers and feed on preen gland oil and material trapped on it.

* Corresponding author: e-mail: sim@hosei.ac.jp
DOI: 10.2300/acari.29.1
In general, these mites have high host specificity and live only on hosts’ feathers (O’Connor, 1982). The feather mites *Compressalges nipponiae* Dubinin, 1950 (Caudiferidae) and *Freyanopterolichus nipponiae* “Dubinin 1953” (Kramerellidae) were found on the crested ibis and described as new species. Infection with these two species was reported from both Japanese and Russian crested ibis, but not from China (Dubinin, 1950; 1956; Ministry of the Environment, 2019b), despite the crested ibis’ wide range distribution throughout the Far East (Yamagishi, 2009).

In Japan, the feather mite *C. nipponiae* was listed in the Red List of the Ministry of the Environment, Japan as “EW”, when the wild host population became extinct and received the same status (Ministry of the Environment, Japan, 2006). In 2019, the position of this mite was reviewed and listed as “Data Deficient (DD)” based on the presence of the new population of introduced Chinese crested ibis in Sado Island (Ministry of the Environment, Japan, 2019a, 2019b). However, the presence of the mites was not surveyed and confirmed in the recent host population in Japan. The major aim of this study was to survey the presence of the feather mite *C. nipponiae* in the released population of the crested ibis in Japan. For this purpose, we sampled feather mites from feather specimens of the original Japanese crested ibises to determine their species composition and compare it to that of introduced host individuals.

**MATERIALS AND METHODS**

Feather specimens of the last two Japanese crested ibises, namely “Midori” and “Kin” which died in 1995 and 2003, respectively (Nishiumi, 2009; Yamagishi, 2009), were used for this study. In total, 17 feathers were observed under the stereomicroscope to detect mites. For the released Chinese crested ibis, we used 10 frozen cadavers (i.e., all available individuals found from 2003-2018, which died from natural or accidental causes), which were preserved in the research center on Sado Island. The frozen cadavers were thawed overnight in a laboratory at room temperature (approximately 20°C). Subsequently, 5–11 wind feathers were sampled from each cadaver for observation under the stereomicroscope. For comparative analysis, we sampled 556 fallen feathers of bred Chinese individuals from the floors of 23 cages of the breeding facility of Sado Island in 2018. In addition, dust and small pieces of feathers were collected from four cages in the facility on Feb. 13, 2019 and assessed to detect feather mites. Species identification of the feather mites was conducted under the stereomicroscope, since the two species can be clearly distinguished based on the difference in shape of idiosoma (Gaud and Atyeo, 1996): *C. nipponiae* has a rhomboid idiosoma, while it is round in *F. nipponiae* (Figs. 1A–D). The number of individuals of each species was determined, excluding exuviae. Selected specimens were fixed in 100% ethanol and mounted on slides with Hoyer’s medium for photographic recording under the light microscope. Any mites not identified as either *C. nipponiae* or *F. nipponiae* were fixed and mounted on slides by the same methods. The mites were observed under the light microscope for identification by Dr. Tomoyuki Hashimoto and Dr. Tetsuo Gotoh, following Gervais (1844), Reck (1953), Oshima (1977) and Ehara and Gotoh (2009).
Fig. 1. Feather mites sampled from the crested ibis *Nipponia nippon*. A, B: *Compressalges nipponiae*. Female (A) and male (B). C, D: *Freyanopterolichus nipponiae*. Female (C) and male (D). Scale bars 100 μm.
RESULTS

In samples from the Japanese crested ibis, 13 and 4 feathers from two hosts were examined and 103 individuals of feather mites were sampled (Table 1). Among them, 68 and 35 mites were identified as *C. nipponiae* (Figs. 1A–B) and *F. nipponiae* (Figs. 1C–D), respectively. No other mites were found on feather samples from the Japanese crested ibis. In contrast, we investigated 65 flight feathers obtained from 10 individuals of Chinese crested ibis, and found 6,827 mites, all of which were identified as *F. nipponiae*. In the feather samples from breeding cages, we examined 556 fallen feathers, and found 10,973 individuals of *F. nipponiae*, but no specimens of *C. nipponiae*. Some mites from this sample were identified as free-living species: *Tenuipalpus zhizhilashviliae* Reck, 1953 (Trombidiiformes, Tenuipalpidae), *Tyrophagus longior* Gervais, 1844 (Sarcoptiformes, Acaridae), and *Tyrophagus* sp. (Table 1, Figs. 2A–D). We sampled 67.0 g of dust and small pieces of feathers from breeding cages which did not yield any mites.

DISCUSSION

In this study, two feather mite species, *C. nipponiae* and *F. nipponiae*, were found on feathers of Japanese crested ibises. Within the sample of Chinese crested ibises introduced to Sado Island, all 17,800 individuals of feather mites were identified as *F. nipponiae*, while *C. nipponiae* was not observed to infect the introduced host individuals. Therefore, we conclude that *C. nipponiae* is truly extinct from Japan after its Japanese native host population disappeared, despite the wild population having been re-constructed by the introduction of crested ibises from China. Currently, *C. nipponiae* is listed as “DD” in the Red List in Japan due to the presence of the host population in Sado Island; however, based on the results of this study, we recommend a revision of the status of *C. nipponiae* to “EX” in near future.

The results of the present study also suggest that *C. nipponiae* did not infect the natural population in the Shaanxi Province of China, where the introduced crested ibis originated. In general, feather mites are thought to be transmitted horizontally between host individuals in the population (O’Connor, 1994). Therefore, the difference in infection with feather mites between Japanese and Chinese host individuals may be a result of geographic isolation of the host populations between two countries. Feng et al. (2019) demonstrated that the genomic composition of crested ibis populations differed between Japan and China. This result supports that the Chinese population was geographically isolated from Japanese one. Thus, it is possible that the distribution of the two feather mite species is tightly connected to the history and expansion of the crested ibis’s distribution range. The remaining possibility is that *C. nipponiae* does infect some Chinese crested ibis in Chinese facilities, but not wild individuals. Indeed, some Japanese ibis (1990–1992) and Chinese ibis (1985–1989, 1990–1992, 1994–1995) were transported to Chinese and Japanese facilities for short periods of mating, respectively, and subsequently returned to their respective original country (Niigata Prefecture, 2000; Shi and Cao, 2001; Yuji Okahisa, personal communication). To further investigate this issue, we have recently begun to survey the infection status of feather mites in crested ibis of the Eurasian Continent, including stuffed or dried feather specimens, to assess the presence or absence of *C. nipponiae*. 
Fig. 2. Free-living mites found on feathers of Chinese crested ibis *Nipponia nippon*. A, B: *Tyrophagus* sp. C: *Tyrophagus longior*. D: *Tenuipalpus zhizhilashviliae*. Scale bars: 100 μm.
Some free-living mites were observed from samples on feathers and dust from the floor of breeding cages. These may either represent a contamination of the samples, or the observed species may act as decomposers of the fallen old feathers.

**ACKNOWLEDGEMENTS**

We thank Dr. Yoshinori Kaneko in Ministry of the Environment, the Sado Japanese Crested Ibis Conservation Center and Dr. Yuji Okahisa in Ministry of the Environment, Sado Ranger Office for providing valuable information. We also thank Dr. Tomoyuki Hashimoto in Japan Environmental Sanitation Center and Prof. Tetsuo Gotoh in Ryutsu Keizai University for identification of free-living mites. The present study was kindly permitted by the Ministry of the Environment, Japan and was authorized by “Field survey on the selection and evaluation of
endangered wildlife” based on Red Data List project, Subcommittee of Invertebrate (except Insecta and Mollusca), organized by Wildlife Division, the Ministry of Environment. We thank the staff of the ministry for facilitating our research. We thank Dr. Satoshi Yamagishi for valuable suggestions. The authors also thank two anonymous reviewers for valuable comments on this paper.

The status was changed to “EX”. Available at https://www.env.go.jp/press/107905.html

REFERENCES

Dubinin, V. B. (1950) Features of the structures of the fastening apparatus of the feather mite Compressalges nipponiae V. Dubinin, gen. and sp. nov. Doklady Akademii Nauk SSSR, 70: 537–540. (In Russian)

Dubinin, V. B. (1953) Feather mites (Analgesoidea). Part II. Families Epipteroptidae and Freyanidae. Fauna USSR. Paushoobranya, 6 (6): 1–411. (In Russian)

Dubinin, V. B. (1956) 24. Genus Compressalges V. Dub. In: Analgesoidea Part III, Family Pterolichidae, Fauna of USSR No. 63 (ed., Dubinin, V. B.), pp. 555–560, Zoologicheskii Inst., Moskow and Leningrad. (In Russian)

Ehara, S. and T. Gotoh (2009) Colored Guide to the Plant Mites of Japan. Zenkoku Noson Kyoiku Kyokai, Tokyo. (In Japanese)

Feng, S., Q. Fang, R. Barnett, C. Li, S. Han, M. Kuhlwilm, L. Zhou, H. Pan, Y. Deng, G. Chen, A. Gamauf, F. Woog, R. Prys-Jones, T. Marques-Bonet, M. Thomas. P. Gilbert and G. Zhang (2019) The genomic footprints of the fall and recovery of the crested ibis. Current Biology, 29: 340–349.

Gaud, J. and W. T. Atyeo (1996) Feather mites of the world (Acarina, Astigmata): the supraspecific taxa. Annales Musée Royale de l’Afrique Centrale. Sciences Zoologiques, 277: (Part I, Text) 1–193, (Part II, Illustrations of feather mite taxa) 1–436.

Gervais, P. M. (1844) Remarques sur la famille des scorpions et description des plusieurs espèces nouvelles de la collection du muséum. Archives du Musée d’Histoire Naturelle. Paris, 4, 201–240.

Lan, H., T. Zhou, Q. H. Wan and S. G. Fang (2019) Genetic diversity and differentiation at structurally varying MHC haplotypes and microsatellites in bottlenecked populations of endangered crested ibis. Cells, 8: 377.

Li, X., H. Tian and D. Li (2009) Why the crested ibis declined in the middle twentieth century. Biodiversity and Conservation, 18: 2165–2172.

Ministry of the Environment (2002) Red Data Book 2nd ed. - Threatened Wildlife of Japan - vol. 2, Aves. Japan Wildlife Research Center, Tokyo. (In Japanese with English summary)

Ministry of the Environment (2006) Red Data Book 2nd ed. - Threatened Wildlife of Japan - vol. 7, Other Invertebrates (except Insecta and Mollusca). Japan Wildlife Research Center, Tokyo. (In Japanese with English summary)

Ministry of the Environment (2019a) Announcement of Ministry of the Environment Red List 2019. Available at https://www.env.go.jp/press/106383.html (9 January 2020). (In Japanese)

Ministry of the Environment (2019b) Red List 2019. Available at https://www.env.go.jp/press/files/jp/110615.pdf (9 January 2020). (In Japanese)

Niigata Prefecture (2000) Protection of Crested Ibis –Progress Report of the Protection and Propagation Program of the International Protected and Japanese Special Natural-Monument Bird, Crested Ibis–. Niigata Prefecture, Niigata. (In Japanese)

Nishiumi, I. (2009) Challenge to Reintroduction of Crested Ibises to the Wild – Preparation for the Second Release. Available at https://www.kahaku.go.jp/userguide/hotnews/theme.php?id=0001252486394226&p=2 (9 January 2020). (In Japanese)

O’Connor, B. M. (1982) Evolutionary ecology of astigmatid mites. Annual Review of Entomology, 27: 385–409.

O’Connor, B. M. (1994) Life-history Modifications in Astigmatid Mites. In: Mites: Ecological and Evolutionary Analysis of Life-History Patterns (ed., Houck, M. A.), pp. 136–159, Springer, Boston.
Oshima, S. (1977) Acaroid Mites of House Dust. In: Contributions to Acarology in Japan (eds., Sasa M. and J. Aoki), pp. 525–568, Zukan-no-Hokuryukan, Tokyo. (In Japanese)

Reck, G. (1953) K izcheniu fauni tetranickovick kleshchei Grunzii. Trudy Instituta Zoologii Akademiya Nauk Gruz SSR, 11: 167–821. (In Russian)

Shi, D. and Y. G. Cao (2001) The Crested Ibis of China. China Forestry Publishing House, Beijing. (In Chinese)

Yamagishi, S. (2009) Protection of Endangered Birds in Japan. Kyoto Univ. Press, Kyoto. (In Japanese)

Yamamoto, Y. (2007) Genetic Diversity of the Crested Ibis. In: Report of the Japan-China International Workshop for Reintroduction of the Crested Ibis (ed. Ministry of the Environment). pp. 22–25, Ministry of the Environment, Japan, Tokyo. (In Japanese)