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Unique Host-parasite Relationships from Wildlife and Pets at a Zoological Medicine Service at Central Oklahoma

Haley Hahn¹, Ian Kanda¹, João Brandão¹, and Bruce H. Noden^{2*}

Abstract. Ectoparasites on wild birds and mammals threaten health of the animal and community. Most studies of ectoparasites tend to be location focused so characterizing wider differences between ectoparasites and hosts is difficult. The aim of this study was to identify ectoparasites from free ranging and captive wildlife at an academic zoological medicine service in Central Oklahoma and record first reports of ectoparasites and hosts. We collected 228 ectoparasites from 47 animals: 111 ectoparasites from 30 birds were 14 lice (n = 78), four hematophagous fly (n = 20), and three tick (n = 13) species. One hundred seventeen ectoparasites from 17 mammals were four flea (n = 8) and four tick (n = 109) species. Results included 13 first-time ectoparasite species and 26 first-time host-ectoparasite reports in Oklahoma. The study portrays closer representation of ectoparasites infesting wild animals in Central Oklahoma and demonstrate possible correlation between mortality and injury to parasitized hosts. Additional studies would document ectoparasites infesting wildlife in Central Oklahoma.

Introduction

Ectoparasites on wild birds and mammals threaten health of the animal and possibly a surrounding community if the ectoparasite is a vector of a zoonotic pathogen. Wild animals, mainly those presenting synanthropic behavior, are important reservoirs of pathogens of zoonotic concern (Simpson 2002, Hassell et al. 2017). Types of ectoparasites on a wild host vary. Lice, mites, ticks, fleas, and hematophagous flies are common ectoparasites on wild birds and mammals. Whether cleaning or damaging feathers, feather mites and lice can result in feather loss that impacts thermoregulation and might weaken and even impact mating success of an animal (Nelson et al. 1977, Clayton 1990b, Lehmann 1993, Cotgreave and Clayton 1994, Brown et al. 1995, Doña et al. 2019). Ticks and fleas are commonly found on wild mammals and create conditions for secondary infections and transmission of lethal pathogens that cause morbidity and mortality (Smith and Cheatum 1944, Nelson et al. 1977, Andrews et al. 1980). The ectoparasites might be reservoirs for viruses (e.g., West Nile virus) or bacteria (e.g., *Bartonella* sp.) transmitted to companion animals that might visit the environment in which host-ectoparasite interactions are occurring or feed on a human and cause disease.

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Studies focus on ectoparasites from a single species of animal, on a group of blood-sucking arthropods from a specific animal, or animals from a specific area. While these studies advance knowledge of diverse ectoparasites on specific animal species in a particular region, they are often very focused on location so it is difficult to bring together the different ectoparasites and hosts in a region and characterize wide differences in an area. Because of specific ectoparasite-host relationships, it is unlikely that many different species of birds and mammals can be examined from one region and all different ectoparasites can be identified from each host. Such was the opportunity we sought to exploit in a zoological medicine service that provides care for exotic, wild, and zoo animals at a School of Veterinary Medicine in Central Oklahoma. With full-functioning emergency services with intake from north central parts of Oklahoma, many animal hosts were presented to the service for medical treatment, and ectoparasites were removed and identified.

Ectoparasites on wild animals on the southern Great Plains are not well studied. In the early 1900s, K. C. Emerson of the Department of Entomology at Oklahoma State University was a world-famous expert on lice species, usually obtained from wild birds and mammals. When he retired, his collection and scientific library were given to Oklahoma State University in 1970 and housed at the K.C. Emerson Entomology Museum. Dr. Cluff Hopla at the University of Oklahoma researched regional ectoparasites until the early 1990s. Since then, Dr. Chris McAllister studied ectoparasites in southeastern Oklahoma. The aim of this study was to identify ectoparasites from free-ranging and captive wildlife at an academic zoological medicine service in central Oklahoma and record first reports of ectoparasites and host records in the state.

Materials and Methods

Between 2016 and 2018, ectoparasites were removed from animal patients at the zoological medicine service at OSU College of Veterinary Medicine. Upon admission, animal patients were assessed, ectoparasites were removed and diagnoses and course of action were determined. Ectoparasite collection was part of the medical treatment of patients in the best interest of the patient. Ectoparasites were removed by hand or forceps and put into plastic 1.3-ml tubes filled with 70% ethanol, labeled with supposed parasite type, case number, and date, and stored at room temperature. During summer 2019, individual specimens were examined using a Wild Heerbrugg stereomicroscope and identified to order, then species, if possible, using published keys. For specimens not easily identified because of missing components, assistance of personnel in the department with expertise in the area was obtained. Published keys were used to identify ticks (Keirans and Litwak 1989, Keirans and Durden 1998, Coley 2015, Dubie et al. 2017, Talley et al. 2017), lice (Price and Beer 1963a,b; Nelson and Price 1965; Scharf and Price 1965; Keirans 1966; Clay 1966, 1968; Clayton and Price 1984; Price et al. 2003; Cicchino and Valim 2008), fleas (Gerhardt and Fritz 1945) and hematophagous flies (Bequaert 1953, 1955). Samples of each species were submitted to K.C. Emerson Museum in OSU Department of Entomology and Plant Pathology, and photographs of most of the ectoparasites are online (<https://vetmed.okstate.edu/site-files/docs/summer-research-training-program/2019-hahnposter.pdf>).

Search for historical reports of ectoparasites or host-ectoparasites in Oklahoma involved using mostly Google, Google Scholar, PubMed, and Scopus and their references to identify studies. Because of a current major project to digitize and

Table 1. Ectoparasites on Avians at OSU Exotic Animal Lab, 2016-2018. (S = new state record, H = new host-ectoparasite state record)

Order	Host (Latin name)	Lice (#*)	Flies (#)	Tick (#)
Passeriformes	Loggerhead shrike (<i>Lanius ludovicianus</i> L.)		<i>Ornithoona fusciventris</i> (Wiedemann) (1A) ^{S,H}	
	Eastern bluebird (<i>Sialia sialis</i> L.)	<i>Philoapterus sialii</i> (Osborn) (2A) ^{S,H}		
	European starling (<i>Sturnus vulgaris</i> L.)		<i>Carnus hemapterus</i> Nitzsch (15A) ^{S,H}	
Galliformes	Common grackle (<i>Quiscalus quiscula</i> L.)	<i>Myrsidea fuscomarginata</i> (Osborn) (4A) ^{S,H}		<i>Haemaphysalis leporispalustris</i> (Packard) (3N) ^H <i>A. americanum</i> (L.) (9N) ^H
	Northern bobwhite (<i>Colinus virginianus</i> L.)			<i>A. americanum</i> (1N)
Gruiformes	American coot (<i>Fulica americana</i> Gmelin)	<i>Laemobothrion (Eulaemobothrion) atrum</i> (Nitzsch) (2A, 3N) ^{S,H}		
	Yellow billed cuckoo (<i>Coccyzus americanus</i> L.)	<i>Cuculiphilus (Cuculiphilus) snodgrassi</i> (Kellogg & Kuwana) (1A) ^{S,H}		
Strigiformes	Barred owl (<i>Strix varia</i> Barton)	<i>Kurodaia (Conciella) magna</i> Emerson (1A)		
	Barn owl (<i>Tyto alba</i> (Scopoli))	<i>Strigiphilus</i> spp. Mjoberg (1A) ^H		
Falconiformes	Great horned owl (<i>Bubo virginianus</i> (Gmelin)) (n=2)	<i>Strigiphilus</i> spp. (10A) ^H		
	Peregrine falcon (<i>Falco peregrinus</i> (Tunstall))	<i>Degeeriella rufa</i> (Bumeister) (1A) ^{S,H}		
Accipitriformes	Broad wing hawk (<i>Buteo platypterus</i> (Vieillot))		<i>Ornithoona erythrocephala</i> (Leach) (1A) ^H	
	Turkey vulture (<i>Cathartes aura</i> (L.)) (n=3)	<i>Laemobothrion (Laemobothrion) glutinans</i> Giebel (3A, 2N) ^{S,H}		
Columbiformes	Mississippi kite (<i>Ictinia mississippiensis</i> (Wilson)) (n=9)	<i>Colpocephalum kelloggi</i> Osborn (24A) ^H		
	Red tailed hawk (<i>Buteo jamaicensis</i> (Gmelin)) (n=5)	<i>Cuculiphilus (Falcophilus) alternatus</i> (Osborn) (1A) ^{S,H}		
		<i>Laemobothrion (Laemobothrion) maximum</i> (Scopoli) (8A, 4N) ^{S,H}	<i>Icosta americana</i> (Leach) (1A) ^H	
		<i>Colpocephalum nanum</i> Piaget (3A) ^{S,H}		
		<i>Degeeriella fulva</i> (Giebel) (1A) ^H		
		<i>Kurodaia (Kurodaia) fulvofasciata</i> (Piaget) (5A, 1N) ^{S,H}		
		<i>L. maximum</i> (1A) ^H	<i>I. americana</i> (2A) ^H	

*A-adult, N-nymp

organize specimens of the K. C. Emerson Museum at OSU Department of Entomology and Plant Pathology, we reviewed only the card catalogue of specimens.

Results and Discussion

In total, we collected 228 ectoparasites from 47 animals: 111 ectoparasites were from 30 birds, consisting of 14 lice (n = 78), four hematophagous fly (ked) (n = 20), and three tick (n = 13) species (Table 1). One hundred seventeen ectoparasites were obtained from 17 mammals consisting of four flea (n = 8) and four tick (n = 109) species (Table 2). Based on background research, we reported 13 first-time ectoparasite species and 26 first-time host-ectoparasites in Oklahoma. Most (n = 11) first-time ectoparasite species were new lice species as were new host-parasite records (n = 15, 60%). There were two first reports of hematophagous flies with five new hematophagous fly host records. The remaining new host records were three flea and three tick species.

Table 2. Ectoparasites from Mammals at OSU Exotic Animal Clinic, 2016-2018 (S = new state record, H = new host-ectoparasite state record)

Host	Host (Latin name)	Fleas (#*)	Ticks (#*)
Rodentia	Fox squirrel (3) (<i>Sciurus niger</i> L.)	<i>Euhoplopsyllus glacialis</i> <i>affinis</i> (Baker) (5A) ^H	<i>Amblyomma</i> <i>americanum</i> (L.) (2N)
	Woodchuck (<i>Marmota monax</i> (L.))		<i>A. americanum</i> (1A, 3N)
Didelphimorphia	Opossum (4) (<i>Didelphis virginiana</i> Kerr)		<i>Dermacentor variabilis</i> (Say) (2A) <i>A. americanum</i> (3N, 4L)
	Rabbit (6) (<i>Sylvilagus floridanus</i> (Allen))	<i>Cediopsylla simplex</i> (Baker) (1A)	<i>Haemaphysalis</i> <i>leporispalustris</i> (Packard) (35A, 25N, 2L) <i>D. variabilis</i> (3A) <i>A. americanum</i> (1A)
Lagomorpha	Bobcat (<i>Lynx rufus</i> (Schreber))		<i>Ixodes scapularis</i> Say (28A) ^H
	Ferret (<i>Mustela putorius furo</i> L.)	<i>Ctenocephalides felis</i> (Bouché) (1A) ^H	
Carnivora	Kinkajou (<i>Potos flavus</i> (Schreber))	<i>Pulex irritans</i> L. (1A) ^{S,H}	

*A-adult, N-nymph, L-larva

Passeriformes: Loggerhead shrike (*Lanius ludovicianus* L.). An immature, unknown sex, shrike was found at Perkins, OK (Payne) on 13 June 2017, infested with hematophagous fly *Ornithoctona fusciventris* (Wiedemann). A broad host ectoparasite with a widespread distribution ranging from Argentina to Canada, *O. fusciventris* has been collected from a wide variety of small-to-medium sized birds (Bequaert 1955, Maa 1969, Ibáñez-Bernal et al. 2015, Reeves and Lloyd 2019). While documented in several states of the U.S. (Maa 1969), this is the first report of *O. fusciventris* in Oklahoma and the first host report of this louse species on *L. ludovicianus* in the United States.

Eastern bluebird (*Sialia sialis* (L.)). An adult male eastern bluebird was found at Stillwater, OK (Payne) during the study period, infested with mallophagan louse *Philopterus sialii* (Osborn). Known to primarily parasitize *S. sialis* and reported widely in the United States (Peters 1936, Emerson 1939, Malcomson 1960, Keirans 1966, Price et al. 2003), this is the first report of *P. sialii* in Oklahoma and the first host report on *S. sialis* in Oklahoma.

European starling (*Sturnus vulgaris* L.). A female European starling nestling was found at Shawnee, OK (Pottawatomie) on 13 June 2016, infested by hematophagous fly *Carnus hemapterus* Nitzsch (n = 15). The fly species was reported in the United States and Canada infesting a wide variety of bird orders (Capelle and Whitworth 1973, Brake 2011, Fairn et al. 2014). It also was reported in a case of accidental external ear myiasis in Japan (Kosone et al. 2018). With lack of published records of the fly species in the Great Plains region (Capelle and Whitworth 1973), this is the first report of *C. hemapterus* in Oklahoma and first host report on *S. vulgaris* in Oklahoma.

Common grackle (*Quiscalus quiscula* (L.)). An adult male grackle was found at Stillwater, OK (Payne), infested with tick species *Amblyomma americanum* (L.) (n = 9 nymphs) and *Haemaphysalis leporispalustris* (Packard) (n = 3 nymphs) and one mallophagan louse species, *Myrsidea fuscomarginata* (Osborn) (n = 4 adults). Different tick species including *H. leporispalustris*, *A. americanum*, *Amblyomma maculatum*, *Ixodes scapularis*, and *Ixodes brunneus* were collected from U.S.-based *Q. quiscula* (Peters 1936, Bishopp and Trembley 1945, Harlan and Kramer 1979, Brillhart and McKown 1991, Nicholls and Callister 1996, Durden et al. 1997). This was the first study to report *A. americanum* and *H. leporispalustris* on *Q. quiscula* in Oklahoma. *Myrsidea fuscomarginata* was reported on grackles in the United States (Emerson 1972, Forrester et al. 1995, Price et al. 2003). While Emerson (1939) reported three *Myrsidea* species in Oklahoma (*Myrsidea mesoleuca americana*, *Myrsidea dissimilis*, *Myrsidea incerta*), this is first report of *M. fuscomarginata* in Oklahoma and the first to report the louse species on *Q. quiscula*.

Galliformes: Northern bobwhite quail (*Colinus virginianus* (L.)). An adult female *Colinus virginianus* was found at Stillwater, OK (Payne), on 29 July 2018, infested with one *A. americanum* nymph. Previous studies reported *A. americanum* on Northern bobwhite quail in the United States (Bishopp and Trembley 1945, Tugwell and Lancaster 1962, Doster et al. 1980) and infestations by larvae and nymphs in eastern Oklahoma (Clymer et al. 1970). This is the first report of *A. americanum* on Northern bobwhite quail in central Oklahoma.

Gruiformes: American coot (*Fulica americana* Gmelin). An adult American coot was found at Stillwater, OK (Payne), on 29 March 2016, infested with mallophagan species *Laemobothrion atrum* (Nitzsch). Measuring 7.5 mm long as an adult, *L. atrum* was collected mostly from *F. americana* and previously recorded in a variety of US states (Keirans 1966, Emerson 1972, Forrester et al. 1995, Price et al. 2003, Canaris and Waldmann 2017). This is the first record of *L. atrum* in Oklahoma and the first host report on *F. americana* in the state.

Cuculiformes: Yellow-billed cuckoo (*Coccyzus americanus* (L.)). An adult *C. americanus* was found at Stillwater, OK (Payne), on 25 May 2016, infested with mallophagan *Cuculiphilus snodgrassi* (Kellogg & Kuwana). A common parasite of birds in the order *Cuculiformes*, the louse species was reported in different states (Scharf and Price 1965, Emerson 1972, Forrester et al. 1995, Price et al. 2003). This appears to be the first record of *C. snodgrassi* in Oklahoma and first report of the louse species on *C. americanus* in Oklahoma.

Strigiformes: Barred owl (*Strix varia* Barton). An adult male barred owl was found at Stillwater, OK (Payne), on 22 April 2017, infested with mallophagan *Kurodaia magna* Emerson. The largest species in the genus, *K. magna* has only three documented hosts: *Bubo virginianus*, *Strix occidentalis*, and *S. varia* (Price and Beer 1963b, Price et al. 2003). The species of louse was reported in several states (Price and Beer 1963b, Hunter et al. 1994, Forrester et al. 1995). *Kurodaia magna* was first reported from a barred owl in southeastern Oklahoma (McAllister et al. 2019).

Barn owl (*Tyto alba* (Scopoli)). An adult *T. alba* was found at Red Rock, OK (Noble) on 23 August 2017, infested with mallophagan *Strigiphilus* spp. Mjoberg. Because of specific components in the keys we could not clearly differentiate at the magnification of our microscopes, we could not identify the specimen to species. Because of the host-specificity of louse species on specific owl species, the species is most likely *S. rostratus* (Burmeister) (Clay 1966) or *S. flammineae* (Phthiraptera.myspecies.info, 2022) as reported on barn owls. *Strigiphilus* spp. was reported on owls in multiple states across the United States (Carriker 1966, Clay 1966, Clayton 1990a), including Oklahoma (*Strigiphilus otus* on an eastern screech owl (McAllister et al. 2018) and *Strigiphilus syrnii* on a barred owl (McAllister et al. 2019). This is the first report of *Strigiphilus* spp. on a barn owl in Oklahoma.

Great horned owl (*Bubo virginianus* (Gmelin)). Two adult great horned owls were found at Stillwater, OK (Payne) on 14 and 17 November 2017, infested with mallophagan *Strigiphilus* spp. (GHOW-1 (n = 2) and GHOW-2 (n = 8)). GHOW-1 produced a positive *Leukocytozoon* blood smear. Because of magnification limitations, we were unable to identify the lice to species. Only reported on owls, different *Strigiphilus* spp. were identified on great horned owls in the United States (Carriker 1966, Keirans 1966, Clayton and Price 1984, Clayton 1990a, Forrester et al. 1995, Price et al. 2003). Louse species *Colpocephalum brachysomum* was reported on a great horned owl in southeastern Oklahoma (McAllister et al. 2017), but this seems to be the first report of *Strigiphilus* spp. on *Bubo virginianus* in Oklahoma.

Falconiformes: Peregrine falcon (*Falco peregrinus* (Tunstall)). An adult, suspected male, peregrine falcon was found at Stillwater, OK (Payne) on 21 October 2016, infested with mallophagan *Degeeriella rufa* (Burmeister). Commonly reported on falcon species (Emerson 1972, Price et al. 2003), *D. rufa* was reported on *F. peregrinus* in different states and Canada (Peters 1936, Spencer 1957, Price et al. 2003). This is the first record of *D. rufa* and first host report on *F. peregrinus* in Oklahoma.

Accipitriformes: Broad-winged hawk (*Buteo platypterus* (Vieillot)). An immature broad-winged hawk was found at Chandler, OK (Lincoln) during the study period, infested with hematophagous fly *Ornithoctona erythrocephala* (Leach). Found on a variety of bird species (Bequaert 1955, Maa 1969), it was reported on *B. platypterus* in North and South America (Mueller et al. 1969, Vaz et al. 2016, Silva et al. 2021). *Ornithoctona erythrocephala* was documented on a red-shouldered hawk (*Buteo lineatus*) in southeastern Oklahoma (McAllister et al. 2018), but this is the first report of this hematophagous fly species on *B. platypterus* in Oklahoma.

Turkey vulture (TUVU; *Cathartes aura* (L.)). Three turkey vultures infested with three species of lice were brought into the clinic during the study period:

- 1) TUVU-1 was found at Coyle, OK (Logan) on 31 October 2016, infested with mallophagan species *Laemobothrion glutinans* Giebel (n = 1) and *Colpocephalum kelloggi* Osborn (n = 1);

- 2) TUVU-2 was found at Chandler, OK (Lincoln) on 23 May 2017, infested with mallophagan species *L. glutinans* (n = 4), *C. kelloggi* (n = 4), and *Cuculiphilus alternatus* (Osborn) (n = 1);
- 3) TUVU-3 was found at Ripley, OK (Payne) on 25 May 2017, infested with louse species *C. kelloggi* (n = 19).

C. kelloggi was previously reported to infest *C. aura* and collected throughout the United States (Osborn 1902, Peters 1936, Spencer 1957, Malcomson 1960, Emerson 1972, Forrester et al. 1995, Price et al. 2003) and Canada (Price and Beer 1963a). *C. kelloggi* was reported in Oklahoma by Emerson (1939) but this the first host record on *C. aura* in Oklahoma.

L. glutinans and *C. (F.) alternatus* were previously reported in the United States and Canada but, *L. glutinans* was mostly associated with king and black vultures (Osborne 1902, Spencer 1957, Malcomson 1960, Nelson and Price 1965, Scharf and Price 1965, Forrester et al. 1995, Emerson 1972, Price et al. 2003). This is the first record of *L. glutinans* and *C. (F.) alternatus* in Oklahoma and first host records for both parasites on *C. aura* in Oklahoma.

Mississippi kite (MIKI; *Ictinia mississippiensis* (Wilson)). Nine Mississippi kites were found during the study period, eight infested with a mallophagan species and one infected with a hematophagous fly species:

- 1) MIKI-1 was found at Perry, OK (Noble), infested by louse species *Laemobothrion maximum* (Scopoli) (n = 2);
- 2) MIKI-2 was found at Stillwater, OK (Payne), infested by *L. maximum* (n = 3);
- 3) MIKI-3 was found at Perry, OK (Noble), infested by *L. maximum* (n = 1);
- 4) MIKI-4 was found at Stillwater, OK (Payne), infested by *L. maximum* (n = 1);
- 5) MIKI-5 was found at Blackwell, OK (Kay), infested by *L. maximum* (n = 1);
- 6) MIKI-6 was found at Stillwater, OK (Payne), infested by *L. maximum* (n = 2);
- 7) MIKI-7 was found at Stillwater, OK (Payne), infested by *L. maximum* (n = 1);
- 8) MIKI-8 was found in Stillwater, OK (Payne), infested by *L. maximum* (n = 2);
- 9) MIKI-9 was found at Stillwater, OK (Payne), infested with hematophagous fly species *Icosta americana* (Leach) (n = 1).

L. maximum is collected from many birds of prey (Peters 1936, Nelson and Price 1965; Emerson 1972, Forrester et al. 1995, Price et al. 2003). This is the first report of *L. maximum* and first host report on *I. mississippiensis* in Oklahoma.

I. americana was identified in multiple states across the United States and previously reported to infest *I. mississippiensis* (Bequaert 1955, Nelson and Price 1965). Some reports detected West Nile Virus and *Haemoproteus* and Trypanosome species, although their vector status is uncertain (Gancz et al. 2004, Farajollahi et al. 2005, Reeves and Lloyd 2019). The species was reported on a barred owl in southeastern Oklahoma (McAllister et al. 2019), and a specimen obtained from a bird hit by a car in Atoka County (Oklahoma) was put into the K. C. Emerson Entomology Museum at Oklahoma State University, Stillwater. This is the first report of *I. americana* on a *I. mississippiensis* in Oklahoma.

Red-tailed hawk (RTHA; *Buteo jamaicensis* (Gmelin)). Five red-tailed hawks were brought into the clinic during the study, three were infested with four mallophagan species and two were infested with a hematophagous fly species:

- 1) RTHA-1 was found at Stillwater, OK (Payne), infested with *Colpocephalum nanum* Piaget (n = 3) and *Kurodaia fulvofasciata* (Piaget) (n = 2).
- 2) RTHA-2 was found at Pawnee, OK (Pawnee), infested with *L. maximum* (n = 1).
- 3) RTHA-3 was found at Stillwater, OK (Payne), infested with *K. fulvofasciata* (n = 4) and *Degeeriella fulva* (Giebel) (n = 1).

4) RTHA-4 was found at Meeker, OK (Lincoln), infested with *Icosta americana* (Leach) (n = 1).

5) RTHA-5 was found at Stillwater, OK (Payne), infested with *I. americana* (n = 1).

L. maximum was reported on this and other bird species in the United States (Nelson and Price 1965, Emerson 1972, Price et al. 2003), but with the previous specimen, this is the first record of the louse species in Oklahoma and of this species on *B. jamaicensis* in Oklahoma.

Degeeriella fulva also was reported on *B. jamaicensis* in the United States (Emerson 1972, Forrester et al. 1995, Morishita et al. 2001, Price et al. 2003) and other countries (de Oliveira et al. 2011). *Degeeriella fulva* was reported on *Buteo lineatus* in southeastern Oklahoma (McAllister et al. 2018) but seems to be the first record of *D. fulva* on *B. jamaicensis* in Oklahoma.

Kurodaia fulvofasciata was reported on *B. jamaicensis* in the United States (Emerson 1972, Forrester et al. 1995, Price et al. 2003). This seems to be the first record of *K. fulvofasciata* in Oklahoma and on *B. jamaicensis* in Oklahoma.

Colpocephalum nanum was reported on a wide variety of hawk species in the United States (Price and Beer 1963a, Emerson 1972, Price et al. 2003). This is the first record of *C. nanum* in Oklahoma and first report on *B. jamaicensis* in Oklahoma.

Commonly found on birds in the United States and Canada (Bequaert 1955, Nelson and Price 1965, Levesque-Beaudin and Sinclair 2021), *Icosta americana* was recorded on *B. jamaicensis* and a variety of birds including owls, hawks, grouse, and turkeys (Maa 1969, Young et al. 1993, Reeves and Lloyd 2019). While *I. americana* was reported on other birds in Oklahoma (McAllister et al. 2019), this is the first host report of the louse species on *B. jamaicensis* in Oklahoma.

Rodentia: Fox squirrel (FOSQ; *Sciurus niger* L.). Three fox squirrels were found during the study, infested with one tick and one flea species:

1) FOSQ-1 was found at Jennings, OK (Pawnee), infested with *A. americanum* (n = 2).

2) FOSQ-2 was found at Stillwater, OK (Payne), infested with *Hoplopyllus affinis* (Baker) (n = 3) fleas.

3) FOSQ-3 was found at Stillwater, OK (Payne), infested with *H. affinis* (n = 2).

Commonly found on squirrels in the United States (Hooker et al. 1912, Bishopp and Trembley 1945, Clymer et al. 1970), larval and nymphal *A. americanum* were reported on *S. niger* in eastern Oklahoma (Koch et al. 1981, McAllister et al. 2017). The only report of *H. affinis* in Oklahoma was from a domestic cat (Ellis 1955) while the flea species was collected from fox squirrels in Kansas (Graham and Uhrich 1943). This is the first report of *H. affinis* from *S. niger* in Oklahoma.

Woodchuck (*Marmota monax* (L.)). One woodchuck was found at Stillwater, OK (Payne), infested with an *A. americanum* tick. Studies reported infestation by *A. americanum* on *M. monax* in other U.S. states (Bishopp and Trembley 1945, Sonenshine and Stout 1971, White et al. 2021) and Oklahoma (Clymer et al. 1970, Koch et al. 1981).

Didelphimorphia: Virginia opossum (VIOP; *Didelphis virginiana* Kerr). Four opossum were found during the study, infested with two tick species:

1) VIOP-1 was found at Stillwater, OK (Payne), infested with *A. americanum* larvae (n = 4).

2) VIOP-2 was found at Stillwater, OK (Payne), infested with *Dermacentor variabilis* (Say) (n = 1).

3) VIOP-3, a newborn, was found at Stillwater, OK (Payne), infested with *A. americanum* nymphs (n = 3).

4) VIOP-4 was found at Stillwater, OK (Payne), infested with *D. variabilis* (n = 1). Tick species *A. americanum* and *D. variabilis* were reported from *D. virginiana* in the U.S., including Arkansas (Bishopp and Trembley 1945, Tugwell and Lancaster 1962, Pung et al. 1994, Zimmerman et al. 1988, Tufts et al. 2021). Tick infestations on opossum in eastern Oklahoma include *I. scapularis* and *D. albipictus* (Clymer et al. 1970) in addition to *A. americanum* and *D. variabilis* (Koch et al. 1981).

Lagomorpha: Eastern cottontail rabbit (ECRA; *Sylvilagus floridanus* (Allen)). Six rabbits were found during the study, infested with three tick and one flea species.

- 1) ECRA-1 was found at Stillwater, OK (Payne), infested with *Haemaphysalis leporispalustris* (Packard) (n = 17).
- 2) ECRA-2 was found at Stillwater, OK (Payne), infested with *H. leporispalustris* (n = 4).
- 3) ECRA-3 was found at Stillwater, OK (Payne), infested with *H. leporispalustris* (n = 2) and *D. variabilis* (n = 3).
- 4) ECRA-4 was found at Pawnee, OK (Pawnee), infested with *H. leporispalustris* (n = 29).
- 5) ECRA-5 was found at Harrah, OK (Oklahoma), infested with *H. leporispalustris* (n = 7), *A. americanum* (n = 1), and *Cediopsylla simplex* (Baker) (n = 1).
- 6) ECRA-6 was found at Cushing, OK (Payne), infested with *H. leporispalustris* (n = 1).

All four ectoparasites, *A. americanum*, *D. variabilis*, *H. leporispalustris*, and *C. simplex*, infest *S. floridanus* in the US and Oklahoma (Ward 1933, Eddy 1943, Bishopp and Trembley 1945, Ellis 1955, Andrews et al. 1980, Koch et al. 1981, McAllister et al. 2018).

Carnivora: Bobcat (*Lynx rufus* (Schreber)). One bobcat was found at Stillwater, OK (Payne), infested with tick species *I. scapularis* Say (n = 28). The number of adult ticks collected on one animal is often indicative of injury or sickness. The bobcat had degloving injury on left front limb digit 4 and laceration on the left hind limb digit 2 and was transferred to a rehabilitation facility where it was expected to recover. While *I. scapularis* was reported to infest *L. rufus* in other states including neighboring Arkansas (Bishopp and Trembley 1945, Tugwell and Lancaster 1962, Wehinger et al. 1995, Goddard et al. 2011), this is the first report on *L. rufus* in Oklahoma.

Domestic ferret (*Mustela putorius furo* L.). A pet, 11-month old, castrated male ferret, from Ponca City, OK (Kay), was infested with a cat flea, *Ctenocephalides felis* (Bouché). Presumably infested by the indoor/outdoor cat who roamed freely in the house, cat fleas are commonly reported on pet ferrets (Visser et al. 2001). This is the first record of *C. felis* on a pet *M. putorius furo* in Oklahoma.

Kinkajou (*Potos flavus* (Schreber)). One 8-year-old female kinkajou from Ponca City, OK (Kay), was seen on 24 October 2016, infested with a human flea, *Pulex irritans* L. Recently acquired at a pet auction, the kinkajou lived with another in an outside enclosure. The infestation source was not clear. Wild-caught kinkajous in Panama and Brazil have been collected with mallaphagan *Trichodectes potus* (Emerson 1966) and nymphs of *Amblyomma* sp. and *Ornithodoros* sp. ticks (Fairchild et al. 1966). This is the first record of *P. irritans* on a pet kinkajou in North America.

Among 47 animals brought to the OSU zoological medicine service during a 3-year period, collected were 228 ectoparasites -- 14 lice, four hematophagous fly (keds), four flea, and four tick species. Most of the ectoparasites were new records for Oklahoma and new host records. Because of the host-specific nature of most

ectoparasites, regional host-ectoparasite relationships are difficult to identify for many wildlife hosts because of challenges involved in collecting from live animals. Many studies use mist-netting (Cerutti et al. 2018, Roselli et al. 2022), but they collect only certain orders of birds, leaving most bird species unavailable because they often involve complicated trapping techniques and specific permits. Live-animal trapping is commonly used for wild animals, but current studies trap one or two host species as part of a larger focus (Pirrello et al. 2015, Bezerra-Santos et al. 2021, Levesque-Beaudin and Sinclair 2021) or continue to use randomness of roadkill or road injury cases to obtain samples (McAllister et al. 2018, 2019; Lavallée et al. 2020). Involvement of regional zoological medicine service or wildlife rehabilitator, often raptor rehabilitation centers, to identify regional ectoparasite-host relationships provide collections in an environment where the animal can be treated and released again into the wild (Morishita et al. 2001, Barino et al. 2021, Gherardi et al. 2021). This study demonstrated direct usefulness of such a clinic to define new host relationships in the region as well as new records for ectoparasites in the state.

While descriptive in nature, this type of study can become the baseline for further studies to determine direct and indirect impacts of ectoparasites on specific hosts. Ectoparasites can impact their hosts by transmitting pathogens that increase host morbidity and mortality as well as serving as reservoirs for pathogens that can spillover to other animals or humans (Gutiérrez et al. 2015, Cerutti et al. 2018, Skvarla and Machtinger 2019, Vidaña et al. 2020, Williams and Dittmar 2020, Bezerra-Santos et al. 2021). For example, West Nile virus was detected in *I. americana* collected from birds known to be reservoirs of the disease (Gancz et al. 2004, Farajollahi et al. 2005). While there is little risk of the flies biting humans, they might be able to transmit the virus to a noninfected bird, leading to mortality or further transmission by mosquito or other biting fly (Vidaña et al. 2020). *E. glacialis affinis*, *C. felis*, and *P. irritans* fleas are vectors for a variety of bacterial pathogens, especially those with zoonotic reservoirs that live near human habitations (Rolain et al. 2005, Laudisoit et al. 2007, Belthoff et al. 2015). All species of ticks collected from birds and mammals are important in transmission of pathogens to humans, companion animals, and wildlife (Saleh et al. 2021, Noden and Dubie 2022). However, identity of different birds and mammals that support life cycles of immature ticks and serve as potential reservoirs for infection for the next stage of tick are not well understood.

This study portrays closer representation of ectoparasites infesting wild animals in central Oklahoma. Results from this case series showed there could be close correlation between mortality and injury with hosts affected by parasitism. Additional studies documenting ectoparasites on wildlife would add to knowledge of ectoparasites infesting wild animals in central Oklahoma.

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