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Oral Capillariasis in Sharp-shinned Hawks (*Accipiter striatus*) During Fall and Spring Migration

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ABSTRACT.—Unusual oral lesions were documented in migrating Sharp-shinned Hawks (*Accipiter striatus*) during spring migration in 2016 in New York, USA. The lesions were caused by *Eucoleus dispar*, a nematode common in the intestinal tracts of many raptor species but not in the oral cavity. We developed a formal data collection protocol and shared it with collaborating North American raptor banding stations to document this capillariasis (clinical parasitic infection by nematodes) in migrating Sharp-shinned Hawks. Using this protocol, we detected the infection at multiple banding stations at variable rates. We found that the infection rates were higher in females than males, and do not appear to impact individual mass. We aim to continue examining and monitoring raptors for lesions during raptor migration and to assess any potential impact oral capillariasis has on raptor populations.

KEYWORDS: *capillaria*; *migration*; *nematode*; *parasite*.

CAPILARIASIS ORAL EN *ACCIPITER STRIATUS* DURANTE LA MIGRACIÓN DE OTOÑO Y PRIMAVERA

RESUMEN.—Se documentaron lesiones orales inusuales en *Accipiter striatus* durante la migración de primavera en 2016 en Nueva York, EEUU. Las lesiones fueron causadas por *Eucoleus dispar*, un nematodo común en los tractos intestinales de muchas especies de rapaces, pero no en la cavidad oral. Desarrollamos un protocolo formal de recolección de datos y lo compartimos con estaciones de anillamiento de rapaces en Norteamérica para documentar capilariasis (infección parasitaria clínica causada por nematodos) en individuos migratorios de *A. striatus*. Utilizando este protocolo, detectamos la infección en múltiples estaciones de anillamiento con tasas variables. Encontramos que las tasas de infección eran más altas en hembras que en machos, y que no parecen afectar la masa corporal del individuo. Nuestro objetivo es continuar examinando y monitoreando a las rapaces en busca de lesiones durante la migración y evaluar cualquier posible impacto de la capilariasis oral en las poblaciones de rapaces.

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INTRODUCTION

The Sharp-shinned Hawk (*Accipiter striatus*) is a small, widespread migratory forest raptor commonly observed at bird banding and count stations across North America (Clark 1985, Goodrich et al. 2012, Bildstein et al. 2020). Despite their relative commonness, a recent assessment from the Raptor Population Index finds Sharp-shinned Hawks are the migratory raptor species whose population has declined the most precipitously, and that these declining trends likely reflect actual population decline (Oleyar et al. 2021).

In spring 2016, banders at Braddock Bay Raptor Research (BBRR), New York, USA, started to notice deformed beaks on some captured Sharp-shinned Hawks in the course of their normal banding operations. Closer examination revealed varying degrees of oral lesions and caseous plaques on the inside and outside of birds' mouths and at beak commissures (Fig. 1). Some infected birds were transported to Cornell University, Ithaca, New York, in the spring of 2017, where Sara Childs-Sanford treated them and determined that the infection was a capillariid nematode *Eucoleus dispar* (Childs-Sanford et al. 2019). This parasitic infection can commonly be found in the gastrointestinal tract of raptors (Yildiz et al. 2015, Cooper 2002), though usually does not present itself orally in such an obvious and graphic way.

Sharp-shinned Hawks are among the most well-known and studied raptor species. However, information about how disease or parasite infections affect Sharp-shinned Hawk health is scant (Gosselin 2010, Bildstein et al. 2020), with studies limited to nest parasites of an island endemic population (McClure et al. 2023) and blood parasites detected during migration (Powers et al. 1994, Phalen et al. 1995, Taft et al. 1996). The degree of transmissibility and the scale of impact this emerging capillaria disease poses for other wild, domestic, or non-avian species is largely unknown. Mortality of the closely related Eurasian Sparrowhawk (*A. nisus;* Montizaan 2023) and Gyrfalcon (*Falco rusticolus*; Clausen and Gudmundsson 1981) has been documented in Europe where *E. dispar* is still relatively uncommon. Radcliffe et al. (2024) surveyed disease in Gyrfalcons in Alaska, USA, and described similar oral lesions caused by *Eucoelus* spp., but PCR testing on a sample subset were negative for capillaria. Interestingly, this work also found capillarid eggs present in nestling Gyrfalcon excreta at another Alaska survey site (Radcliffe et al. 2024).

Since this discovery, banders at BBRR began more careful examinations of Sharp-shinned Hawks and documented the prevalence of observed capillaria. A formal 0–5 scoring protocol was implemented in the spring of 2020. Similar reports of Sharp-shinned Hawk infection during both spring and fall migration from wildlife rehabilitators and banding stations suggest that this parasitic infection may be widespread. To document the prevalence of lesions in Sharp-shinned Hawks, BBRR began a data collection protocol and shared it with other bird banding stations to gather and submit data on a broader geographical scale. We report the findings from 4 yr of Sharp-shinned Hawk lesion data collected collaboratively at banding stations across North America.

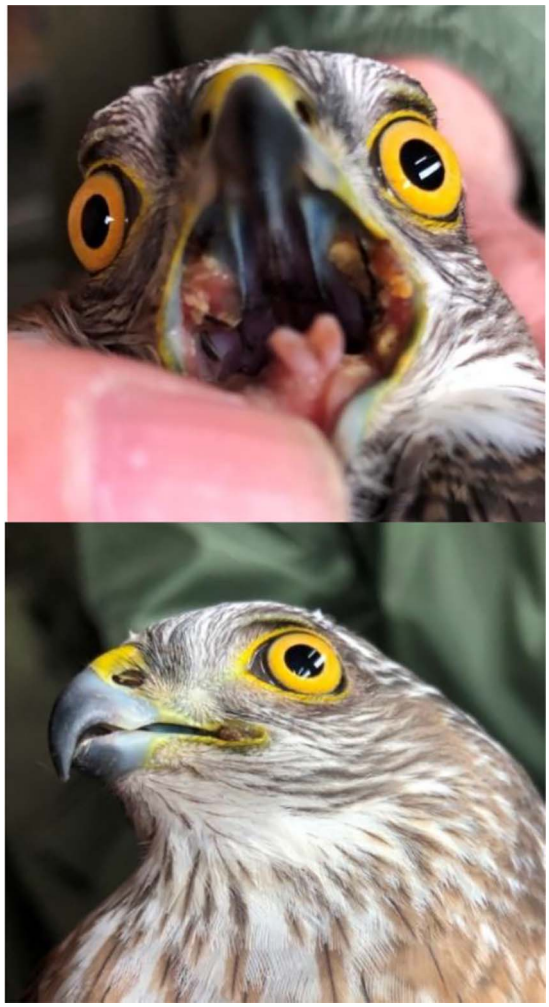

Figure 1. Juvenile female Sharp-shinned Hawk with oral lesions caused by *Eucoleus dispar*. Photographs by David Mathiason.

METHODS

We captured Sharp-shinned Hawks during their migration at participating raptor banding stations and fitted each with a USGS aluminum band. We recorded unflattened wing chord and mass measurements, and aged and sexed each individual following Liguori et al. (2020). We examined the oral cavity of each captured bird for capillaria infection and scored it on the 0–5 scale that was developed by BBRR banders (Supplemental Material Table S1). Because capillaria scores of 3 or more were relatively uncommon (i.e., 2% of all examined birds in fall, 13% in spring), we collapsed the data into just two groups for analysis ('no' for scores of zero, and 'yes' for scores above zero).

This capillaria scoring protocol was implemented at BBRR in 2020; Cedar Grove Ornithological Research Station (CGORS), Wisconsin, USA, in 2020; Cape May Raptor Banding Project (CMRBP), New Jersey, USA, in 2021; Mackinac Straits Raptor Watch (MSRW), Michigan, USA, in 2022; Hawk Ridge Bird Observatory (HRBO), Minnesota, USA, in 2022; Intermountain Bird Observatory (IBO), Idaho, USA, in 2022; Holiday Beach Migration Observatory (HBMO), Ontario, Canada, in 2022; and Hawk Cliff Raptor Banding Station (HCRB), Ontario, Canada in 2022. We looked for differences in infection rates across age and sex classes, then tested if capillaria infection had an impact on mass across age and sex.

Sharp-shinned Hawks have recognizable molt patterns that banders use for aging. Birds in their juvenile first-year plumage are called hatch-year (HY) in the fall and second-year (SY) the following spring. Birds in their adult definitive plumage are termed after hatch-year (AHY) in the fall and after second-year (ASY) in the spring (Liguori et al. 2020). Accordingly, fall (HY) and spring (SY) birds are young (juvenile) birds and AHY/ASY birds are old (adult) birds.

We used Minitab® Statistical Software to perform seven different two-factor ANOVAs, analyzing male and females separately for each of four banding stations where details were provided. The analysis was not done for males at MSRW due to the small sample size. For each of these seven analyses the response variable was mass; the two factors were age (young, old) and capillaria (yes, no). The two-factor models all included the interaction term. Minitab was also used to generate the two-way tables of infection rates by age and sex. We considered $P < 0.05$ to be significant for all tests. Logistic regression was used to compare the observed infection rates across stations, age, and sex.

RESULTS

All eight banding stations collected and submitted Sharp-shinned Hawk capillaria data. Four stations (HRBO, IBO, HBMO, and HCRB) had substantially fewer observations of capillaria, with none recorded at IBO in 2023 (Table 1). Because of these lower detections, we excluded data from these four stations from detailed analysis. We analyzed data from the other four raptor migration banding stations, two of which operate during spring migration (BBRR and MSRW) and two that operate during the fall migration (CGORS and CMRBP). Fall of 2021 was a pilot year for CMRBP, with not all banders participating, so sample size was smaller than in the following years.

For the four banding stations with a substantial presence of capillaria, there was an increase in capillaria detection rate over 4 yr for both females and males ($P < 0.001$ and $P < 0.001$, respectively; Table 1). In addition, infection rates were higher for females than males for both spring and fall banding stations ($P < 0.001$).

Infection rates at the spring banding stations were higher than those at the fall banding stations (Table 1). Among females, the two spring stations had similar infection rates ($P = 0.431$) and the two fall stations had similar rates ($P = 0.177$), but infection rates in the spring were higher than those in the fall (Table 2; see Supplemental Material S3 for details of pairwise comparisons). Among males, there were no significant differences in infection rates among the four stations.

The influence of age differed for spring and fall banding stations. At spring banding stations, infection rate was higher for younger birds than for older birds ($P < 0.001$). In contrast, at fall banding stations, infection rate was higher among older birds ($P < 0.001$).

At all four stations, mass differed significantly by age for females, with older birds weighing more than younger ones (Table S2). Mass did not differ by age for males. The presence of observed capillaria was not related to the mass of birds ($P > 0.05$, Supplemental Material S4).

DISCUSSION

Our primary goal in presenting these results is to raise awareness of the capillaria infection in migrating Sharp-shinned Hawks and encourage more researchers to engage in this project. For some of the stations with a significant occurrence of observed capillaria, the rate of infection has been increasing. We recommend that all banding stations involved in this study continue to monitor and score birds for capillaria.

Table 1. Proportion of inspected Sharp-shinned Hawks showing capillaria, by year and sex between spring and fall migration sites. All age classes aggregated.

Season	Site	Sex	2020	2021	2022	2023
Spring	BBRR[a]	Female	41/116 (35%)	80/180 (44%)	95/187 (51%)	115/219 (53%)
		Male	0/9 (0%)	1/16 (6%)	2/59 (3%)	4/22 (18%)
	MSRW[b]	Female	–	–	23/51 (45%)	25/49 (51%)
		Male	–	–	1/3 (33%)	1/5 (20%)
Fall	CGORS[c]	Female	2/115 (2%)	23/95 (24%)	25/173 (14%)	35/163 (21%)
		Male	1/88 (1%)	0/77 (0%)	3/149 (2%)	11/116 (9%)
	CMRBP[d]	Female	–	5/52 (10%)	40/159 (25%)	47/197 (24%)
		Male	–	2/31 (6%)	8/92 (9%)	12/97 (12%)
	HBMO[e]	Female	–	–	0/135 (0%)	1/110 (1%)
		Male	–	–	0/70 (0%)	0/185 (0%)
	HCRB[f]	Female	–	–	29/362 (8%)	17/477 (4%)
		Male	–	–	1/236 (<1%)	1/336 (<1%)
	HRBO[g]	Female	–	–	13/447 (3%)	18/443 (4%)
		Male	–	–	7/311 (3%)	4/386 (1%)
	IBO[h]	Female	–	–	1/179 (<1%)	0/227 (0%)
		Male	–	–	1/125 (<1%)	0/173 (0%)

[a] Braddock Bay Raptor Research.
[b] Mackinac Straits Raptor Watch.
[c] Cedar Grove Ornithological Research Station.
[d] Cape May Raptor Banding Project.
[e] Holiday Beach Migration Observatory.
[f] Hawk Cliff Raptor Banding Station.
[g] Hawk Ridge Bird Observatory.
[h] Intermountain Bird Observatory.

The overall impact, if any, that capillaria infections may have on Sharp-shinned Hawks is uncertain. It was unexpected to find that there is no statistically significant impact on mass given these lesions occur in the mouth and ostensibly could hinder eating and swallowing. Montizaan (2023) reported two dead Eurasian Sparrowhawks, a closely related raptor species, emaciated with capillaria oral lesions but noted these birds' deaths could not be positively confirmed to result from capillaria infection. Whether capillaria impacts Sharp-shinned Hawk behavior during migration is unknown. Migrating Sharp-shinned Hawks can have elevated baseline levels of corticosterone (a stress hormone related to controlling daily energy use) correlated with low fat scores (Rogers et al. 2010). The high energy costs of long-distance migration that Sharp-shinned Hawks undergo twice annually could raise stress levels in certain individuals and make them more prone to disease infection. Year-to-year variation in count and banding data, primarily due to weather conditions, could further obscure the impact of contributing factors.

We did not test for relationships of capillaria infections with fat scores, muscle scores, stress response, or energetic measures in this pilot study. However, fungal oral lesions in vultures indicated lower immune response leading to overall lower body condition, pain, and averseness to swallow, triggering dehydration and emaciation sometimes leading to death (López-Rull et al. 2015, Pitarch et al. 2017). This does not appear to be the case for Sharp-shinned Hawks, but we recommend further targeted analyses.

Oral lesions in raptors may be connected to environmental degradation in their breeding and nonbreeding habitats. For example, the poor health of nestling Black Kites (*Milvus migrans*) with high prevalence of oral lesions was linked to nesting in highly modified habitats (Blanco et al. 2022). Anthropogenic stressors could trigger poor body condition, thus leaving an individual's immune system vulnerable to disease. Lesions generally may be the result of poor body condition, exposing individuals to additional disease. Capillaria could thus be an indicator of an underlying disease in Sharp-shinned Hawks, warranting further study.

This capillaria nematode can be passed directly from parent to offspring without an intermediate host, though it also can be contracted through earthworms (Cooper 2002). It is possible that all, or

Table 2. Proportion of inspected female Sharp-shinned Hawks showing capillaria, by year and age between spring and fall migration sites. HY = hatch-year, SY = second-year, ASY = after second-year, and AHY = after hatch-year.

Season	Site	Age[e,f]	2020	2021	2022	2023
Spring	BBRR[a]	SY	27/79 (34%)	71/128 (55%)	62/116 (53)%	75/132 (57%)
		ASY	14/37 (38%)	9/52 (17%)	33/71 (46%)	40/87 (46%)
	MSRW[b]	SY	–	–	14/27 (52%)	16/29 (55%)
		ASY	–	–	9/24 (38%)	9/20 (45%)
Fall	CGORS[c]	HY	1/80 (1%)	2/38 (5%)	9/111(8%)	18/109 (17%)
		AHY	1/35 (3%)	21/57 (37%)	16/62 (26%)	17/54 (31%)
	CMRBP[d]	HY	–	4/45 (9%)	36/148 (24%)	42/180 (23%)
		AHY	–	1/7 (14%)	4/11 (36%)	5/17 (29%)

[a] Braddock Bay Raptor Research.
[b] Mackinac Straits Raptor Watch.
[c] Cedar Grove Ornithological Research Station.
[d] Cape May Raptor Banding Project.
[e] Juvenile birds assigned hatch-year (HY) in fall and second-year (SY) in spring.
[f] Adult birds in fall combined ages > HY and ASY in spring.

most, of the Sharp-shinned Hawks are infected with capillaria at a non-observable level. The observable effects of the capillaria nematode are possibly developmental, with many of the hatch-year birds in the fall infected with this parasite, though the impacts may not yet be detectable. Then throughout the winter season, the lesions may become more prevalent. That this infection is developmental aligns with data we have presented. During the fall, the juvenile hatch-year birds have a lower infection rate of capillaria than adults, with the opposite trend observed in the spring. Ashford et al (1990) detected a similar trend in Eurasian Sparrowhawks, with lower blood parasite (*Leukocytozoon toddi)* levels between October and April, with a spring increase in infection rate. Alternatively, it could be that some factor on the wintering grounds causes manifestation of the lesions.

We do not know why these lesions appear to be more prevalent in females than in males, nor why the two Canadian stations recorded such low numbers of infected Sharp-shinned Hawks, as they are geographically surrounded by the four stations with higher rates. The fewer observations of Sharp-shinned Hawk capillaria from stations in Idaho and Minnesota could mean that these oral infections are restricted locally in the Great Lakes region.

Capillaria infection and potential impacts on Sharp-shinned Hawks and other raptor species is an area of active study. Growing research suggests climate change may foster novel interactions between raptor populations and pathogens over broad geographic areas (Martínez-Ruiz et al. 2023). There is thus a need for continued monitoring to document disease prevalence and infection rates across North America. For banding stations interested in contributing data, resources are available at the website link in the supplemental material. Further active studies using stable isotopes, mouth swab analysis, and transmitter deployment will help determine potential impact of lesions on migration and differences in habitat use. This data may be used to inform future disease control measures and help uncover the scope of this disease epizootiology and its impacts on raptor populations.

SUPPLEMENTAL MATERIAL (available online). Table S1: Grading system for Sharp-shinned Hawks mouth lesions and waxy plaques. Table S2: Data on mass by sex, age, and presence of capillaria in Sharp-shinned Hawks. S3: Analysis of proportions. S4: Analysis of mass. Lesion inspection protocol, photographs, and past reports are available at https://www.bbrr.org/sharp-shinned-hawk-project/.

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