Atypical knemidokoptosis in two Dunnocks (*Prunella modularis*) in southern England.

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Abstract

Avian knemidokoptosis, caused by knemidokoptid mites (Knemidokoptinae: Epidermoptidae), has been reported in wild and domestic birds globally. We report two cases of severe knemidokoptosis in dunnocks (*Prunella modularis*) from separate sites in Great Britain, where the disease has previously been reported predominantly in finches and, less frequently, in corvids.

Main Text

Knemidokoptosis has been reported in a wide range of wild and domestic birds. The causative agents are mites of the subfamily Knemidokoptinae (Epidermoptidae), of which 15 species across six genera are currently recognised (Mironov et al. 2005). *Knemidokoptes jamaicensis* is the mite most frequently reported in wild birds, having been detected in over 40 species of passerine globally (Dabert et al. 2013; Jackson et al. 2015; Janra et al. 2018).

The presentation of knemidokoptosis is variable, dependent upon host, parasite and environmental factors (Pence 2008). *Knemidokoptes jamaicensis* can cause a disease known colloquially as ‘scaly leg’, characterised by hyperkeratotic dermatitis, most commonly affecting the distal legs and feet (Dabert et al. 2013).

Most reports of knemidokoptosis in wild birds involve gregarious passerines such as the American robin (*Turdus migratorius*) and the common chaffinch (*Fringilla coelebs*) (Lawson et al., 2018a; Pence et al., 1999). In Great Britain (GB), knemidokoptosis is widespread in chaffinches and also occurs, albeit less frequently, in greenfinches (*Chloris chloris*), goldfinches (*Carduelis carduelis*), bullfinches (*Pyrrhula pyrrhula*), rooks (*Corvus frugilegus*), jackdaws (*Corvus monedula*) and carrion crows (*Corvus corone*) (Pennycott, 2016; Lawson et al., 2018a;). Whilst most cases in wild birds appear to be mild or moderate, it has been proposed that severe lesions may predispose individuals to predation, trauma or co-infection (Pence 2008; Lawson et al. 2018a).

The dunnock (*Prunella modularis*) is a small, omnivorous, predominantly solitary, ground-feeding passerine found throughout Europe and western Asia (Davies 1992).

Dunnocks are frequently observed in peridomestic habitats and their population in GB is considered stable (Harris et al. 2020).

Here we report severe knemidokoptosis in an atypical species, involving two dunnocks found dead in southern England that were submitted for postmortem examination as part of a GB wildlife disease surveillance scheme. The first bird (D1) was discovered in February 2019 and the second (D2) in January 2020, at separate sites, roughly 270km apart.

Postmortem examinations were conducted following a standardised protocol (Lawson et al. 2010). Both birds were adult females in normal body condition, based on assessment of muscle mass and body weight. Severe skin lesions were evident in both cases. In D1, proliferative, beige, powdery, scaley lesions with marked skin thickening were limited to both distal legs and feet (Figure 1A). In D2, similar severe lesions were noted on the head and neck (Figure 1B), with milder lesions affecting the ventrum and legs (Figure 1C). Both birds exhibited digit loss: D1 had a single digit missing while D2 had lost the distal phalanges of three digits (Figure 1A & 1C). In both birds, the cause of death appeared to be acute trauma, with gross lesions in both cases including rib fractures with associated pulmonary and subcutaneous haemorrhage. Based on the circumstances of carcass discovery, window collision or cat predation were considered to be the most likely causes of trauma.

Microscopic examination of crush preparations from skin lesions from both birds showed numerous *Knemidokoptes* sp. mites. Wet preparations of small intestinal contents revealed no metazoan or protozoan parasites. Bacteriological culture of the liver, small intestinal contents and skin lesions yielded *Staphylococcus aureus* from all three sites in D2, but no significant growth from D1. *Staphylococcus aureus* is a

commensal bacterium frequently isolated from the skin of birds and opportunistic infection can occur where the integrity of the skin barrier is compromised (Benskin et al. 2009).

Histopathological examination of sections of affected skin from both birds revealed severe multifocal, chronic dermatitis with epidermal hyperplasia and hyperkeratosis. Within the stratum corneum, *Knemidokoptes* sp. were admixed with multifocal aggregates of bacteria, indicating secondary bacterial infection (Figure 2A). Dermal involvement was apparent in both birds, with infiltration of predominantly mononuclear cells (lymphocytes and plasma cells) and fewer heterophils, eosinophils and macrophages. In D2, liver, spleen, brain, heart and lung were also examined with no abnormalities or indication of comorbidities evident, except those associated with trauma or autolysis. The state of carcass preservation in D1 only allowed for histopathological examination of the skin.

Previously, passerine knemidokoptosis in GB had almost exclusively been reported in species of the families Fringillidae and, much less frequently, Corvidae. Over the period August 2005 – January 2020, a total of 95 dunnocks have been examined postmortem within this wildlife disease surveillance scheme, but the two dunnocks described here are the first in which knemidokoptosis has been diagnosed.

The severe presentation of knemidokoptosis in the two cases likely predisposed both birds to trauma through impairment of vision or locomotion. The aetiological factors underlying this severe presentation could relate to the host, parasite, environment, or a combination thereof.

Host immunosuppression is one possible contributory factor: no evidence of nutritional debility, concurrent disease or underlying immunosuppressive viral

infection (e.g. circovirus infection) was detected, although extensive histopathological examination was limited to only one of the birds and no specific virological examinations were performed. Techniques, such as next generation sequencing or microarray, could be used to investigate the occurrence of coinfections in future investigations. Additionally, both dunnocks were found in winter, which might indicate an underlying seasonal immunosuppressive effect, as has been suggested in the epizootiology of salmonellosis in passerines in GB (Lawson et al. 2010).

Knemidokoptes jamaicensis is the most likely species of knemidokoptid mite to be involved in these cases, considering morphology and host species (Pence 2008). Dabert et al. (2013), however, suggest that *K. jamaicensis* may in fact comprise a multi-species complex, with variation in target host and virulence between multiple cryptic species. It is therefore possible that these dunnocks were infected with a hypervirulent knemidokoptid. Further investigation using molecular techniques on knemidocoptic mites from the affected dunnocks and from a range of wild birds could provide further insight into the taxonomy and diversity of these parasites in GB.

Both dunnocks were found in the winter, when southern England experiences an influx of chaffinches migrating from continental Europe (Wernham 2002). With knemidokoptosis being widespread among chaffinches in GB, and a peak of infection known to occur in the winter months, it is possible that this creates a greater biotic reservoir of infection, heightening the risk of interspecific spillover from chaffinches to other passerines (Lawson et al. 2018a). This risk could be compounded by a concomitant increase in congregations of passerines using supplementary feeding stations during the winter months when natural food sources can be scarce (Lawson et al. 2018b).

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Literature Cited

Benskin CMcWH, Wilson K, Jones K, Hartley IR. 2009. Bacterial pathogens in wild birds: a review of the frequency and effects of infection. *Biol. Rev. Camb. Philos. Soc.* 84:349–373.

Dabert J, Dabert M, Gal AF, Miclăuş V, Mihalca AD, Sándor AD. 2013. Multidisciplinary analysis of Knemidocoptes jamaicensis parasitising the Common Chaffinch, Fringilla coelebs: proofs for a multispecies complex? *J. Parasitol. Res.* 112:2373–2380.

Davies NB. 1992. *Dunnock behaviour and social evolution*. Oxford University Press, Oxford, England, 272 pp.

Harris SJ, Massimino D, Balmer DE, Eaton MA, Noble DG, Pearce-Higgins JW, Woodcock P, Gillings S. 2020. *The Breeding Bird Survey 2019*. British Trust for Ornithology Report.

Jackson B, Heath A, Harvey C, Holyoake C, Jakob-Hoff R, Varsani A, Robertson I, Warren K. 2015. Knemidokoptinid (epidermoptidae: knemidokoptinae) mite infestation in wild red-crowned parakeets (cyanoramphus novaezelandiae): correlations between macroscopic and microscopic findings. *J. Wildl. Dis.* 51:651–663.

Janra MN, Herwina H, Febria FA, Darras K, Mulyani YA. 2018. Knemidokoptiasis in a Wild Bird, the Little Spiderhunter (Arachnothera longirostra cinereicollis), in Sumatra, Indonesia. *J. Wildl. Dis.* 55:509–511.

Lawson B, Howard T, Kirkwood JK, Macgregor SK, Perkins M, Robinson RA, Ward LR, Cunningham AA. 2010. Epidemiology of Salmonellosis in Garden Birds in England and Wales, 1993 to 2003. *EcoHealth* 7:294–306.

Lawson B, Robinson RA, Fernandez JR-R, John SK, Benitez L, Tolf C, Risely K, Toms MP, Cunningham AA, Williams RAJ. 2018a. Spatio-temporal dynamics and aetiology of proliferative leg skin lesions in wild British finches. *Sci. Rep.* 8:14670.

Lawson B, Robinson RA, Toms MP, Risely K, MacDonald S, Cunningham AA. 2018b. Health hazards to wild birds and risk factors associated with anthropogenic food provisioning. *Philos. Trans. R. Soc. Lond., B, Biol. Sci.* 373:20170091.

Mironov SV, Bochkov AV, Fain A. 2005. Phylogeny and evolution of parasitism in feather mites of the families Epidermoptidae and Dermationidae (Acari: Analgoidea). *Zool. Anz.* 243:155–179.

Pence DB. 2008. Acariasis. In: *Parasitic Diseases of Wild Birds.* Atkinson CT, Thomas NJ & Hunter FB, editors. Wiley-Blackwell, Ames, Iowa, pp. 527–536.

Pence DB, Cole RA, Brugger KE, Fischer JR. 1999. Epizootic podoknemidokoptiasis in American Robins. *J. Wildl. Dis.* 35:1–7.

Pennycott TW. 2016. Diseases of wild birds of the orders Passeriformes and Columbiformes - a review of conditions reported from the United Kingdom and an analysis of results from wild bird disease surveillance in Scotland 1994-2013. The University of Edinburgh. https://era.ed.ac.uk/handle/1842/23001. Accessed July 2020.

Wernham CV. 2002. *The migration atlas: movements of the birds of Britain and Ireland*. Poyser, London, 884 pp.

Figure Captions

Figure 1. Gross skin lesions associated with knemidokoptosis in two dunnocks (*Prunella modularis*) found in southern England. A: proliferative leg skin lesions in dunnock (D1), with loss of digit two on right foot; B: proliferative skin lesions affecting the head and neck, in a second dunnock (D2); C: leg lesions in D2 with loss of distal phalanx of digits 2-4 on right foot.

Figure 2. Micrograph of head skin lesions associated with knemidokoptosis in a dunnock (*Prunella modularis*) (D2) found in southern England showing severe multifocal, chronic dermatitis with epidermal hyperplasia and hyperkeratosis (star), and intralesional mites (arrows) and bacteria (circles), consistent with knemidokoptosis.