Pathology in Practice

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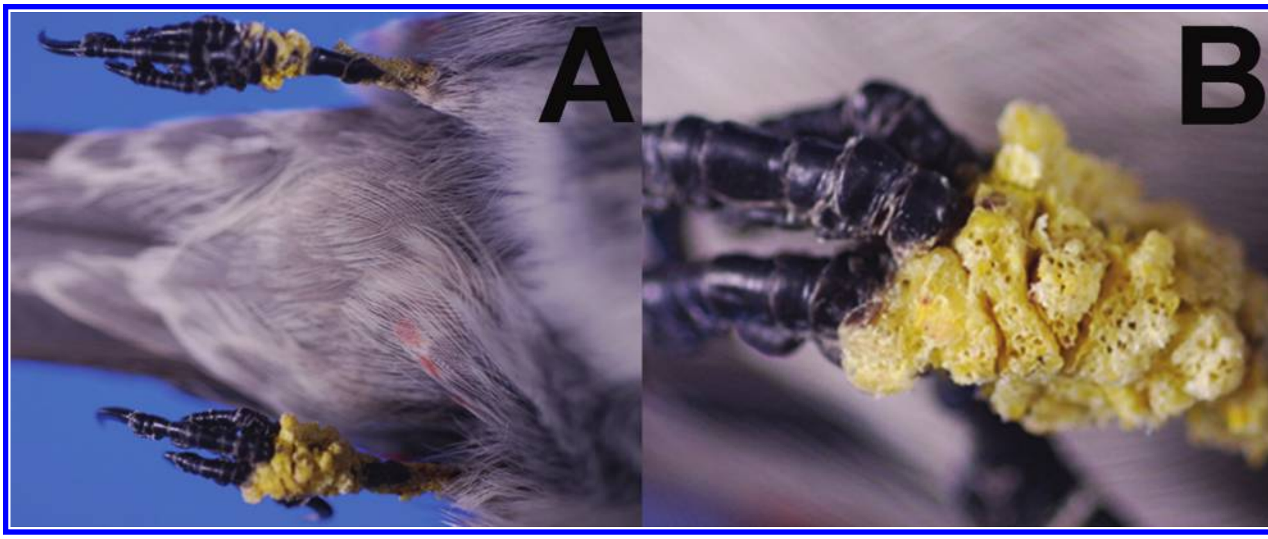

Figure 1—Photographs of the legs of an adult male pine grosbeak (*Pinicola enucleator*) that was found dead under a window. A—Yellow, raised, nodular crusts encircle the tarsometatarsi and are present on the cranial and lateral aspects of the tibiotarsi. B—A higher-magnification view of the left leg illustrating yellow, raised, nodular crusts on the tarsometatarsal region.

History

An adult male 74-g (0.16-lb) pine grosbeak (*Pinicola enucleator*) with crusts on its legs was found dead under a window in November 2015 in Galena, Alaska. The Alaska Department of Fish and Game personnel reported higher than usual numbers of pine grosbeaks in the area during the fall and winter, some of which were observed with similar crusts.

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Gross Findings

On external examination, yellow, raised, nodular crusts encircled both tarsometatarsi and were present on the cranial and lateral aspects of both tibiotarsi **(Figure 1)**. The metatarsal regions were not affected. There were moderate amounts of subcutaneous, visceral, and epicardial fat indicative of good body condition. The proventriculus and ventriculus contained a large amount of sunflower seeds. Hemorrhages, consistent with trauma (associated with a window strike), were observed in the oral cavity, tracheal lumen, lungs, liver, and distal portions of the intestines.

Formulate differential diagnoses from the history, clinical findings, and Figure 1—then turn the page→

Histopathologic, Parasitological, and Molecular Findings

In sections of the left cranial tibiotarsal region that were examined histologically, there was locally extensive, severe orthokeratotic hyperkeratosis. Throughout the stratum corneum, clear spaces that often contained sections of mites or their eggs were evident **(Figure 2)**. The mites were approximately 300 µm wide with an eosinophilic exoskeleton and spines, a hemocoel, striated muscle, and jointed appendages. The mite eggs were approximately 25 µm in diameter. Microscopic examination of skin scrapings from the leg identified > 150 *Knemidocoptes* organisms that were morphologically similar to *Knemidocoptes jamaicensis*[1,2] **(Figure 3)**.

Mites were isolated[3] for DNA extraction from thawed tissue from the right leg that had been frozen for approximately 3 months; extracted DNA underwent a PCR assay to amplify the cytochrome oxidase subunit I gene by the methods of Dabert et al[4] with elimination of overnight pre-incubation (voucher specimens archived at US National Museum, Entomology Collections, USNMENT 01021424-01021426 as whole vouchers and USNMENT 01021426.1 as the DNA voucher). A 700-bp fragment was visualized on a 0.1% agarose gel, and the DNA was sequenced at the University of Wisconsin-Madison Biotechnology Center by means of a DNA sequencing system.[a] The

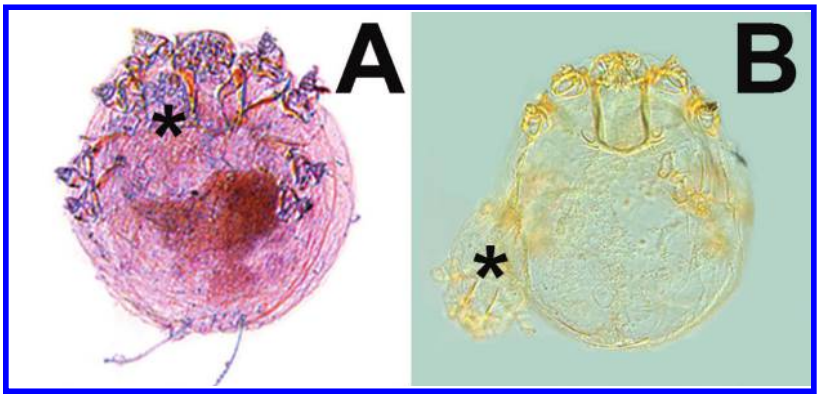

Figure 3—Photomicrographs of mites extracted from thawed tissue of the frozen right leg of the bird in Figure 1. A—Ventral view of a female *Knemidocoptes jamaicensis* mite with a larva (asterisk) in situ. B—Dorsal view of a female *K jamaicensis* mite with 2 larvae (asterisk).

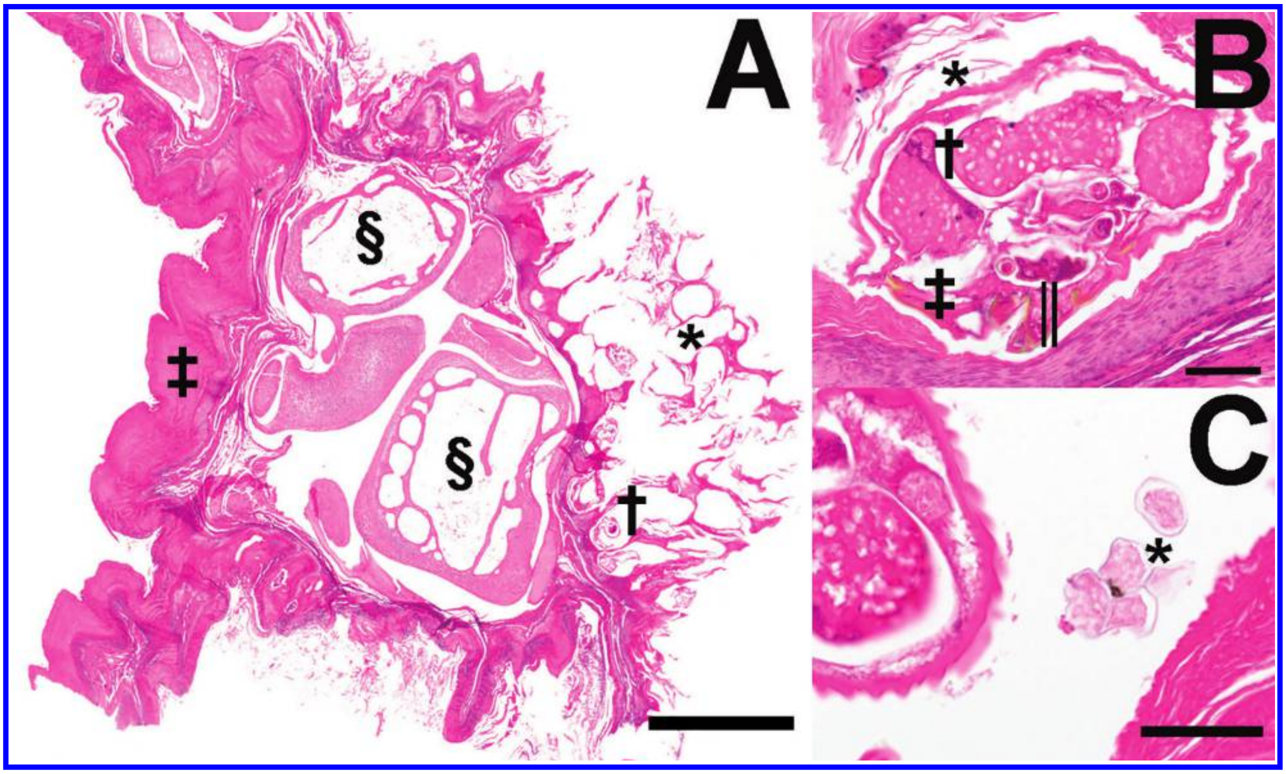

Figure 2—Photomicrographs of a transverse section of the left tibiotarsal region from the bird in Figure 1. A—Within the stratum corneum of the cranial portion of the tibiotarsus, there is diffuse severe orthokeratotic hyperkeratosis. Throughout the keratin, there are clear spaces (mite tunnels [asterisk] that often contain sections of mites [dagger]). Notice the presence of normal skin (double dagger) in a more caudal location. The tibiotarsal bones are evident in the center of the section (section mark). H&E stain; bar = 1 mm. B—A higher-magnification view of a mite in a section from the tibiotarsal region. Mites are approximately 300 µm in width and have an eosinophilic exoskeleton with spines (asterisk), a hemocoel (dagger), striated muscle (double dagger), and jointed appendages (parallel mark). H&E stain; bar = 50 µm. C—Mite eggs (asterisk) were occasionally observed adjacent to mites within the stratum corneum of the tibiotarsal region. H&E stain; bar = 50 µm.

DNA sequence was deposited in GenBank (accession No. MF043583) and used in a bioinformatic search tool.[b] The amplified sequence was most closely related (88%) to *K jamaicensis* (GenBank JQ037816.1).

Morphologic Diagnosis and Case Summary

Morphologic diagnosis: severe, chronic, multifocal proliferative dermatitis with orthokeratotic hyperkeratosis and intracorneal mites consistent with *Knemidocoptes* spp.

Case summary: proliferative dermatitis caused by *K jamaicensis* infestation in a pine grosbeak.

Comments

Mites that parasitize the skin of birds are members of the families Epidermoptidae and Dermationidae. Whereas most species in these families only parasitize the surface of the skin, mites in the family Epidermoptidae, subfamily Knemidocoptinae bury deep into the skin of their hosts causing disease similar to mange.[5] Genera within the subfamily Knemidocoptinae include *Knemidocoptes*, *Neocnemidocoptes*, *Procnemidocoptes*, *Evansacarus*, *Picicnemidocoptes*, and *Micnemidocoptes*.[5] Species within the genus *Knemidocoptes* known as face mites invade the stratum corneum and feather follicles of the face and cere of birds; so-called scaly leg mites inhabit the legs and feet.[2] Some *Knemidocoptes* spp affect both the legs and face, and others infest the base of feathers (depluming mites).[6]

The entire life cycle of *Knemidocoptes* mites occurs on the host; therefore, transmission is generally direct.[2] Clinical signs vary according to the species of parasite and host and may be influenced by immunosuppression and genetic factors in a given bird.[7] For mites affecting the skin of the legs and face, mechanical trauma from the burrowing activity of the mites as well as the release of excretory and secretory products results in development of hyperkeratosis and dermal inflammation.[8] Grossly, these changes appear as thickened skin with scales, crusts, and scabs.[4] When hyperkeratosis is severe, there can be loss of digits, feet, or limbs.[9] Depluming mites burrow to the feather base and result in feather loss without hyperkeratosis.[10]

When hyperkeratotic growths are present on the face and legs of birds, knemidocoptic acariasis (knemidocoptiasis) may be the suspected diagnosis. However, infestations may resemble avian pox[9] or papillomatosis,[11] and these infections should be considered as differential diagnoses. Mites are members of the phylum Arthropoda and are recognized histologically by their chitinous exoskeleton, striated muscles, tracheal ring, and jointed appendages.[12] A diagnosis of knemidocoptic acariasis (mange) may be achieved by microscopic examination of deep skin scrapings that have been prepared in 10% KOH solution to identify morphological features of the mites.[8] Molecular techniques are useful for corroboration of species identification, and subsequent phylogenetic analysis allows for taxonomic diagnosis.[5]

Knemidocoptic acariasis in domestic poultry and pet birds is commonly reported worldwide.[2] Infestations with *Knemidocoptes mutans* or *Knemidocoptes gallinae* develop in poultry, whereas *Knemidocoptes pilae* affects psittacines.[13] *Knemidocoptes jamaicensis* infestation develops in wild passerines but not in gallinaceous or psittacine birds.[13] For birds with knemidocoptic acariasis, the recommended treatment is a dose of ivermectin (0.2 mg/kg [0.09 mg/lb], PO, IM, or topically) or moxidectin (0.2 mg/kg, PO or topically), which is repeated after 2 weeks.[13,14] For small birds, IM administration of medications may have toxic effects, and oral or topical routes of administration are preferred.[13] In larger birds, topical creams and liquids are generally not as effective because the skin of the entire bird has to be treated.[7] Topical use of rotenone-orthophenylphenol, crotamiton, or lindane is not recommended for treatment of birds with knemidocoptic acariasis because of possible toxic effects.[13]

Information regarding the frequency of occurrence, pathological changes, and clinical importance of knemidocoptic acariasis in wild birds is comparatively limited.[15] Infestations in wild birds[2] in the orders Anseriformes,[13] Charadriiformes,[2] Columbiformes,[2] Falconiformes,[16] Galliformes,[17] Passeriformes,[18] Piciformes,[19] Psittaciformes,[20] and Strigiformes have been reported.[21] In recent years, reports of knemidocoptic acariasis in wild birds have increased.[2,7,10,15,22–31] It is not known whether this represents a true increase in disease occurrence or simply increased frequency of reporting and investigation of cases by wildlife health diagnostic laboratories. Factors that are potentially associated with increased numbers of such reports include stressors in hosts (making them more susceptible to disease), expansion of the parasites' range to new hosts or geographic areas, or increased virulence of the parasites.[32]

Although infestation with *Knemidocoptes* spp can result in debilitation and death in individual birds, the impact of such infestations on avian populations is not well known.[8] During a *Knemidocoptes* epizootic in a population of evening grosbeak (*Hesperiphona vespertina*) from Flagstaff, Arizona, it was estimated that 25% of the flock had knemidocoptic acariasis affecting the legs and feet.[33] Affected birds had limited walking and perching ability, but there were no major differences in body weight or gonad-to-body weight ratios between affected and unaffected birds. Similarly, in a study[24] of Eurasian tree sparrows (*Passer montanus*) from Hong Kong, body weights of birds infested with *Knemidocoptes* spp and unaffected birds were not significantly different. However, among warblers in the Dominican Republic, birds infested with *K jamaicensis* had reduced muscle mass and these warblers had lower overwinter site persistence, compared with unaffected birds, and did not return following annual migration.[34] During a *K jamaicensis* epizootic in American robins, affected birds were lethargic and had debilitating lesions that likely interfered with feeding and increased susceptibility to predation.[9] Although epizootic knemidocoptic acariasis is unlikely to have a long-term effect on the size of bird populations, many factors should be considered in the management of populations of infested birds including host population dynamics and parasite transmission rates, virulence, and spontaneous recovery rates.[9] In the case described in the present report, knemidocoptic acariasis was not thought to have contributed to death of the pine grosbeak because the bird was in good body condition with evidence of active feeding and window strike-related trauma. Although multiple reports of affected pine grosbeaks in the area suggested an epizootic, only a single bird was found dead and examined.

Acknowledgments

The use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the US government.

Footnotes

a. BigDye Terminator v3.1, Applied Biosystems, Foster City, Calif.
b. BLAST, National Center for Biotechnology Information, National Institutes of Health, Bethesda, Md. Available at: blast.ncbi.nlm.nih.gov/. Accessed Apr 17, 2017.

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