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GASTROINTESTINAL PARASITES OF THE SWALLOW-TAILED KITE (*ELANOIDES FORFICATUS*), INCLUDING A REPORT OF LESIONS ASSOCIATED WITH THE NEMATODE *DISPHARYNX* SP.

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ABSTRACT.—Endoparasites of raptors are rarely documented to cause pathogenecity. We examined 60 live and 5 salvaged Swallow-tailed Kites (*Elanoides forficatus*) for gastrointestinal parasites. Methods included screening excreta collected from nestling and adult kites and their nests and dissecting the alimentary canals of salvaged nestlings. Kites hosted the following helminths (nematodes: *Dispharynx* sp., *Procyrnea* sp., and an immature ascarid; trematodes: Order Strigeatida; cestodes: *Taenia vexata*; acanthocephalan: *Centrorhynchus spinosus*), and two taxa of protozoans (Phylum Sporozoa: unidentified coccidia; and Phylum Metamonada: *Giardia* sp.). Two of 43 nestlings we examined during banding hosted larval *Protocalliphora* sp. (Diptera: Calliphoridae). Helminth prevalence was 27.7%, with trematodes and nematodes being most prevalent, 13.8% and 10.8% respectively ($n = 65$). The prevalence of *Dispharynx* sp. in first-year kites was 11.5% ($n = 52$). *Dispharynx* sp. caused stomach lesions in two first-year kites.

KEY WORDS: *Swallow-tailed Kite*; Elanoides forficatus; Dispharynx; *helminth*; Procyrnea; *protozoon*.

PARÁSITOS GASTROINTESTINALES DE *ELANOIDES FORFICATUS*, INCLUYENDO UN REGISTRO DE LESIONES RELACIONADAS AL NEMÁTODO *DISPHARYNX* SP.

RESUMEN.—Rara vez se ha documentado que los endoparásitos de las rapaces sean patogénicos. Examinamos 60 individuos vivos y 5 individuos rescatados de *Elanoides forficatus* en busca de parásitos gastrointestinales. Los métodos incluyeron la revisión de excrementos recolectados de pichones y adultos de *E. forficatus* y de sus nidos y de la disección de los canales alimenticios de pichones encontrados muertos. Las aves hospedaron una serie de helmintos (nematodos: *Dispharynx* sp., *Procyrnea* sp. y un áscaris inmaduro; tremátodos: Orden Strigeatida; céstodos: *Taenia vexata*; acantocéfalos: *Centrorhynchus spinosus*) y dos taxones de protozoarios (Phylum Sporozoa: coccidio no identificado; y Phylum Metamonada: *Giardia* sp.). Dos de los 43 pichones examinados durante el anillado hospedaron larvas de *Protocalliphora* sp. (Diptera: Calliphoridae). La prevalencia de helmintos fue de 27.7%. Los tremátodos y nemátodos fueron los más prevalentes, con 13.8% y 10.8%, respectivamente ($n = 65$). La prevalencia de *Dispharynx* sp. en las aves del primer año de edad fue de 11.5% ($n = 52$). *Dispharynx* sp. causó lesiones estomacales en dos aves en su primer año de vida.

[Traducción del equipo editorial]

Although endoparasites have sometimes caused morbidity and mortality in wild and captive raptors, they are not usually considered important pathogens (Smith 1993, Krone and Cooper 2002). Cases of parasitic disease typically involve additional factors that weaken the raptor's immune system (Krone and Cooper 2002). However, few studies have addressed the pathogenecity of endoparasites in wild raptorial hosts (Lacina and Bird 2000, Krone and Cooper 2002, Martínez-Padilla and Millán 2007).

From 1880–1940, the northern Swallow-tailed Kite's (*Elanoides forficatus forficatus*) population

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size declined and its breeding range contracted (Cely 1979, Meyer 1995). We do not know why the northern subspecies has failed to recover its former population size and breeding range. Identifying sources of morbidity and mortality could be particularly valuable to its conservation because a telemetry study indicated that survival to one and two years of age may be exceptionally poor in Florida, the center of the breeding range: 9.7% and 1.4%, respectively (n = 72; Meyer 2004). No diseases have been reported for the northern Swallow-tailed Kite (Meyer 1995), and little is known about its gastrointestinal parasites or their potential to cause disease and death. Intestinal bacteria and a budding yeast were studied in 21 nestlings from Florida, Georgia, and South Carolina (Mealey et al. 2006). The known helminths, based on the dissection of the alimentary canal of three specimens, include: the trematodes *Neodiplostomum attenuatum* and *Stomylotrema vicarium*, nematodes *Dispharynx nasuta* and larval spirurids, an acanthocephalan, *Centrorhynchus spinosus*, and a cestode, *Taenia vexata* (Meyer 1995, Forrester and Spalding 2003).

We became interested in helminth parasites of the Swallow-tailed Kite when we were presented with a kite undergoing rehabilitation that was near death and regurgitating *Dispharynx* sp. The discovery of *Dispharynx nasuta* in two Florida nestlings (Forrester and Spalding 2003) and our discovery of *Dispharynx* sp. in a moribund kite suggested that *Dispharynx* sp. could be a frequent parasite of northern Swallow-tailed Kite and possibly one important to health and survival. Therefore, we investigated the prevalence and pathogenecity of *Dispharynx* sp. and other gastrointestinal parasites in Swallow-tailed Kites on their breeding grounds.

Study Areas

We studied Swallow-tailed Kites nesting in large, river-basin swamps of southern Louisiana and southwestern Mississippi. Study areas included the Atchafalaya River Basin (30°28′N, 91°42′W) in Louisiana, and the lower Pearl River–Lake Pontchartrain basins study area (30°34′N, 89°59′W) consisting of the Lake Pontchartrain Basin, in Louisiana, the lower Bogue Chitto River Basin in Louisiana, and the lower Pearl River Basin in Louisiana and Mississippi. A kite undergoing rehabilitation was found south of our study areas (29°12′N, 91°11′W) in Terrebonne Parish, Louisiana and was included in our study.

Methods

For six breeding seasons, we monitored nests in Louisiana and Mississippi for multiple purposes including documenting parasitism (methods provided in Coulson et al. 2008). Our investigation of the prevalence and pathogenecity of gastrointestinal parasites of Swallow-tailed Kite included the examination of the alimentary tract of salvaged kites, coprological screening to detect parasites in live kites, and nest monitoring to document possible effects of parasitism on host survival. The Tulane University Institutional Animal Care and Use Committee approved animal protocols (Assurance Number A3552-01).

Excreta and parasites came from several sources. Salvaged nestlings found dead were transported on ice to the laboratory for dissection. We employed standard necropsy techniques and preserved parasites and intestinal contents in 10% buffered formalin. During banding of adults and nestlings, we collected excreta samples from nests and from live birds in holding containers with plastic liners, or by inserting a sterile 1-ml syringe through the proctodeum of those kites that did not excrete during banding. We also opportunistically collected kite excreta from the ground directly below nests. We preserved excreta samples in 10% formalin. In 1997 we collected regurgitated parasites before and after worming from a kite undergoing rehabilitation.

We prepared excreta samples using the formalin/ethyl acetate sedimentation technique and examined them with brightfield and differential interference (Nomarski) microscopy. We identified parasites to the most specific taxon possible and tabulated their prevalence as defined by the number of positive individuals of a host species examined divided by the total number of that host species examined (Margolis et al. 1982). Parasites were identified by SJT and associates at the University of Wisconsin–Stevens Point.

Results

We examined a total of 65 Swallow-tailed Kites or their excreta for gastrointestinal parasites (Table 1). We recovered helminthes and protozoons from the digestive tract and excreta (Table 2). Over five breeding seasons (2001–2005) we collected and examined excreta samples from 52 live kites (43 nestlings, 9 adults) during banding. We also collected excreta samples from the surface of eight nests and beneath seven other active nests. During the moni-

Table 1. Prevalence (%) of helminth and protozoon parasites from digestive tracts and excreta of Swallow-tailed Kites.

PARASITE	ALL KITES $n = 65$	LIVE ADULTS $n = 13$	SALVAGED NESTLINGS $n = 5$	LIVE NESTLINGS $n = 46$	REHABILITATED POST-FLEDGLING $n = 1$
Phylum Nematoda					
Dispharynx sp.	9.2		20.0	8.7	100.0
Ascarid (immature)	1.5		20.0		
Procyrnea sp.	1.5		20.0		
Class Trematoda					
Unidentified	7.7			10.9	
Order Strigeatida	6.2			8.7	
Class Cestoda					
Taenia vexata	1.5		20.0		
Unidentified	1.5	7.7			
Phylum Acanthocephala					
Centrorhynchus spinosus	1.5		20.0		
Phylum Sporozoa					
Coccidian	13.8	15.4		15.2	
Phylum Metamonada					
Giardia sp.	1.5			2.2	
Birds without parasite infections (%)	40	10	2	28	0

toring of 227 nests (2000–2005), we salvaged five dead nestlings and examined them for gastrointestinal parasites. We also studied a kite undergoing rehabilitation.

Prevalence of Parasites. Our study provides the first record of Swallow-tailed Kite hosting the following parasites: nematodes of the Family Habronematidae, *Procyrnea* sp.; an immature ascarid; and coccidia and *Giardia* sp. (Table 1). We found one or more species of helminth in 27.7% of the 65 Swallow-tailed Kites we examined (Table 1). Patterns of helminth prevalence revealed that trematode infections (13.8%) were more common than nematode infections (10.8%), followed by cestodes (3.1%) and acanthocephalans (1.5%). We detected *Dispharynx* sp. only in first-year kites (11.5%, $n = 52$).

Pathogenicity of Parasites. We documented one case of mortality and one of morbidity in Swallow-tailed Kites that coincided with *Dispharynx* sp. infections. Case 1 involved a fledged 1997 hatch-year male that collapsed on 12 August 1997. We examined the kite 4 d later, after it had received one feeding by a wildlife rehabilitator. It was dehydrated and extremely emaciated with a body mass of 265 g. The kite was unable to fly, hung its head and both wings, and was able to perch but only in a crouched position. We estimated that it would have died within 1–2 d without human intervention.

The kite was initially too weak to survive worming. While it was regaining body mass and undergoing fluid therapy, on several occasions it regurgitated adult *Dispharynx* sp. The kite was later wormed with a 10% fenbendazole paste (20 mg/kg by mouth every 24 hr for 5 d). Post-worming, the kite shed and regurgitated its entire stomach lining. Multiple adult worms perforated and were present in the lining. The kite recovered and had a body mass of 440 g at the time of its release, 41 d after it was found.

Case 2 involved a 2000 hatch-year male from a nest we were monitoring in a forested, suburban area. The homeowner observed the kite falling from its nest, collected the carcass, and contacted us. She stored it on ice, and we examined it 45 min later. The kite, one of the five salvaged nestlings, was near fledging age when it died. It was dehydrated and extremely emaciated at the time of death with a body mass of 231.5 g, 51% the mass of a healthy kite of the same age range (based upon mean body mass of 453.4 g, 95 nestlings 28–41 d old; J. Coulson unpubl. data).

Necropsy revealed large numbers of *Dispharynx* sp. and *Procyrnea* sp. worms embedded in the lining

Table 2. Anatomical locations where parasites, eggs, or oocysts were recovered from Swallow-tailed Kites.

	STOMACH			INTESTINE			
	LUMEN	P[1]	V[2]	SMALL	LARGE	REGURGITATED	EXCRETA
Dispharynx sp.		2	2			1	4
Immature ascarid	1						
Procyrnea sp.		1					
Trematode, unidentified							5
Class Trematoda, Order Strigeatida							4
Taenia vexata					1		
Cestode, unidentified							1
Centrorhynchus spinosus				1			
Coccidian							9
Giardia sp.							1

[1] P = Proventriculus.
[2] V = Ventriculus.

of the proventriculus, and *Dispharynx* sp. worms embedded in the lining of the ventriculus. *Dispharynx* sp. was larger than *Procyrnea* sp., caused larger perforations, and was more numerous. The mucous membrane lining the stomach was inflamed and ulcerated at the site of the *Dispharynx* sp. perforations.

***Protocalliphora* sp. and Myiasis.** We detected myiasis at one nest. The ears of one nestling were swollen shut and those of the other were nearly closed. *Protocalliphora* sp. was present in the ears and anus of both nestlings. *Protocalliphora* sp. larvae infected 3.8% of nests to which we climbed (n = 26) or 4.6% of banded nestlings (n = 43).

Multiple Parasitic Infections. We detected cases of multiple parasitic infections in nestling kites, a few of which involved gastrointestinal parasites (Table 3). Other cases involved nestlings infected with combinations of endo- and ectoparasites.

DISCUSSION

Few diseases of raptors are known to affect the proventriculus (glandular stomach) and ventriculus (muscular stomach or gizzard; Klaphake and Clancy 2005). Santoro et al. (2009) studied helminths causing lesions of the digestive and respiratory tracts. Of 116 diurnal raptors, 69.8% had parasitic lesions from helminths, and only nematodes caused stomach lesions. *Dispharynx falconis*, *Synhimantus* spp., and *Procyrnea leptoptera* produced stomach lesions in all positive Common Buzzards (*Buteo buteo*) and Eurasian Kestrels (*Falco tinnunculus*). *Synhimantus laticeps* caused lesions in all positive Eurasian Sparrowhawks (*Accipiter nisus*), Common Buzzards, and Eurasian Kestrels, but not in any Western Marsh Harriers (*Circus aeruginosus*) or European Honey-buzzards (*Pernis apivorus*). *Procyrnea* spp. caused stomach lesions in most Eurasian Sparrowhawks but not in Honey Buzzards. *Physaloptera* spp. produced superficial erosions and necrotic foci in the stomachs of several species of hawks and falcons, but not in harriers. Krone and Cooper (2002) reported that *Synhimantus* spp. and *Cyrnea* spp. can cause irritation of the upper alimentary tract and proventriculus of diurnal and nocturnal raptors and subsequent problems in feeding. *Dispharynx nasuta* infections in the Crested Goshawk (*Accipiter trivirgatus*) did not cause lesions in the digestive tract (Su and Fei 2004). The nematode *Cyrnea* (*Procyrnea*) *spinosa* did not cause any histolytic damage in Chimango Caracaras (*Milvago chimango*; Sanmartín et al. 2006). Red-tailed Hawks (*Buteo jamaicensis*) are often hosts to *Microtetrameres* sp. (Smith 1993). Adult female worms live in glands of the proventriculus, but do not cause inflammation or morbidity.

The nematode *Dispharynx* sp. sometimes caused lesions (detected macroscopically) in the proventriculus and ventriculus of Swallow-tailed Kite. *Dispharynx* sp. perforated the mucosal stomach lining and caused inflamed, ulcerated lesions in two kites. In one of them, *Procyrnea* sp. also perforated the lining but did not cause irritation that was detectable macroscopically. However, our interpretation of lesions was based on observations with a dissecting microscope and not histopathology.

Nematodes affecting the stomach have rarely been documented to cause mortality in raptors. A Japanese Mountain Hawk-Eagle (*Spizaetus nipalen-*

Table 3. Incidence of multiple parasitic infections in Swallow-tailed Kite nestlings, n = number of nestlings positive for the combination of parasites.

n	HELMINTHES	SPOROZOA	ECTOPARASITES
1	*Dispharynx* sp., *Procyrnea* sp.		
3	trematode	coccidian	
1	trematode		mite: *Ornithonyssus* sp.
1	trematode		*Protocalliphora* sp.
1	*Taenia vexata*, *Centrorhynchus spinosus*		

sis) died from nematodiasis of the gizzard, but the nematodes were too deteriorated to be identified (Nakamura et al. 2001). Santoro et al. 2009 found that 18.9% of 116 deaths of diurnal raptors at a wildlife rehabilitation center were attributable to parasitism, but in most cases they did not report the causal agents. In the Swallow-tailed Kite, stomach lesions from *Dispharynx* sp. probably contributed to one death (Case 2) and one case of severe morbidity (Case 1).

In birds of prey, nematodes are usually the most prevalent helminths (Smith 1993). Patterns of prevalence of gastrointestinal helminths for Swallow-tailed Kite (n = 65) were as follows: trematodes were more common than nematodes, followed by cestodes, and acanthocephalans were least common. These patterns agree with those reported for intestinal helminths of both diurnal (n = 119) and nocturnal (n = 100) raptors in Spain except that nematodes were more common than trematodes (Ferrer et al. 2004a, 2004b). Another Spanish study on the helminths of diurnal and nocturnal raptors (n = 285) found that nematodes were most common, followed by cestodes, with fewer trematodes and only one species of acanthocephalan (Sanmartín et al. 2004).

Our estimates of parasite prevalence in Swallow-tailed Kite are probably low because we mostly screened excreta and performed few dissections, which likely would have enhanced detection of helminths. Helminth prevalence for kites (27.7%, n = 65) was lower than that reported for studies using dissection only. In Spain, 79.8% of 119 diurnal raptors hosted helminths of the digestive tract (Ferrer et al. 2004a), and in southern Italy, 95% of 116 diurnal raptors hosted helminths of the digestive and respiratory tracts (Santoro et al. 2009). The prevalence of nematodes (10.8%, n = 65) in Swallow-tailed Kite was low compared to dissection studies. The highest nematode prevalence reported in the literature was 75.6% for 119 diurnal raptors in Spain (Ferrer et al. 2004a). In China, 33.3% of 72 diurnal raptors were infected with nematodes, but included in this were nematodes found outside the alimentary canal (Zhang et al. 2008). Honisch and Krone (2008) examined both the digestive and respiratory systems and found that 51.7% of 153 raptors harbored nematodes. We detected a low prevalence of coccidians in live Swallow-tailed Kites: 15.4% of 13 adults and 15.2% of 46 nestlings (Table 1). Prevalence of the coccidian *Caryospora* sp. in young Eurasian Kestrels was much higher: 59.2% of 71 nestlings (adults were not sampled; Martínez-Padilla and Millán 2007).

We documented *Dispharynx* sp. infecting only young of the year, but our sample size for adults was small. However, our finding of a higher prevalence in young kites could be valid because adult galliform and passeriform birds often have a significantly lower prevalence of *Dispharynx nasuta* than do juveniles (Goble and Kutz 1945, Davidson et al. 1980).

Nestlings hosted parasites such as *Dispharynx* sp. and *Procyrnea* sp. that are transmitted by intermediate hosts, indicating that kites encounter these parasites on breeding grounds in the southeastern U.S. Woodlice (Order Isopoda, Families Porcellionidae, Armadillidiidae) are known intermediate hosts for *Dispharynx nasuta* (Cram 1931), but insects are suspected intermediate hosts of the acuaroid nematodes infecting raptors (Acosta et al. 2010).

Acuaroid nematodes are prevalent and diverse for the Eurasian Kestrel (63.4%, n = 41) probably because of this raptor's highly insectivorous diet (Acosta et al. 2010). *Dispharynx nasuta* was also the most prevalent helminth in another insectivore, the American Kestrel (*Falco sparverius*; Taft et al. 1993). Although vertebrates made up 97% of the biomass of 1092 prey items which Swallow-tailed Kites delivered to nests, a diversity of insects were also identified (Meyer et al. 2004). Proportions of prey types varied between years, and in one of the two study years, kites delivered significantly more insects to nests. This variability in the host's diet could provide a mechanism for higher prevalence and intensity of parasitism by acuaroid nematodes in some years. Identifying the insects that serve as intermediate hosts would be helpful in predicting conditions under which *Dispharynx* sp. prevalence and infection intensity might be high in Swallow-tailed Kite.

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