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Haemoproteus spp. and *Leukocytozoon* spp. in a Captive Raptor Population

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ABSTRACT: Raptors are commonly infected with two blood parasites of the family Haemoproteidae, *Haemoproteus* spp. and *Leukocytozoon* spp. To determine if age or length of time in captivity influence prevalence of *Haemoproteus* spp. and *Leukocytozoon* spp. infection in captive raptors, blood samples were collected from 55 birds from April 1999 to May 2000. Blood smears were examined for parasitemia and influence of age and length of time in captivity at the time of sample collection were compared. We found juvenile and adult birds were more likely to be infected with *Leukocytozoon* spp. than were nestlings ($P=0.006$) and birds present for >365 days were more likely to be infected with *Haemoproteus* spp. and/or *Leukocytozoon* spp. than were birds captive for <365 days.

Key words: *Haemoproteus*, *Leukocytozoon*, parasite, raptor.

Resistance to blood parasites in birds may be genetic or may be more prevalent in birds from certain locations (Ricklefs, 1992). Additionally, resistance may be associated with age, as older birds may have an acquired immunity (Shutler et al., 1995; Heidenreich, 1997). Parasite prevalence in captive raptors is of interest because, even though these parasites may not be particularly pathogenic to raptors, infected birds may serve as reservoirs for infection for more vulnerable species such as waterfowl. Influence of age and time spent in captivity on *Haemoproteus* and *Leukocytozoon* infection in captivity were examined. *Haemoproteus* and *Leukocytozoon* are commonly found in birds of prey and are transmissible via biting insects. The life cycle and morphology of *Haemoproteus* are described by Beynon (1996), Heidenreich (1997), and Apanius (2000). Campbell (1995), Olsen and Gaunt (1985), and Fraser (1991) describe the lifecycle and morphology of *Leukocytozoon*.

A total of 55 birds were sampled; some birds were bled more than once. A total of 87 samples were evaluated, with 12 samples from birds bled twice and 10 samples from birds bled three times. The study took place at the California Raptor Center (CRC), University of California, Davis, California (USA; 38.529N, 121.761W), from 2 April 1999 to 25 May 2000. Some birds are rehabilitated and released shortly after entering CRC, while nonreleasable birds are used for public education and become permanent residents. All birds sampled were injured or weakened. Age groups included nestlings (<58 days of age), juveniles (1–2 yr of age), and adult birds (>2 yr of age). We also considered whether parasite prevalence in captive raptors differed between short-term birds (present at the CRC for <365 days) and long-term (present for ≥365 days) captive residents. Raptor species sampled included great horned owl (*Bubo virginianus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), golden eagle (*Aquila chrysaetos*), barn owl (*Tito alba*), bald eagle (*Haliaeetus leucocephalus*), spotted owl (*Strix occidentalis*), and barred owl (*Strix varia*).

Raptors at the CRC were housed with no more than four birds per enclosure; usually one bird was housed per enclosure. Birds were fed once daily a diet of euthanized chicks, mice, or rats and given free access to water. Housing was, in part, made of chain link fence and it was possible for the birds to be exposed to insect vectors.

Blood samples were taken and smears made as described by Tella et al. (1999) with minor differences. Blood was drawn from the medial metatarsal vein and placed into a CBC Monoject® (Kendall Healthcare, Mansfield, Massachusetts,

USA) samplette capillary whole-blood collector with potassium ethylenediaminetetraacetic acid. Slides were cover slipped and examined on a Microstar microscope (AO Scientific Instruments, Southbridge, Massachusetts). Larger parasites such as *Leukocytozoon,* were viewed at 40× and oil immersion (100×) was used to view *Haemoproteus.* Because speciation of *Haemoproteus* and *Leukocytozoon* is difficult based on morphology alone, only the genus was recorded.

Prevalence was calculated by determination of infected or no evidence of parasitemia for each raptor. Overall prevalence was calculated without regard to age or length of time in captivity. Data from all 55 individuals were compared. If a bird was found to be positive in any bleeding, the bird was designated as infected for that parasite. Finally, using the pooled data set, we calculated prevalence based on age class and then length of time in captivity.

Fisher's exact tests were calculated (α 0.05) with statistical software (SAS Institute Inc., Carey, North Carolina, USA) for both *Haemoproteus* and *Leukocytozoon* infected birds compared to birds without evidence of parasitemia.

Fifty-five birds were sampled; 39 short-term and 16 long-term birds. Days in captivity for short-term birds ranged from 1–244 and the range for long-term birds was 760–5,724 days. Seventy-eight percent (43/55) had *Haemoproteus* and 35% (19/55) had *Leukocytozoon.* Neither parasite was observed in two birds (4%). Of all birds sampled 47% (26/55) were adults, 9% (5/55) were juveniles, and 44% (24/55) were nestlings. *Haemoproteus* was found in all 26 adults, all five juveniles, and 88% (21/24) of nestlings. *Leukocytozoon* was observed in 54% (14/26) adults, 40% (2/5) juveniles, and 13% (3/24) nestlings. Seventy-one percent (39/55) of the birds were in captivity for <365 days. Of these birds, 69% (27/39) were positive for *Haemoproteus* and 23% (9/39) were positive for *Leukocytozoon.* Sixteen birds (29%; 16/55) were present for >365 days. Of these birds, all 16 had *Haemoproteus* and 63% (10/16) had *Leukocytozoon.*

Calculations for infectivity were modified in SAS by valuing infected birds by half if they were bled twice and by 0.3 if they were bled three times (e.g., a bird bled twice has a greater chance of being found positive for either parasite, therefore to make the twice-bled bird's results equal to a bird that was bled once, we valued it half as much).

Haemoproteus infection was not influenced by age; however adults and juvenile birds were more likely to be infected with *Leukocytozoon* than nestlings (P=0.006). *Haemoproteus* (P=0.012) and *Leukocytozoon* (P=0.011) infections were significantly influenced by captivity for ≥365 days.

Prevalence of *Haemoproteus* and *Leukocytozoon* infection of captive raptors in our study was higher than that reported in free-flying birds (Forrester et al., 1994). Possibly, the stress of captivity increased susceptibility to infection (Munoz et al., 1999). However, birds housed at CRC are fed daily and receive medical care, so they may be less stressed in some ways than their free-flying counterparts. Studies conducted on captive raptors have reported similar (Olsen and Gaunt, 1985) and different (Munoz et al., 1999) results compared to ours.

Three nestlings sampled at 17, 84, and 85 days of life at CRC in our study were infected with *Haemoproteus.* At the CRC, nestlings are placed with foster mothers between 10 and 20 days of life. Raptor hosts may carry gametocytes in their blood in as few as 6 days after being infected and thus may be sources for transmission of the parasite via fly vectors (Shutler et al., 1995). *Haemoproteus* transmission may increase during the breeding season (Tella et al., 1999), which may be why all three nestlings were infected. We do not know if raptors sampled were infected before being brought into captivity or if they acquired infection during confinement. However, one infected individual intro-

duced into a captive population could serve as a source of infection for other raptors.

The majority of CRC birds sampled (78%) were infected with *Haemoproteus.* Birds in rehabilitation centers are in close proximity and are weakened which may facilitate transmission. Although immunocompetent raptors tolerate the parasite well (Campbell, 1995), captive raptors infected with parasites of the order Haemosporidia (including *Haemoprotues* and *Leukocytozoon*) typically took longer to rehabilitate and had higher mortality than uninfected raptors (Olsen and Gaunt, 1985). Perhaps captive raptors are immunocompromised and are therefore unable to rid themselves of infection, but develop low-grade chronic infection with few signs. Blood smears from some birds sampled more than once were positive for *Haemoproteus* at one bleeding, *Leukocytozoon* at another, and sometimes neither parasite was detected. More research is needed to determine the cause for such high *Haemoproteus* prevalence at the CRC.

Low prevalence of *Leukocytozoon* (35%) in comparison with *Haemoproteus* (78%) may be due to decreased numbers of *Simulium* near human domiciles (Kucera, 1981). Birds at the CRC are housed in enclosures near buildings and facilities. The findings that older birds (adults and juveniles) and birds confined for >1 yr, were more likely to be infected with *Leukocytozoon* suggest that even if the insect vector is rare around human constructions, infection with the parasite at the CRC may occur over time.

The time in captivity was arbitrarily categorized as long-term or short-term based on the residency status of the birds included in our study. Also, *Leukocytozoon* was rarely found more than once on a slide. Thus, due to the low numbers of this parasite in the blood, the actual number of infected birds in this population may have been higher than we reported. To get a more accurate infectivity ranking, we would need to employ use of more sensitive detection techniques, such as PCR or serology, which might provide more accurate estimates of prevalence.

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