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Soboliphyme baturini Infection Does Not Affect the Nutritional Condition of American Marten *(Martes americana)* in Alaska

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ABSTRACT: *Soboliphyme baturini,* a stomach-dwelling nematode of American martens *(Martes americana).* reaches high levels of infection; however, its effects on the nutritional condition of the host are unknown. To understand the effects of this parasite on American martens, we collected *S. baturini* and measured abdominal fat deposits from 155 marten carcasses on Prince of Wales Island, southeastern Alaska, in the winter 2006..2007. We analyzed how the dried mass of abdominal fat varied as a function of S. *baturini* intensity. Parasite intensity and nutritional condition were not correlated; these results suggest that Arnerican martens were able to withstand even very high levels of *S. baturini* infection (up to 178 parasites per host).

Soboliphyme baturini is a common nematode parasite of mustelids, infecting species of *Martes,* *Mustela,* *Neovison,* and *Gulo* (Zarnke et al., 2004). *Soboliphytne baturini* is a member of the monotypic Soboliphymidae, Dioctophyrnidea (Karmanova, 1986). The parasite has a complex life cycle involving enchytraeid oligochaetes as intermediate hosts and shrews *(Sorex* spp.) as paratenic hosts (Karpenko et al., 2007). Mustelids acquire S. *baturini* by consuming enchytraeids directly or via consumption of infected shrews (Karpenko et al., 2007). Adult nematodes mature in the stomach of definitive hosts, with females releasing eggs that are shed in the host's feces. Although *S. baturini* causes morbidity (anemia and stomach ulcers) and mortality in sables *(Maries zibellina;* Kurmanova, 1986), no pathological implications for American martens *(Maries americana)* have been reported (Zarnke et al., 2004). The distribution of *S. baturini* extends hom cast of the Ural Mountains, Russia. across Beringia. into North America. In North America, *S. baturini* is largely limited to the Pacific Coast, with an eastward projection into the southern Rocky Mountains (Koehler, 2006). coinciding with American marten distribution.

Although past studies (e.g., Zarnkc et al., 2004; Koehler, 2006) have documented patterns of *S. baturini* infection across North America, the effects of the parasite in the nutritional condition of martens remain unknown. To better understand the effect of *S. baturini* on the nutritional condition of American martens, we compared parasite intensity with the dry mass of omental and mesentery fat (OMF). Because martens are lean-bodied carnivores that possess limited amounts of subcutaneous fat, internal macroscopic fat deposits are generally used to assess health and nutritional condition (Robitaille and Jensen, 2005). Particularly for martens, studies have found that OMF is an accurate index of physical condition (Buskirk. and Harlow, J 989), and a strong predictor of percentage of body fat (Robitaille and Cobb, 2003).

We collected 155 American marten carcasses during December 2006-January 2007 from commercial trappers on Prince of Wales Island (56°00'N. 133°00'W), Alaska. The largest island (5,778 km^2) of the Alexander Archipelago, Prince of Wales Island. receives > 140 cm of precipitation annually. and it is characterized by temperate min forests of spruce *(Picco sitchcnsis),* hemlock *(Tsuga hcterophylla),* and cedar *(Thuja plicata;* Dellasala et al., 1996). Range-wide. *S. bnaturiui* prevalence and intensity in martens are highest in southeastern Alaska, with nearly half of martens being infected and individuals harboring up to 250 nematodes (Zarnke et al. 2004). Thus. Prince of Wales Island is an ideal study area for investigating the effects of *S. baturini* infections on American martens.

From each marten carcass, we identified the sex and estimated the age via counts of cementum annuli (Matson's Laboratory. Milltown. Montana). We removed the stomach and OMF from each carcass and examined stomachs for presence of *S. baturini.* Nematodes were identified according to Cheng (1964). and specimens were deposited at the diagnostic parasitology collection at the Wyoming State Veterinary Laboratory (Laramie. Wyoming). After removal of the spleen. excised OMF was washed with water and dried at 75 C to a constant mass. \Ve compared prevalence (percent of hosts infected) of *S. baturini* infections between sexes with log-likelihood ratios (G-tests). Mass of OMF (grams) and *S. baturini* infection intensity (number of nematodes per host) were compared between sexes and ages of marten with univariate analyses of variance. We assessed the effect of parasite intensity on nutritional condition via linear regression models.

Infection intensity exhibited an overdispersed pattern ($X = 9.1$, $S^2 = 366.5$), with most martens harboring few or no nematodes and a few individuals infected by large numbers (range, 0-178; Fig. 1). This pattern of infection was well described by a negative binomial probability distribution fitted via a maximum-likelihood method (Krebs, 1999). with $k = 0.155$ (Fig. 1). Although prevalence of S. *baturini* seemed higher in females (61% *[47/77])* than males (49% *[38/78]),* we did not detect any significant differences among sex and age classes ($G^3 = 3.98$. $P = 0.26$). Conversely, we detected a significant interaction between sex and age for intensity of infection ($F_{3.85} = 4.13$, $P = 0.045$). with mean intensity of infection highest in adult females ($x = 26.3$, $SE = 8.8$) and juvenile males ($x = 21.4$, $SE = 7.7$). compared with juvenile females ($x = 13.8$, $SE = 2.2$) and adnlt males ($X = 10.3$, $SE = 3.5$). This pattern is inconsistent with helminth parasitism observed for many other species of mammals, which generally exhibit extreme male-biased parasitism (Klein, 2004; Cowan et al., 2007). The lack of difference in prevalence and intensities between sexes suggests that male and female martens possess similar foraging behaviors that expose them to *S. baturini.* Because this nematode is transmitted primarily by shrews *(Sorex* spp.; Karpenko et al. 2007), our data suggest that shrews are consumed by all age-sex groups of marten on Prince of Wales Island.

Our analysis of OMF revealed that nutritional condition was not affected by S. *baturini* infection (Fig. 2) and age of American martens ($F_{1,155} = 0.29$. $P = 0.59$) but that it differed between male $X = 22.2$, $SE = 1.7$) and female ($x = 13.9$, $SE = 1.3$) martens ($F_{1,155}$ 14.36. $P < 0.001$). Because American martens display sexually dimorphic body weight (with females 60.5% smaller; Nagorsen, 1994). sex-based differences in the mass of OMF are expected. However. as suggested by

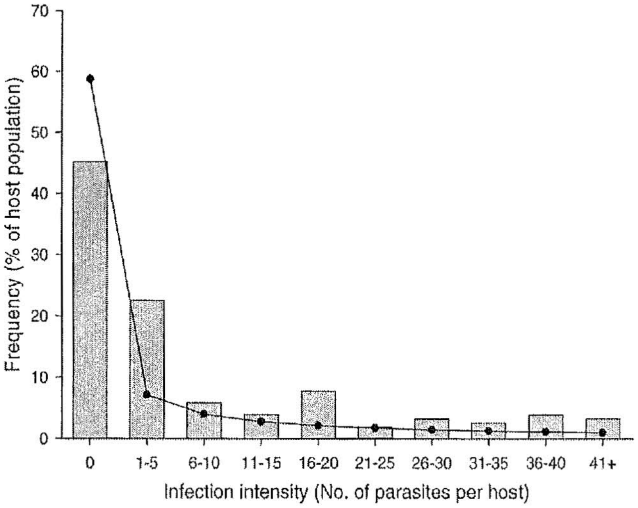

FIGURE 1. Histogram depicting *Soboliphyme baturini* infection of American martens (*Martes americana*) collected from Prince of Wales Island, Alaska, in winter 2006–2007. Infection exhibited an overdispersed pattern, with most hosts harboring few or no parasites and a few hosts with high intensities. Line represents a negative binomial probability distribution ($k = 0.155$) fitted with a maximum likelihood method.

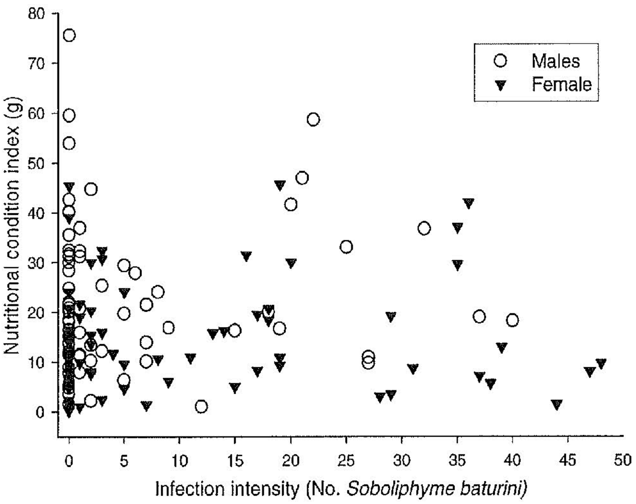

FIGURE 2. Relationship of individual nutritional condition (measured from dry omental and mesentery fat) and intensity of *Soboliphyme baturini* in American martens (*Martes americana*) collected from Prince of Wales Island, Alaska, in winter 2006–2007. Infection intensity did not affect nutritional condition ($F_{1,152}$ = 0.90, P = 0.35, r = 0.08) of martens. Two observations (1, 75.6 and 178, 48.6) were excluded because of extreme leverage.

Zarnke et al. (2004), the high intensity of infection with nematodes (23 individuals with >20 worms) should have had adverse affects, reducing the mass of fat depots; yet, we detected no change in the mass of OMF for even heavily parasitized martens. In a closely related taxon, i.e., sable, even moderate infection had significant adverse effects (Karmanova, 1986). Increased abundance of helminth parasites is often associated with negative implications for the nutritional condition of the host either through nutrient diversion or physical blockage of the gastrointestinal tract (Holmstad et al., 2005; Eira et al., 2007). Because changes in fat stores of carnivores are most apparent during winter months (coinciding with our sampling), when food resources are scarcest and fat reserves most limited (Buskirk and Harlow, 1989). it is surprising that we found no relationship between parasite load and nutritional condition.

Molecular analyses indicate that S. *baturini* is a single and widespread species across western North America and eastern Asia (Koehler et al., 2007). However, the origin of *S. baturini* and its direction of dispersal across Beringia remain unknown. Our results indicate that American martens are resilient to high levels of infection (up to 178 nematodes per host), whereas previous work has shown that low or moderate levels of infection cause substantive pathologies for sables (Karrnanova, 1986). Because definitive hosts possessing longer evolutionary histories with their helminth parasites generally exhibit greater resilience to infection (Moore, 2002), our data may suggest that *S. baturini* possesses longer coevolutionary relationship with American martens. Two distinct subspecies of marten with divergent evolutionary histories, *M. a. americana* and *M. a. caurina,* exist in North America (Stone et al., 2002). Further investigation into the effects of *S. baturini* on both groups will help elucidate the origin and biogeography of *S. baturini,*

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