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PELODERA STRONGYLOIDES INFECTION IN PACIFIC HARBOR SEALS (*PHOCA VITULINA RICHARDII*) FROM CALIFORNIA

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Abstract: Skin biopsies were collected from free-ranging harbor seals (*Phoca vitulina richardii*) from central California ($n = 53$). Microscopic examination of hematoxylin and eosin-stained tissue sections revealed the presence of tightly coiled nematode larvae within the ostia of numerous hair follicles of four seals. Parasites were characterized by paired lateral alae, platymyarian musculature, and an indistinct, uninucleate digestive tract. Mild chronic superficial dermatitis and perifolliculitis were evident microscopically in association with the intrafollicular parasites. Histomorphologic features of the larvae and their presence within hair follicles are consistent with previous reports of the facultative nematode parasite *Pelodera strongyloides*. This is the first published report of *P. strongyloides* infection in any marine mammal. This parasite may be acquired by marine mammals through close contact with soil or decaying organic material and should be considered as a potential differential diagnosis for dermatitis in marine mammals that use terrestrial resting sites.

Key words: Dermatitis, harbor seal, *Pelodera strongyloides*, *Phoca vitulina*, Tomales Bay.

BRIEF COMMUNICATION

Skin biopsies were collected from free-ranging harbor seals (*Phoca vitulina richardii*) captured in San Francisco Bay (37.92°N, 122.4°W) and Tomales Bay (38.21°N, 122.95°W) in 2009 and 2010 as part of a larger study of harbor seals from central California. Six-millimeter punch biopsies of nonshaved integument and blubber from the left lateral cervical region were collected and fixed in 10% buffered formalin. When possible, additional biopsies were collected from seals that exhibited alopecia or other skin abnormalities. Skin biopsies of seals from San Francisco Bay ($n = 26$) and Tomales Bay ($n = 27$) were submitted to the California Department of Fish and Wildlife for examination by a veterinary pathologist.

Microscopic examination of 5- μ m thick, paraffin-embedded hematoxylin and eosin (H&E)-stained tissue sections revealed numerous tightly coiled larval nematodes within the ostia of hair follicles in skin of four seals from Tomales Bay (Fig. 1A). These larval nematodes were identified

as *Pelodera strongyloides* based on their presence inside hair follicles and histomorphologic characteristics (i.e., paired lateral alae, platymyarian musculature, and an indistinct digestive tract composed of uninucleate cells) (Fig. 1B). One seal exhibited small patches of alopecia over its face and head, back, dorsal sides, and around its flippers. The seal weighed 40 kg at the time of biopsy collection in June 2010, which was considered underweight given its sex and age class (adult female), length (140 cm), and data from a previous capture event in June 2008 when the animal weighed 67 kg. The three remaining *P. strongyloides*-infected seals appeared in good or adequate body condition with no noticeable alopecia, although mild chronic dermatitis and perifolliculitis were evident on histologic examination. Examination of the skin of the ventral chest and abdomen was not possible for any of the seals because they were alert and physically restrained.

Pelodera strongyloides is a facultatively parasitic, free-living soil nematode that invades the hair follicles of mammals through direct contact of skin with contaminated material. Infection is most commonly reported in domestic dogs and livestock but also has been described in rodents, a black bear, and humans.^{1,2,4–8,10,11} Infections in animals and people may be characterized by intense pruritis, erythema, alopecia, and follicle-centered dermal papules, pustules, crusts, erosions, or ulcers. Domestic animals with *P. strongyloides*-associated folliculitis may exhibit alopecia and dermatitis of varying severity; and in rare cases, severe ulcerative dermatitis and emaciation can

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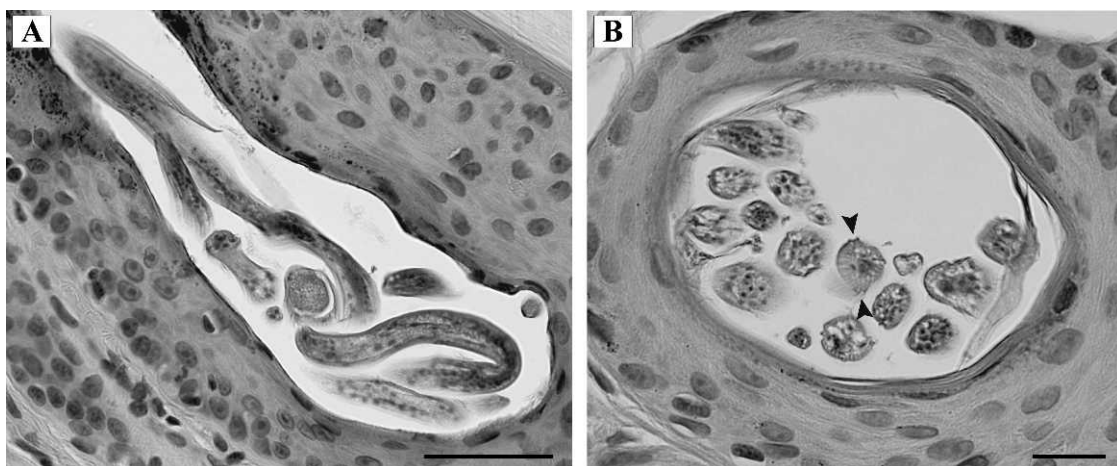


Figure 1. Micrographs of *Pelodera strongyloides* larvae stained with H & E. (A) Larvae within the hair follicle of a harbor seal (bar = 50 μ m). (B) A cross-section of larvae showing the paired lateral alae indicated by arrows (scale bar = 20 μ m).

result from chronic infection, possibly as a result of severe pruritus.^{6–8,11} Larval stages are common in decaying organic matter and damp soil, and lesions typically occur on areas of skin (such as the limbs, ventral chest and abdomen, and perineum) in close contact with *P. strongyloides*-infested material. Infection of domestic animals is often associated with dirty environmental conditions and poor husbandry.^{6–8,11} Differential diagnoses include dermal acariasis, dermatophytosis, pyoderma, and other cutaneous larval infestations, including hookworm dermatitis. Diagnosis of a *P. strongyloides* infection is confirmed through skin biopsy and histopathology, scrapings of affected skin, or cultivation of larvae from skin scrapings on blood agar.

This is the first report of *P. strongyloides* infection in any marine mammal. Although we could not isolate the nematodes to facilitate taxonomic or molecular confirmation as *P. strongyloides*, histomorphologic characteristics of the parasites, and their location within the lumen of hair follicles are consistent with reports of *P. strongyloides* infections in other mammals, and few differential diagnoses exist for follicular invasion by nematode parasites. The lack of prior descriptions could be because infection by *P. strongyloides* is relatively uncommon in marine species, or simply because microscopic examination of skin biopsies is not routinely performed for marine wildlife. The lack of external lesions for three of the infected seals may indicate that *P. strongyloides* infection is often subclinical in seals, or that the more severely affected portions of skin are in

areas, such as the ventral chest and abdomen, that are not amenable to examination and biopsy for live, physically restrained seals. On histopathology, mild chronic superficial dermatitis and perifolliculitis were noted for all four infected seals, but some apparently noninfected seals from both locations also displayed dermatitis. Thus, the dermatitis may not have resulted from *P. strongyloides* infection, or the collection of a single 6-mm punch biopsy was not sufficient to confirm infection in all cases. Careful microscopic examination of the lumen of multiple hair follicles is required to visualize the parasites and confirm the diagnosis, and in many 6-mm punch biopsies, the lumens of only one or two hair follicles were apparent within each 5- μ m tissue section. In addition, these parasites are difficult to see during microscopic examination of infected skin owing to their small size and lack of concurrent severe lesions; because only small parasite profiles are visible inside many follicles; and because these nematodes are often apposed to the hair surface, or admixed with exfoliated squames and keratin debris. Based on insight gained from this preliminary study, it is predicted that the prevalence of *P. strongyloides* infection in harbor seals from Tomales Bay is greater than the 15.4% measured in this study and may occur in seals from central California sites not sampled as part of this study.

Seals in this study likely became infected by *P. strongyloides* when they were resting ashore (hauled-out), as this would be the most likely time when they would come into contact with infested soil or decaying organic debris. Harbor

seals in Tomales Bay may use a variety of substrates for resting, but the main haul-out sites within the bay are tidally influenced sandbars and a rocky beach on an island within the bay. It is not possible to determine the exact geographic location(s) where the seals became infected with *P. strongyloides* because these animals are mobile and may travel upwards of 100 km among haul-out sites;³ however, it is likely that infection occurred at a haul-out site within or near Tomales Bay as harbor seals have strong site-fidelity to one or several sites.^{9,12} Additionally, all four *P. strongyloides*-infected seals were captured at the same sandbar in Tomales Bay, and one of these infected individuals was captured over multiple years at the same site in Tomales Bay. Of interest, two researchers developed a transient dermatitis of undetermined cause following 3 days of harbor seal captures in June 2010 at the same sandbar where all *P. strongyloides*-infected seals were captured. This dermatitis was characterized by an itchy, bumpy rash on the arms, shoulders, abdomen, and legs that developed by the third day and resolved without medical treatment after approximately 1 wk. Because histodiagnosis of *P. strongyloides* infection in the first seal was made several months following captures, investigation of possible *P. strongyloides*-associated dermatitis in capture personnel was not possible; however, skin infection by this ubiquitous, facultative parasite should be considered as a differential diagnosis for skin rashes that develop following marine mammal handling and capture activities in the future. Although these nematodes could potentially be zoonotic, a more likely source of skin infection is extended contact with contaminated soil during capture activities.

Differences in the prevalence of *P. strongyloides* infection between harbor seals in San Francisco Bay (0%) and Tomales Bay (15.4%) may be the result of differences in land use practices between these locations. San Francisco Bay is a heavily urbanized and industrialized estuary, whereas land use in Tomales Bay is dominated (>50%) by agriculture, primarily for livestock grazing and dairy farming of cattle and sheep. Cattle and sheep are hosts for *P. strongyloides*, and conditions that can facilitate proliferation and survival of these free-living nematodes can be associated with cattle farming and other agricultural practices.^{6,11} Collectively, these local land use practices in near-shore terrestrial habitats could enhance the risk of *P. strongyloides* infection for downstream-dwelling harbor seals residing in Tomales Bay. Localized enrichment of preferred haul-out

sites by defecating harbor seals and other wildlife also might facilitate *P. strongyloides* survival and proliferation.

The discovery of *P. strongyloides* infection in harbor seals indicates that it should be considered as a potential differential diagnosis for dermatitis in marine mammals, especially for species that use terrestrial haul-out sites. Detection of this nematode in multiple seals hauled-out in Tomales Bay indicates that other animals and humans that use the same coastal areas may also be at enhanced risk for infection through contact with contaminated organic material and soil. This may be especially true for humans, given that clamming is a common occurrence in Tomales Bay and frequently occurs at the same sandbar where all harbor seals were captured. This preliminary study indicates the presence of another, previously unrecognized land-sea link for marine mammal disease. This link should be investigated through morphologic and molecular characterization of *P. strongyloides* isolates from harbor seals, with comparison to similar isolates obtained from terrestrial sources, especially those from animals and contaminated soils of the Tomales Bay region of California.

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