

A STUDY OF THE PARASITIC FAUNA OF NORTH AMERICAN SPOTTED SKUNKS
(GENUS *SPILOGALE*) ACROSS THE EASTERN AND CENTRAL UNITED STATES

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ABSTRACT

To date, few studies exist on the extent of the parasitic fauna found on and within spotted skunks (genus *Spilogale*). Most research has focused either on skunks from a portion of their range, or on a specific parasite group, creating a bias towards heterogeneous sampling efforts and incomplete sampling. As such, the goal of this project is to report on the parasite community of spotted skunks, *Spilogale interrupta*, *S. leucoparia*, and *S. putorius*, collected across their ranges. Skunks collected represent nine states and were obtained from vehicle-killed animals, mortalities from previous research projects, donations from natural history collections, and legally harvested animals by fur trappers. We found 62 out of 73 hosts from seven states parasitized by ectoparasites, identifying five species of fleas (*Orchopeas howardi*, *Ctenophthalmus* sp., *Echidnophaga gallinacea*, *Pulex irritans*, and *Xenopsylla cheopis*), one genus of lice (*Neotrichodectes* sp.), one mite species (*Haemolaelaps glasgowi*), and two genera of ticks (*Ixodes texanus* and *Rhipicephalus sanguineus*). We found 46 out of 49 hosts from nine states parasitized with endoparasites and identified two species of acanthocephalans (*Macracanthorhynchus ingens* and *Pachysentis canicola*), two genera of cestodes (*Mesocestoides variabilis* and *Taenia* sp.), and five species of nematodes (*Baylisascaris columnaris*, *Capillaria putorii*, *Crenosoma mephitidis*, *Physaloptera maxillaris*, and *Skrjabingylus chitwoodorum*).

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CHAPTER 1: ECTOPARASITES OF SPOTTED SKUNKS

INTRODUCTION

Spotted skunks (genus *Spilogale*) are small skunks from the family Mephitidae found throughout North and Central America. Spotted skunks are found in wooded habitats, tall-grass prairies, and sometimes rocky lands, usually denning in natural cavities (Kinlaw 1995; Verts et al. 2001). Their omnivorous food habits follow seasonal patterns and availability, with reported diets including insects, bird eggs, small rodents, fruit, and corn (Kinlaw 1995; Verts et al. 2001).

Spotted skunk species have undergone numerous taxonomic changes since first being described by Gray 1865, with the most recent proposal being based on molecular phylogenetic analyses and geographic patterns (Shaffer et al. 2018; McDonough et al. 2021). For this study, we followed the taxonomic recommendations of McDonough et al. (2021) based on the geographic distributions determined by the researchers. We have three species represented in this study: *Spilogale leucoparia*, *S. putorius*, and *S. interrupta*. The desert spotted skunk (*S. leucoparia*) has a proposed range bound by the temperate grasslands of the southern Rocky Mountains, the Trans-Mexican Volcanic Belt, the Colorado River, Mojave Desert, and the Great Plains. The Alleghenian spotted skunk (*S. putorius*) had an initial range proposed by Howell (1906) that included Mississippi, Alabama, western Georgia, western South Carolina, and northern Virginia. The newly proposed range includes the Appalachian Mountains and is bound by the Allegheny plateau, the Gulf of Mexico, the Mississippi River, and the Atlantic Coastal Plain. The southern Canadian forests, the Tamaulipan biotic

province, the Rocky Mountains, and the Mississippi River are the boundaries for the proposed range of the plains spotted skunk, *S. interrupta* (McDonough et al. 2021).

To date, few, if any, comprehensive studies have reported on the extent of parasitic fauna found in these species of spotted skunks across their ranges (Table 1.1). There have been 45 species from five orders of ectoparasites documented in the genus *Spilogale* in the United States. Most research has focused on either a single state or area of the spotted skunk's range, or the focus was on a particular parasite species (or group) and the researchers were able to obtain a spotted skunk to search for their target parasite.

In Alleghenian spotted skunks examined from Florida (Layne 1971; Kinlaw 1995; Mertins et al. 2016), the flea *Polygenis gwyni* has been reported, along with the ticks *Dermacentor variabilis* and *Ixodes cookei*. 17 ectoparasites have been documented to occur across the range of western spotted skunks – *S. gracilis* and *S. leucoparia* (Mead 1963; Verts et al. 2001; Ford et al. 2004), including six fleas (*Cternocephalides felis*, *Echidnophaga gallinacea*, *Foxella ignota*, *Hoplopsyllus anomalus*, *Oropsylla montanus*, and *Pulex simulans*), the louse *Neotrichodectes mephitidis*, eight mites (*Andolaelaps fahrenheitzi*, *Echinonyssus staffordi*, *Eucheyletia bishoppi*, *Eulaelaps stabularis*, *Euryparasitus* sp., *Haemogamasus reidi*, *Pygmephorus designatus*, and *Xenoryctes lattiporus*), and two ticks (*Amblyomma americanum* and *D. variabilis*).

There are a few shortfalls from previous research. A majority of research done concerning the ectoparasites of spotted skunks have either focused on one specific group of parasites (e.g., ticks, fleas) or one location (e.g., Florida, California Islands). Very few research papers have focused either on a large portion of the skunk's range or on a complete ectoparasite investigation. This creates a bias towards heterogeneous sampling efforts and

incomplete sampling (Wells et al. 2015). This study aims to avoid bias by examining skunks collected across the range and document a comprehensive list of ectoparasites present on spotted skunks throughout their range.

METHODS AND MATERIALS

Host acquisition

To obtain a large enough sample size of spotted skunk specimens, various methods were used. Previous research at Angelo State University by Dr. Robert Dowler resulted in numerous spotted skunk specimens that were collected and stored in freezers for examination. Additional specimens were obtained from road-kill salvages, incidental kills associated with wildlife control trapping, and animals that died in wildlife rehabilitation facilities. We sent donation requests to research facilities, animal control centers, wildlife trapping control centers, natural history museums, and wildlife rehabilitation facilities within the range of spotted skunks.

We were able to examine 73 spotted skunks for ectoparasites from seven states (Figure 1.1), 40 of which were plains spotted skunks from Harris County, Texas. These skunks were trapped in Tomahawk live traps, anesthetized, and examined for parasites by a research team before being radio-collared and released (Perkins et al. 2021). The remaining 33 hosts were examined post-mortem. A portion of these 73 hosts were also examined for endoparasites (Appendix A), discussed in Chapter 2.

Parasitic examination and identification

For the specimens collected from the Harris County project, researchers performed three one-minute manual examinations while the host was under anesthesia. The head, dorsum and tail, and ventral side were checked and any parasites were removed using forceps. Any parasites that fell off the host were collected from a tarp placed on top of the work area (Perkins et al. 2021).

For the specimens collected post-mortem, we used the sides of forceps to rub the body of the specimen to dislodge any ectoparasites in the fur (Galbreath et al. 2019). We then closely examined the specimen for any parasites imbedded in the skin that were not dislodged, along with checking the ears, between paw pads, and other hard-to-reach areas of the body. Collected parasites were preserved in 80% ethanol to maximize the quality of identification by morphological means and for possible future molecular analysis (Galbreath et al. 2019). We used a selection of various dichotomous keys to identify the parasites as close to species level as possible (Strandtmann 1949; Hopkins and Rothschild 1953; Price et al. 2003; Guzman-Cornejo and Robbins 2010; Mathison and Pritt 2014; Dubie et al. 2017). Vouchers of hosts (Appendix B) were deposited primarily in the Angelo State Natural History Collections with remaining hosts deposited in other natural history collections based on agreements with donors.

RESULTS

We identified 10 ectoparasite species, collected from 62 hosts across six states. The most common species of parasites (Table 1.2) were lice identified as *Neotrichodectes* sp., ticks identified as *Ixodes texanus*, and the flea *Pulex irritans*.

We identified five species of fleas from 18 hosts across four states (Table 1.3). *Ctenophthalmus* sp. and *Orchopeas howardii* were identified on plains spotted skunks from Arkansas. Three species of fleas were identified on spotted skunks from Texas: *E. gallinacea* on a desert spotted skunk, *P. irritans* on eight plains spotted skunks, and *Xenopsylla cheopis* from three plains spotted skunks.

One genus of louse, *Neotrichodectes* sp., was identified on 45 hosts across all three spotted skunk species in Florida, South Dakota, and Texas (Table 1.4). We were unable to identify the specific species in the genus, but we did determine all of the lice were the same species.

We found mites on four plains spotted skunks, one in Arkansas and three in Texas (Table 1.5). Unfortunately, three out of four of the samples were lost or damaged during the identification process so were unable to be identified. The one sample from Texas was *Haemolaelaps glasgowi*.

Three species of ticks were identified from plains spotted skunks across four states. *Rhipicephalus sanguineus* was identified on five hosts from South Dakota and Texas (Table 1.6). *Ixodes texanus* was found on 10 hosts from Arkansas and Texas. Eight hosts from Arkansas, Texas, and Virginia were found with immature *Ixodes* sp. We were able to identify them to genus level based on their anal groove, but have not identified them to species level.

DISCUSSION

We were unable to identify all of the collected parasites beyond the ordinal level. This depended on a variety of circumstances, including damaged or degraded specimens due to the nature of how the specimens were collected. Future work will be needed to identify these parasites, dependent on the specimen quality.

We identified five species of fleas from 18 hosts across four states. *Ctenophthalmus* sp. was identified on one plains spotted skunk from Arkansas in this study, but no previous studies recorded this genus on spotted skunks from the United States. *Orchopeas howardii* was also found on a plains spotted skunk from Arkansas, but has only been recorded on spotted skunks in Georgia (Morlan 1952). Within Arkansas, *O. howardii* has been recorded on numerous species of tree squirrels, wood rats, and opossums (Schiefer and Lancaster 1970).

Three species of fleas were identified on spotted skunks from Texas that have not been previously recorded on spotted skunks in the state: *E. gallinacea* on a desert spotted skunk, *P. irritans* on eight plains spotted skunks, and *X. cheopis* from three plains spotted skunks. *Echidnophaga gallinacea* has previously only been recorded on spotted skunks from California (Verts et al. 2001), Florida (Layne 1971), and Georgia (Morlan 1952). *Pulex irritans* was recorded on spotted skunks from California (Holdenried et al. 1951), and Morlan (1952) recorded both *P. irritans* and *X. cheopis* on spotted skunks in Georgia. *Echidnophaga gallinacea* and *P. irritans* have been recorded on coyotes (*Canis latrans*) throughout Texas and *P. irritans* have been found on swift foxes (*Vulpes velox*) in the Texas Panhandle (Eads 1948; Pence et al. 2004). In Galveston, Texas, *X. cheopis* was recorded on opossums during a study on murine typhus (Blanton et al. 2016).

The single louse genus, *Neotrichodectes*, found on 45 hosts across all three spotted skunk species in Florida, South Dakota, and Texas, was the most common ectoparasite on spotted skunks. Two species in this genus, *N. mephitidis* and *N. osborni*, have been recorded on spotted skunks in California and Georgia (Morlan 1952; Verts et al. 2001). Neither of these species have been recorded on spotted skunks or related taxonomic groups in Texas.

Our one identified mite from a Texas plains spotted skunk was *H. glasgowi*, which has been recorded on spotted skunks from Georgia (Morlan 1952). A considerable number of other mite species have been reported from spotted skunks (Table 1.1) but only *Hirstionyssus staffordi* has been reported in Texas (Whitaker and Wilson 1974). A future study focusing on mites of spotted skunks would be worthwhile.

The tick, *R. sanguineus*, was identified on five hosts from South Dakota and Texas, but has not been recorded on spotted skunks in the United States previously. They are noted to have a worldwide distribution and commonly parasitize domestic dogs, but can be found on many other taxonomic groups (Gray et al. 2013; Maestas 2019). *Ixodes texanus* was found on 10 hosts from Arkansas and Texas. It has only been recorded on spotted skunks from Utah (Allred et al. 1960) but has been found on swift foxes in South Dakota and raccoons (*Procyon lotor*) and gray foxes (*Urocyon cinereoargenteus*) in Texas (Eads and Menzies 1950; Dharmarajan et al. 2011; Maestas 2019).

We were able to identify 10 ectoparasite species from 62 spotted skunk hosts from six different states. Our study recorded two new ectoparasite species for the genus *Spilogale*: *Ctenophthalmus* sp. and *R. sanguineus*. Additionally, we documented numerous state records in five states: *I. texanus*, and *O. howardi* in Arkansas; *Neotrichodectes* sp. in Florida and South Dakota; *I. texanus*, *R. sanguineus*, *Neotrichodectes* sp., *P. irritans*, *X. cheopis*, and *H.*

glasgowi in Texas pains spotted skunks; and *Neotrichodectes* sp. and *E. gallinacea* in Texas desert spotted skunks.

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TABLE 1.1. Ectoparasite species recorded on spotted skunks (genus *Spilogale*) in past literature throughout their range.

Order	Scientific Name	Distribution	Source
Ixodida	<i>Amblyomma americanum</i>	Georgia, Texas	Morlan 1952; Verts et al. 2001
Ixodida	<i>Amblyomma auricularium</i>	Florida	Mertins et al. 2016
Ixodida	<i>Dermacentor occidentalis</i>	California	Holdenried et al. 1951
Ixodida	<i>Dermacentor variabilis</i>	California, Florida, Georgia, Mississippi	Morlan 1952; Mead 1963; Kinlaw 1995; Bullock 2008
Ixodida	<i>Ixodes bishoppi</i>	Georgia	Morlan 1952
Ixodida	<i>Ixodes cookei</i>	Florida, Georgia, Mississippi	Morlan 1952; Kinlaw 1995; Bullock 2008
Ixodida	<i>Ixodes kingi</i>	California, Utah	Allred et al. 1960; Crooks et al. 2003
Ixodida	<i>Ixodes pacificus</i>	California	Crooks et al. 2003
Ixodida	<i>Ixodes rugosus</i>	California	Holdenried et al. 1951
Ixodida	<i>Ixodes scapularis</i>	Oklahoma	Ellis 1955
Ixodida	<i>Ixodes sculptus</i>	California	Holdenried et al. 1951
Ixodida	<i>Ixodes sp.</i>	California	Holdenried et al. 1951
Ixodida	<i>Ixodes texanus</i>	Utah	Allred et al. 1960
Mesostigmata	<i>Androlaelaps casalis</i>	Georgia	Whitaker and Wilson 1974
Mesostigmata	<i>Androlaelaps fahrenheitsi</i>	Georgia, Oregon	Whitaker and Wilson 1974; Verts et al. 2001
Mesostigmata	<i>Androlaelaps geomys</i>	Georgia	Whitaker and Wilson 1974
Mesostigmata	<i>Echinonyssus staffordi</i>	Oregon	Verts et al. 2001
Mesostigmata	<i>Eucheyletia bishoppi</i>	Oregon	Verts et al. 2001
Mesostigmata	<i>Eulaelaps stabularis</i>	Georgia, Oregon	Whitaker and Wilson 1974; Morlan 1952
Mesostigmata	<i>Euryparasitus sp.</i>	Oregon	Verts et al. 2001
Mesostigmata	<i>Haemogamasus reidi</i>	Oregon	Verts et al. 2001
Mesostigmata	<i>Haemolaelaps geomys</i>	Georgia	Morlan 1952
Mesostigmata	<i>Haemolaelaps glasgowi</i>	Georgia	Morlan 1952
Mesostigmata	<i>Haemolaelaps megaventralis</i>	Georgia	Morlan 1952
Mesostigmata	<i>Hirstionyssus staffordi</i>	Georgia, Oklahoma, Texas, Utah	Whitaker and Wilson 1974; Morlan 1952
Mesostigmata	<i>Ornithonyssus bacoti</i>	Georgia	Morlan 1952
Mesostigmata	<i>Xenoryctes lattiporus</i>	Oregon	Verts et al. 2001
Phthiraptera	<i>Neotrichodectes mephitidis</i>	California	Verts et al. 2001
Phthiraptera	<i>Neotrichodectes osborni</i>	Georgia	Morlan 1952
Phthiraptera	<i>Trichodectes mephitidis</i>	California	Holdenried et al. 1951
Phthiraptera	<i>Trichodectes osborni</i>	Texas	Mayberry et al. 2000
Prostigmata	<i>Pygmephorus designatus</i>	Oregon	Verts et al. 2001

TABLE 1.1. continued

Order	Scientific Name	Distribution	Source
Siphonaptera	<i>Anomiopsyllus nudata</i>	New Mexico	Ford et al. 2004
Siphonaptera	<i>Ctenosephalides felis</i>	Arkansas, California, Florida, Georgia	Morlan 1952; Layne 1971; Verts et al. 2001; McAllister et al. 2017
Siphonaptera	<i>Echidnophaga gallinacea</i>	California, Florida, Georgia	Morlan 1952; Layne 1971; Verts et al. 2001
Siphonaptera	<i>Foxella ignota</i>	California	Verts et al. 2001
Siphonaptera	<i>Hoplopsyllus anomalus</i>	California, New Mexico, Utah	Holdenried et al. 1951; Parker and Howell 1959; Ford et al. 2004
Siphonaptera	<i>Hystrihopsylla dippiei</i>	Oregon	Lewis and Maser 1961; Verts et al. 2001
Siphonaptera	<i>Megarhroglossus sp.</i>	Utah	Parker and Howell 1959
Siphonaptera	<i>Nosopsyllus fasciatus</i>	California	Crooks et al. 2003
Siphonaptera	<i>Orchopeas howardi</i>	Georgia	Morlan 1952
Siphonaptera	<i>Orchopeas sexdentatus</i>	California, Utah	Holdenried et al. 1951; Parker and Howell 1959
Siphonaptera	<i>Orchopeas nevadensis</i>		Verts et al. 2001
Siphonaptera	<i>Oropsylla montanus</i>	California, New Mexico, Oregon	Lewis and Maser 1961; Verts et al. 2001; Ford et al. 2004
Siphonaptera	<i>Polygenis gwyni</i>	Florida, Georgia, Mississippi	Morlan 1952; Layne 1971; Bullock 2008
Siphonaptera	<i>Pulex irritans</i>	California, Georgia	Holdenried et al. 1951; Morlan 1952
Siphonaptera	<i>Pulex simulans</i>	Arizona, California	Wilson and Bishop 1966
Siphonaptera	<i>Xenopsylla cheopis</i>	Georgia	Morlan 1952

TABLE 1.2. Percentage of *Spilogale* hosts parasitized by ectoparasite species.
 C=*Ctenophthalmus* sp., E=*Echidnophaga gallinacea*, H=*Haemolaelaps glasgowi*, I=*Ixodes*
 sp., It=*Ixodes texanus*, N=*Neotrichodectes* sp., O=Overall, Oh=*Orchopeas howardi*,
 P=*Pulex irritans*, R=*Rhipicephalus sanguineus*, U=Unidentified, X=*Xenopsylla cheopis*

	C	E	Oh	Fleas				Lice			Mites		Ticks		
				P	X	U	O	N	H	U	O	I	It	R	O
<i>S. interrupta</i>															
Arkansas (n=3)	33	0	33	0	0	33	100	0	0	33	33	33	33	0	66
South Dakota (n=8)	0	0	0	0	0	25	25	25	0	0	0	0	0	12	12
Texas (n=44)	0	0	0	20	7	0	27	84	2	4	7	14	20	9	43
<i>S. leucoparia</i>															
Texas (n=10)	0	10	0	0	0	10	20	50	0	0	0	0	0	0	0
<i>S. putorius</i>															
Alabama (n=2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Florida (n=2)	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0
Mississippi (n=1)	0	0	0	0	0	100	100	0	0	0	0	0	0	0	0
Virginia (n=3)	0	0	0	0	0	0	0	0	0	0	0	33	0	0	33

TABLE 1.3. Flea specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I05	13200	Madison	Arkansas	Unidentified
I26	15923	Scott	Arkansas	<i>Ctenophthalmus</i> sp.
I26	15923	Scott	Arkansas	<i>Orchopeas howardii</i>
I35	15180	Harris	Texas	<i>Pulex irritans</i>
I36	15192	Harris	Texas	<i>Pulex irritans</i>
I37	15218	Harris	Texas	<i>Xenopsylla cheopis</i>
I40	15246	Faulk	South Dakota	Unidentified
I41	15245	Edmunds	South Dakota	Unidentified
I46	15147	Harris	Texas	<i>Pulex irritans</i>
I46	15147	Harris	Texas	<i>Xenopsylla cheopis</i>
I50	15205	Harris	Texas	<i>Pulex irritans</i>
I52	15159	Harris	Texas	<i>Xenopsylla cheopis</i>
I53	15224	Harris	Texas	<i>Pulex irritans</i>
I55	15196	Harris	Texas	<i>Pulex irritans</i>
I56	15207	Harris	Texas	<i>Pulex irritans</i>
I57	15170	Harris	Texas	<i>Pulex irritans</i>
I65	15212	Harris	Texas	<i>Pulex irritans</i>
L01	15654	Tom Green	Texas	Unidentified
L04	9965	Val Verde	Texas	<i>Echidnophaga gallinacea</i>
P11	15250	Claiborne	Mississippi	Unidentified

TABLE 1.4. Louse specimens (all *Neotrichodectes* sp.) collected during our study from examined spotted skunk hosts.

ID	ASK	County	State
I04	11873	Wichita	Texas
I10	15026	Harris	Texas
I12	15020	Harris	Texas
I14	14274	Coleman	Texas
I15	15009	Harris	Texas
I17	15025	Harris	Texas
I23	14004	Harris	Texas
I25	15008	Harris	Texas
I28	15161	Harris	Texas
I29	15921	Brule	South Dakota
I35	15180	Harris	Texas
I36	15192	Harris	Texas
I37	15218	Harris	Texas
I42	15249	Edmunds	South Dakota
I44	15065	Harris	Texas
I45	15083	Harris	Texas
I46	15147	Harris	Texas
I47	15085	Harris	Texas
I48	15211	Harris	Texas
I49	15091	Harris	Texas
I50	15205	Harris	Texas
I52	15159	Harris	Texas
I53	15224	Harris	Texas
I54	15150	Harris	Texas
I55	15196	Harris	Texas
I56	15207	Harris	Texas
I57	15170	Harris	Texas
I58	15203	Harris	Texas
I59	15183	Harris	Texas
I60	15208	Harris	Texas
I61	15209	Harris	Texas
I62	15213	Harris	Texas
I63	15216	Harris	Texas
I64	15219	Harris	Texas
I65	15212	Harris	Texas
I66	15182	Harris	Texas
I67	15195	Harris	Texas
I68	15215	Harris	Texas
I69	15223	Harris	Texas
L01	15654	Tom Green	Texas
L02	13408	Burnet	Texas
L03	7157	Tom Green	Texas
L10	15243	Jeff Davis	Texas
L11	15242	Tom Green	Texas
P08	15237	Santa Rosa	Florida

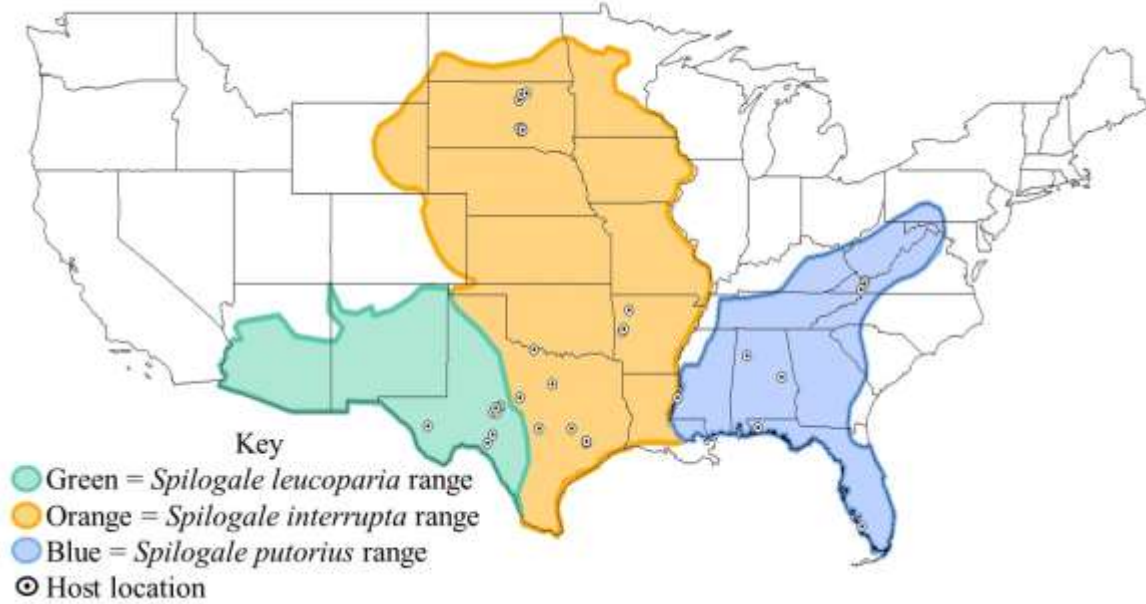
TABLE 1.5. Mite specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I05	13200	Madison	Arkansas	Unidentified
I48	15211	Harris	Texas	<i>Haemolaelaps glasgowi</i>
I53	15224	Harris	Texas	Unidentified
I59	15183	Harris	Texas	Unidentified

TABLE 1.6. Tick specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I10	15026	Harris	Texas	<i>Ixodes</i> sp.
I23	14004	Harris	Texas	<i>Ixodes texanus</i>
I26	15923	Scott	Arkansas	<i>Ixodes</i> sp.
I27	15923	Scott	Arkansas	<i>Ixodes texanus</i>
I28	15161	Harris	Texas	<i>Ixodes</i> sp.
I39	15248	Edmunds	South Dakota	<i>Rhipicephalus sanguineus</i>
I43	15021	Harris	Texas	<i>Ixodes</i> sp.
I43	15021	Harris	Texas	<i>Ixodes texanus</i>
I46	15147	Harris	Texas	<i>Ixodes</i> sp.
I46	15147	Harris	Texas	<i>Ixodes texanus</i>
I48	15211	Harris	Texas	<i>Rhipicephalus sanguineus</i>
I49	15091	Harris	Texas	<i>Ixodes texanus</i>
I51	15119	Harris	Texas	<i>Ixodes texanus</i>
I55	15196	Harris	Texas	<i>Ixodes texanus</i>
I56	15207	Harris	Texas	<i>Ixodes texanus</i>
I60	15208	Harris	Texas	<i>Ixodes texanus</i>
I61	15209	Harris	Texas	<i>Rhipicephalus sanguineus</i>
I62	15213	Harris	Texas	<i>Ixodes</i> sp.
I63	15216	Harris	Texas	<i>Rhipicephalus sanguineus</i>
I64	15219	Harris	Texas	<i>Ixodes texanus</i>
I65	15212	Harris	Texas	<i>Rhipicephalus sanguineus</i>
I70	15705	Scott	Arkansas	<i>Ixodes</i> sp.
P07	13640	Washington	Virginia	<i>Ixodes</i> sp.

FIG 1.1. Distribution map of ectoparasite necropsied hosts in the United States. Points represent location of necropsied host within their species' range: green = *Spilogale leucoparia*, orange = *Spilogale interrupta*, and blue = *Spilogale putorius*



CHAPTER 2: ENDOPARASITES OF SPOTTED SKUNKS

INTRODUCTION

Spotted skunks (genus *Spilogale*) are small skunks from the family Mephitidae found throughout North and Central America. Spotted skunks are found in wooded habitats, tall-grass prairies, and sometimes rocky lands, usually denning in natural cavities (Kinlaw 1995; Verts et al. 2001). Their omnivorous food habits follow seasonal patterns and availability, with reported diets including insects, bird eggs, small rodents, fruit, and corn (Kinlaw 1995; Verts et al. 2001).

Spotted skunk species have undergone numerous taxonomic changes since first being described by Gray 1865, with the most recent proposal being based on molecular phylogenetic analyses and geographic patterns (Shaffer et al. 2018; McDonough et al. 2021). For this study, we followed the taxonomic recommendations of McDonough et al. (2021) based on the geographic distributions determined by the researchers. We have three species represented in this study: *Spilogale leucoparia*, *S. putorius*, and *S. interrupta*. The desert spotted skunk (*S. leucoparia*) has a proposed range bound by the temperate grasslands of the southern Rocky Mountains, the Trans-Mexican Volcanic Belt, the Colorado River, Mojave Desert, and the Great Plains. The Alleghenian spotted skunk (*S. putorius*) had an initial range proposed by Howell (1906) that included Mississippi, Alabama, western Georgia, western South Carolina, and northern Virginia. The newly proposed range includes the Appalachian Mountains and is bound by the Allegheny plateau, the Gulf of Mexico, the Mississippi River, and the Atlantic Coastal Plain. The southern Canadian forests, the Tamaulipan biotic province, the Rocky Mountains, and the Mississippi River are the boundaries for the proposed range of the plains spotted skunk, *S. interrupta* (McDonough et al. 2021).

To date, few, if any, comprehensive studies have reported on the extent of parasitic fauna found in spotted skunks across their ranges. There have been 29 species from four phyla of endoparasites documented in the genus *Spilogale* in the United States (Table 2.1). Most research has focused on either a single state or area of the spotted skunk's range, or the focus was on a particular parasite species (or group) and the researchers were able to obtain a spotted skunk to search for their target parasite.

Within the plains and Alleghenian spotted skunk ranges, there have been reports of several helminths: *Capillaria hepatica*, *Oochoristica pedunculata*, *O. wallacei*, *O. oklahomensis*, and *Skrjabingylus chitwoodorum* (Kinlaw 1995; Higdon and Gompper 2020). In Arkansas, Lesmeister et al. (2008) collected 82 fecal samples from plains spotted skunks and examined them for parasites. Seven genera of nematodes were found, including *Baylisascaris columnaris*, *Capillaria aerophila*, *C. procyonis*, *C. putorii*, *Crenosoma* sp., *Molineus* sp., *Physaloptera* sp., *Placoconus lotoris*, and *Skrjabingylus* sp. Three genera of protozoan parasites were also reported: *Eimeria mephitidis*, *Isospora sengeri*, *I. spilogales*, and *Sarcocystis* sp. (Lesmeister et al. 2008).

In Minnesota, Erickson (1946) examined eastern spotted skunks and mustelids for parasitic worms. Within the spotted skunk specimens, two nematodes (*Ascaris columnaris* and *Physaloptera maxillaris*), three cestodes (*Mesocestoides* sp., *M. latus*, and *M. variabilis*), and two trematodes (*Alaria taxideae* and *A. mustelae*) were found.

From 1953-1961, Zimmerman et al. (1962) examined various species of wildlife in Iowa for *Trichinella spiralis* which is responsible for trichinosis. They examined 406 eastern spotted skunks and found seven of them to be infected. Three of the seven infected had over

4,000 larvae in the tissue, with a maximum of 30,375. The remaining four contained less than 40 larvae.

In western spotted skunks, now considered two species – *S. gracilis* and *S. leucoparia*, Verts et al. (2001), reported the endoparasites *S. chitwoodorum*, *O. pedunculata*, and *Mesocestoides corti* across their range, in addition to the larvae of botflies (*Cuterebra* sp.). Voge (1955) examined the cestodes found within vertebrates in California, including the western spotted skunk (*S. gracilis*) and found three cestode species: *M. corti*, *O. oklahomensis*, and *O. pedunculata*.

There are a few shortfalls from previous research. A majority of research done concerning the parasites of spotted skunks have either focused on one specific group of parasites (e.g., cestodes, nematodes) or one location (e.g., Florida, California Islands). Very few research papers have focused either on a large portion of the skunk's range or on a complete parasite investigation. This creates a bias towards heterogeneous sampling efforts and incomplete sampling (Wells et al. 2015). This study aims to avoid bias by examining skunks collected across their range and document endoparasites present in three species of spotted skunks, *S. putorius*, *S. leucoparia*, and *S. interrupta*.

METHODS AND MATERIALS

Host acquisition

To obtain a large enough sample size of spotted skunk specimens, various methods were used. Previous research at ASU by Dr. Robert Dowler resulted in numerous spotted skunk specimens that were collected or salvaged and stored in freezers for examination. Additional specimens were obtained from road-kill salvages, incidental kills associated with wildlife control trapping, and animals that died in wildlife rehabilitation facilities. We sent donation requests to research facilities, animal control centers, wildlife trapping control centers, natural history museums, and wildlife rehabilitation facilities within the range of spotted skunks.

Parasitic examination and identification

We were able to examine 49 spotted skunks for endoparasites from nine states (Figure 2.1). A portion of these 49 hosts were also examined for ectoparasites (Appendix A), discussed in Chapter 1. Some spotted skunk necropsies were performed by Hannah Jones prior to the beginning of my thesis studies. Data on the endoparasites she collected are included in this study. We examined the body cavity, mesenteries, digestive tract, nasal cavity, organs, and muscle for endoparasites (Galbreath et al. 2019). When possible, we collected fecal samples and Nobuto blood filter strips, although these were not analyzed in this study.

Each organ and portion of the gastrointestinal (GI) tract were examined separately in their own petri dish by cutting a slit in one side, using a microscope slide to scrape the walls and dislodge any endoparasites, and then searching the contents by eye under a dissecting microscope (Galbreath et al. 2019). To find smaller parasites that may have been missed by the naked eye, the contents within an organ were placed in a petri dish with water and stirred;

the contents at the bottom of the petri dish would contain parasites, while the other unwanted materials, such as plant parts or food items, would float. This top layer would be carefully removed and more water would be added to clear the sample.

Collected parasites were preserved in 80% ethanol to maximize the quality of identification using morphological means and allow potential future molecular analyses (Galbreath et al. 2019). Identifications were made using available keys and a portion of specimens were sent to Dr. John E. Ubelaker, Southern Methodist University, for assistance in morphological identification. Vouchers of hosts (Appendix B) were deposited primarily in the Angelo State Natural History Collections with remaining hosts deposited in other natural history collections based on agreements with donors. Helminth vouchers will be deposited in the Harold W. Manter Laboratory of Parasitology, University of Nebraska State Museum, Lincoln, Nebraska.

RESULTS

We identified nine endoparasite species, collected from 37 hosts across nine states. Nematodes were the most common endoparasite found in each spotted skunk species (Table 2.2), with five different species being identified from 21 hosts across all nine states.

We identified two species of acanthocephalans (Table 2.3): *Macracanthorhynchus ingens* from plains and Alleghenian spotted skunks in Alabama, Virginia, and Texas; and *Pachysentis canicola* in an Arkansas plains spotted skunk and four desert spotted skunks from Texas.

For cestodes (Table 2.4), the adult tapeworms were identified as *M. variabilis* from South Dakota plains spotted skunks and Alleghenian spotted skunks from Alabama and Virginia. We identified encysted forms of *Taenia* sp. in the intestinal track of plains spotted skunks from Arkansas and South Dakota, and in the body cavity and mesenteries from desert spotted skunks in Texas.

We identified five species of nematodes from 21 hosts (Table 2.5). *Skrjabinylus chitwoodorum*, the sinus roundworm found in the cranium, was found in six plains spotted skunks from Arkansas, Nebraska, South Dakota, and Texas. One plains spotted skunk from Iowa was found with *B. columnaris*. *Capillaria putorii* was found in a South Dakota plains spotted skunk. We identified *P. maxillaris* in a plains spotted skunk from Arkansas. Two Alleghenian spotted skunks from Alabama and Florida were found with *C. mephitidis*.

DISCUSSION

We were unable to identify some of the collected parasites beyond higher taxonomic levels. This depended on a variety of circumstances, including damaged or degraded specimens. We plan to continue working to identify these parasites, dependent on the specimen quality.

For acanthocephalans, we documented *M. ingens* from plains spotted skunks in Texas and Alleghenian spotted skunks from Alabama and Virginia. *Macracanthorhynchus ingens* has been recorded from the Alleghenian spotted skunk in Florida (Harris et al. 2021) and previously from desert spotted skunks in Texas (Neiswenter et al. 2006); however, this is the first report of this species in the plains spotted skunk. We also documented *P. canicola* in plains spotted skunks from Arkansas, a new record for this host. In the desert spotted skunk, *P. canicola* has been previously recorded in Texas from desert spotted skunks, hog-nosed skunks (*Conepatus leuconotus*), and striped skunks (*Mephitis mephitis*) (Neiswenter et al. 2006).

Adult *M. variabilis* (Class Cestoda) were found in plains and Alleghenian spotted skunks in South Dakota, Alabama, and Virginia. Previous records of *M. variabilis* have been reported in spotted skunks from Minnesota (Erickson 1946) and Oklahoma (Self and McKnight 1950), as well as other carnivores including raccoons (*Procyon lotor*) in Alabama (Johnson 1970). We found encysted forms of *Taenia* sp. in plains and desert spotted skunks from Arkansas, South Dakota, and Texas. To our knowledge, this is the first record of the genus *Taenia* being found in spotted skunks.

Nematodes had the highest diversity with five species identified from 24 hosts. *Skryjabinngylus chitwoodorum*, the sinus roundworm found in the cranium, was present in six

plains spotted skunks from Arkansas, Nebraska, South Dakota, and Texas. The recorded distribution of *S. chitwoodorum* in spotted skunks is Arkansas (Tumlison and Tumlison 2019), California (Mead 1963), Mississippi (Bullock 2008), Oklahoma (Hill 1939), South Dakota (Denham et al. 2021), and Texas (Mayberry et al. 2000). Hosts infected with this sinus roundworm are noted to exhibit abnormal behavior that can increase the host's likelihood of death due to decreases in overall health and increases in risk of predation (Hughes et al. 2018; Higdon and Gompper 2020).

Our plains spotted skunk record of *B. columnaris* from Iowa is new for the state, but it has been recorded in spotted skunks in Arkansas (Lesmeister et al. 2008) and Minnesota (Erickson 1946). Moreover, it has been found in groundhogs (*Marmota monax*) and eastern cottontails (*Sylvilagus floridanus*) in Iowa (Kazacos 2001). Our record of *C. putorii* in a South Dakota plains spotted skunk has been recorded previously only in spotted skunks from Arkansas (Lesmeister et al. 2008). We identified *P. maxillaris* in a plains spotted skunk from Arkansas, which has only been recorded in spotted skunks from Florida (Harris et al. 2021), Minnesota (Erickson 1946), and Texas (Mayberry et al. 2000; Neiswenter et al. 2006); the parasite has been recorded in raccoons (*P. lotor*) in Arkansas (Richardson et al. 1992). The records for *C. mephitidis* in Alleghenian spotted skunks were the first for Alabama and Florida, but previously had been recorded in *S. gracilis* from California (Erickson 1946; Voge 1956).

We were able to identify 10 endoparasite species from 37 spotted skunk hosts from nine different states. Our study recorded one new endoparasite species for the genus *Spilogale*: *Taenia* sp. from plains spotted skunks in Arkansas, South Dakota, and Texas. Additionally, we had numerous state records in eight states: Alabama Alleghenian spotted

skunks had first records of *M. ingens*, *C. mephitidis*, and *M. variabilis*; Arkansas plains spotted skunks had first records of *P. canicola*, *P. maxillaris*, and *Taenia* sp.; Iowa plains spotted skunks had a first record for *B. columnaris*; Florida spotted skunks (*S. putorius ambarvalis*) had a first record for *C. mephitidis*; Nebraska plains spotted skunks had a first record for *S. chitwoodorum*; South Dakota plains spotted skunks had first records for *C. putorii*, *M. variabilis*, and *Taenia* sp.; Texas desert spotted skunks had a first record of *Taenia* sp.; and Virginia Alleghenian spotted skunks had first records for *M. ingens* and *M. variabilis*.

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TABLE 2.1. Endoparasite species recorded on spotted skunks (genus *Spilogale*) in past literature throughout their range.

Phylum	Scientific Name	Distribution	Source
Acanthocephala	<i>Acanthocephala</i> sp.	Minnesota, Texas	Erickson 1946; Mayberry et al. 2000
Acanthocephala	<i>Centrorhynchus conspectus</i>	Virginia	Richardson and Nickol 1995; Yabsley and Noblet 1999
Acanthocephala	<i>Centrorhynchus wardae</i>	Virginia	Holloway 1958
Acanthocephala	<i>Macracanthorhynchus ingens</i>	Florida, Texas	Neiswenter et al. 2006; Harris et al. 2021
Acanthocephala	<i>Pachysentis canicola</i>	Texas	Neiswenter et al. 2006
Nematoda	<i>Ascaris columnaris</i>	Minnesota	Erickson 1946
Nematoda	<i>Baylisacaris columnaris</i>	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Capillaria aerophila</i>	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Capillaria hepatica</i>	Florida, Mississippi	Layne and Winegarner 1971; Bullock 2008
Nematoda	<i>Capillaria procyonis</i>	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Capillaria putorii</i>	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Crenosoma mephitidis</i>	California	Erickson 1946; Voge 1956
Nematoda	<i>Crenosoma</i> sp.	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Molineus</i> sp.	Arkansas, Texas	Mayberry et al. 2000; Lesmeister et al. 2008
Nematoda	<i>Physaloptera maxillaris</i>	Florida, Minnesota, Texas	Erickson 1946; Harris et al. 2021
Nematoda	<i>Physaloptera</i> sp.	Arkansas, Texas	Neiswenter et al. 2006; Lesmeister et al. 2008
Nematoda	<i>Placoconus lotoris</i>	Arkansas	Lesmeister et al. 2008
Nematoda	<i>Skrjabinogylus chitwoodorum</i>	Arkansas, California, Mississippi, Oklahoma, South Dakota, Texas	Hill 1939; Mead 1963; Mayberry et al. 2000; Bullock 2008; Tumilson and Tumilson 2019; Denham et al. 2021
Nematoda	<i>Skrjabinogylus</i> sp.	Arkansas	Kirkland and Kirkland 1983
Nematoda	<i>Trichinella spiralis</i>	Iowa, Virginia	Zimmermann et al. 1959; Solomon and Warner 1969
Platyhelminthes	<i>Alaria taxideae</i>	Minnesota	Erickson 1946
Platyhelminthes	<i>Alaria mustelae</i>	Minnesota	Erickson 1946
Platyhelminthes	<i>Mathevotaenia mephitis</i>	Texas	Neiswenter et al. 2006
Platyhelminthes	<i>Mesocestoides corti</i>	California	Voge 1955
Platyhelminthes	<i>Mesocestoides latus</i>	Minnesota	Erickson 1946
Platyhelminthes	<i>Mesocestoides</i> sp.	Minnesota, Texas	Erickson 1946; Mayberry et al. 2000
Platyhelminthes	<i>Mesocestoides variabilis</i>	Minnesota, Oklahoma	Erickson 1946; Self and McKnight 1950
Platyhelminthes	<i>Nanophyetus salmincola</i>	Oregon	Schlegel 1969

TABLE 2.1. continued

Phylum	Scientific Name	Distribution	Source
Platyhelminthes	<i>Oochoristica oklahomensis</i>	California, Mississippi, Oklahoma	Chandler 1952; Voge 1955; Bullock 2008
Platyhelminthes	<i>Oochoristica pedunculata</i>	California, Mississippi	Voge 1955; Bullock 2008
Platyhelminthes	<i>Oochoristica</i> sp.	Texas	Mayberry et al. 2000
Platyhelminthes	<i>Oochoristica wallacei</i>	Minnesota, Mississippi	Chandler 1952; Bullock 2008
Platyhelminthes	<i>Spirometra</i> sp.	Florida	Harris et al. 2021
Protozoa	<i>Eimeria mephitidis</i>	Arkansas	Lesmeister et al. 2008
Protozoa	<i>Isospora sengeri</i>	Arkansas, Florida	Kinlaw 1995; Lesmeister et al. 2008
Protozoa	<i>Isospora spilogales</i>	Arkansas, Florida	Kinlaw 1995; Lesmeister et al. 2008
Protozoa	<i>Sarcocystis</i> sp.	Arkansas	Lesmeister et al. 2008

TABLE 2.2. Percentage of *Spilogale* hosts parasitized by endoparasite species.
 B=*Baylisascaris columnaris*, Cm=*Crenosoma mephitidis*, Cp=*Capillaria putorii*,
 Mi=*Macracanthorhynchus ingens*, M=*Mesocestoides variabilis*, O=Overall,
 P=*Pachysentis canicola*, Pm=*Physaloptera maxillaris*, S=*Skrjabinigylus chitwoodorum*,
 T=*Taenia* sp., U=Unidentified.

	Acanthocephalans					Cestodes				Nematodes				
	Mi	P	O	M	T	U	O	B	Cp	Cm	Pm	S	U	O
<i>S. interrupta</i>														
Arkansas (n=1)	0	100	100	0	100	0	100	0	0	0	100	100	0	100
Iowa (n=1)	0	0	0	0	0	100	100	100	0	0	0	0	0	100
Nebraska (n=1)	0	0	0	0	0	0	0	0	0	0	0	100	0	100
South Dakota (n=16)	0	0	0	6	6	12	25	0	6	0	0	19	31	56
Texas (n=10)	30	0	30	0	0	10	10	0	0	0	0	10	20	30
<i>S. leucoparia</i>														
Texas (n=9)	0	44	44	0	22	22	44	0	0	0	0	0	33	33
<i>S. putorius</i>														
Alabama (n=3)	66	0	66	33	0	0	33	0	0	33	0	0	0	33
Florida (n=4)	0	0	0	0	0	25	25	0	0	25	0	0	0	25
Mississippi (n=1)	0	0	0	0	0	100	100	0	0	0	0	0	100	100
Virginia (n=3)	33	0	33	33	0	0	33	0	0	0	0	0	33	33

TABLE 2.3. Acanthocephalan specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I05	13200	Madison	Arkansas	<i>Pachysentis canicola</i>
I11	13637	Burleson	Texas	<i>Macracanthorhynchus ingens</i>
I17	15025	Harris	Texas	<i>Macracanthorhynchus ingens</i>
I38	15236	Parker	Texas	<i>Macracanthorhynchus ingens</i>
L02	13408	Burnet	Texas	<i>Pachysentis canicola</i>
L07	15924	Sutton	Texas	<i>Pachysentis canicola</i>
L11	15242	Tom Green	Texas	<i>Pachysentis canicola</i>
L12	15241	Tom Green	Texas	<i>Pachysentis canicola</i>
P01	12466	Cleburne	Alabama	<i>Macracanthorhynchus ingens</i>
P05	13635	Fayette	Alabama	<i>Macracanthorhynchus ingens</i>
P07	13640	Washington	Virginia	<i>Macracanthorhynchus ingens</i>

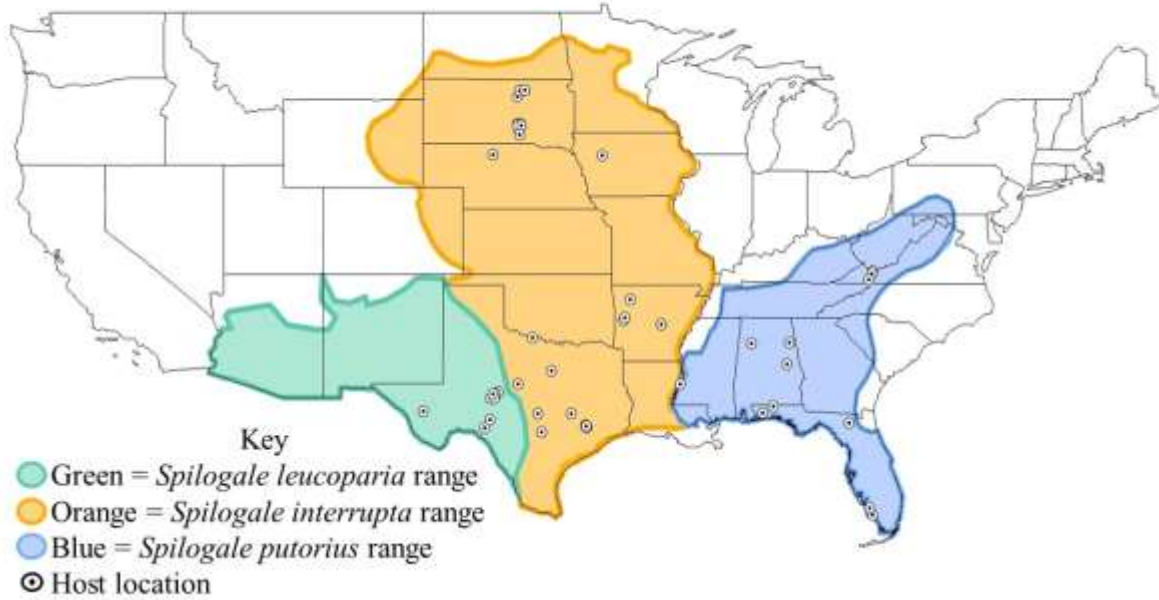
TABLE 2.4. Cestode specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I03	11929	Sac	Iowa	Unidentified
I07	11870	Brule	South Dakota	Unidentified
I18	15023	Harris	Texas	Unidentified
I24	15626	Brule	South Dakota	<i>Mesocestoides variabilis</i>
I41	15245	Edmunds	South Dakota	Unidentified
L01	15654	Tom Green	Texas	Unidentified
L08	15235	Tom Green	Texas	Unidentified
P01	12466	Cleburne	Alabama	<i>Mesocestoides variabilis</i>
P02	13636	Collier	Florida	Unidentified
P04	13638	Tazewell	Virginia	<i>Mesocestoides variabilis</i>
P11	15250	Claiborne	Mississippi	Unidentified
I01	12461	Brule	South Dakota	<i>Taenia</i> sp.
I05	13200	Madison	Arkansas	<i>Taenia</i> sp.
L05	12465	Comal	Texas	<i>Taenia</i> sp.
L06	15920	Tom Green	Texas	<i>Taenia</i> sp.

TABLE 2.5. Nematode specimens collected during our study from examined spotted skunk hosts.

ID	ASK	County	State	Scientific name
I01	12461	Brule	South Dakota	<i>Capillaria putorii</i>
I02	12462	Brule	South Dakota	Unidentified
I03	11929	Sac	Iowa	<i>Baylisascaris columnaris</i>
I05	13200	Madison	Arkansas	<i>Physaloptera maxillaris</i>
I05	13200	Madison	Arkansas	<i>Skrjablingylus chitwoodorum</i>
I06	11881	Cherry	Nebraska	<i>Skrjablingylus chitwoodorum</i>
I07	11870	Brule	South Dakota	Unidentified
I07	11870	Brule	South Dakota	<i>Skrjablingylus chitwoodorum</i>
I08	11871	Brule	South Dakota	<i>Skrjablingylus chitwoodorum</i>
I09	11872	Brule	South Dakota	<i>Skrjablingylus chitwoodorum</i>
I12	15020	Harris	Texas	<i>Skrjablingylus chitwoodorum</i>
I14	14274	Coleman	Texas	Unidentified
I22	13423	Brule	South Dakota	Unidentified
I24	15626	Brule	South Dakota	Unidentified
I38	15236	Parker	Texas	Unidentified
I41	15245	Edmunds	South Dakota	Unidentified
L10	15243	Jeff Davis	Texas	Unidentified
L11	15242	Tom Green	Texas	Unidentified
L12	15241	Tom Green	Texas	Unidentified
P01	12466	Cleburne	Alabama	<i>Crenosoma mephitidis</i>
P03	13641	Okaloosa	Florida	<i>Crenosoma mephitidis</i>
P07	13640	Washington	Virginia	Unidentified
P11	15250	Claiborne	Mississippi	Unidentified

FIG 2.1. Distribution map of endoparasite necropsied hosts in the United States. Points represent location of necropsied host within their species' range: green = *Spilogale leucoparia*, orange = *Spilogale interrupta*, and blue = *Spilogale putorius*



Appendix A. Summary of spotted skunk (*Spilogale*) hosts checked for ectoparasites and endoparasites. Gastrointestinal condition (GI Cond) is based on a scale of 0 to 5, 0 being poor, 5 being excellent condition, and X not being recorded.

Y = Yes, N = No, blank does not apply

ID	ASK	Ectoparasites						Endoparasites					
		Checked	Found	Flea	Lice	Mite	Tick	Checked	GI Cond	Found	Acanthocephalan	Cestode	Nematode
I01	12461	N						Y	X	Y	N	Y	Y
I02	12462	N						Y	X	Y	N	N	Y
I03	11929	N						Y	X	Y	N	Y	Y
I04	11873	Y	Y	N	Y	N	N	Y	X	Y	N	N	N
I05	13200	Y	Y	Y	N	Y	N	Y	X	Y	Y	N	Y
I06	11881	N						Y	X	Y	N	N	Y
I07	11870	N						Y	X	Y	N	Y	Y
I08	11871	N						Y	X	Y	N	N	Y
I09	11872	N						Y	X	Y	N	N	Y
I10	15026	Y	Y	N	Y	N	Y	N	X				
I11	13637	Y	N	N	N	N	N	Y	3	Y	Y	N	N
I12	15020	Y	Y	N	Y	N	N	Y	0	Y	N	N	Y
I13	15019	Y	N	N	N	N	N	N	X				
I14	14274	Y	Y	N	Y	N	N	Y	3	Y	N	N	Y
I15	15009	Y	Y	N	Y	N	N	N	X				
I16	15006	N						Y	2	Y	N	N	N
I17	15025	Y	Y	N	Y	N	N	Y	2	Y	Y	N	N
I18	15023	Y	N	N	N	N	N	Y	X	Y	N	Y	N
I19	15628	Y	N	N	N	N	N	Y	4	N	N	N	N
I20	15627	Y	N	N	N	N	N	Y	3	N	N	N	N
I21	13424	Y	N	N	N	N	N	Y	4	N	N	N	N
I22	13423	N						Y	2	Y	N	N	Y
I23	14004	Y	Y	N	Y	N	Y	N	X				
I24	15626	N						Y	3	Y	N	Y	Y
I25	15008	Y	Y	N	Y	N	N	N	X				
I26	15923	Y	Y	Y	N	N	Y	N	X				
I27	15923	Y	Y	N	N	N	Y	N	X				
I28	15161	Y	Y	N	Y	N	Y	N	0				
I29	15921	Y	Y	N	Y	N	N	Y	2	N	N	N	N
I30	15922	N						Y	3	N	N	N	N
I31	15926	N						N	0				
I32	15928	N						N	0				
I33	15927	N						N	0				
I34	15929	N						N	0				
I35	15180	Y	Y	Y	Y	N	N	N	0				
I36	15192	Y	Y	Y	Y	N	N	Y	2	N	N	N	N
I37	15218	Y	Y	Y	Y	N	N	Y	3	N	N	N	N
I38	15236	Y	N	N	N	N	N	Y	2	Y	Y	N	Y
I39	15248	Y	Y	N	N	N	Y	Y	4	N	N	N	N
I40	15246	Y	Y	Y	N	N	N	Y	2	N	N	N	N
I41	15245	Y	Y	Y	N	N	N	Y	4	Y	N	Y	Y
I42	15249	Y	Y	N	Y	N	N	Y	5	N	N	N	N
I43	15021	Y	Y	N	N	N	Y	N	X				
I44	15065	Y	Y	N	Y	N	N	N	X				

Appendix A. continued

ID	ASK	Ectoparasites						Endoparasites					
		Checked	Found	Flea	Lice	Mite	Tick	Checked	GI Cond	Found	Acanthocephalan	Cestode	Nematode
I45	15083	Y	Y	N	Y	N	N	N	X				
I46	15147	Y	Y	Y	Y	N	Y	N	X				
I47	15085	Y	Y	N	Y	N	N	N	X				
I48	15211	Y	Y	N	Y	Y	Y	N	X				
I49	15091	Y	Y	N	Y	N	Y	N	X				
I50	15205	Y	Y	Y	Y	N	N	N	X				
I51	15119	Y	Y	N	N	N	Y	N	X				
I52	15159	Y	Y	Y	Y	N	N	N	X				
I53	15224	Y	Y	Y	Y	Y	N	N	X				
I54	15150	Y	Y	N	Y	N	N	N	X				
I55	15196	Y	Y	Y	Y	N	Y	N	X				
I56	15207	Y	Y	Y	Y	N	Y	N	X				
I57	15170	Y	Y	Y	Y	N	N	N	X				
I58	15203	Y	Y	N	Y	N	N	N	X				
I59	15183	Y	Y	N	Y	Y	N	N	X				
I60	15208	Y	Y	N	Y	N	Y	N	X				
I61	15209	Y	Y	N	Y	N	Y	N	X				
I62	15213	Y	Y	N	Y	N	Y	N	X				
I63	15216	Y	Y	N	Y	N	Y	N	X				
I64	15219	Y	Y	N	Y	N	Y	N	X				
I65	15212	Y	Y	Y	Y	N	Y	N	X				
I66	15182	Y	Y	N	Y	N	N	N	X				
I67	15195	Y	Y	N	Y	N	N	N	X				
I68	15215	Y	Y	N	Y	N	N	N	X				
I69	15223	Y	Y	N	Y	N	N	N	X				
I70	15705	Y	Y	N	N	N	Y	N	X				
L01	15654	Y	Y	Y	Y	N	N	Y	5	Y	N	Y	N
L02	13408	Y	Y	N	Y	N	N	Y	X	Y	Y	N	N
L03	7157	Y	Y	N	Y	N	N	N	X				
L04	9965	Y	Y	Y	N	N	N	N	X				
L05	12465	N						Y	3	Y	N	Y	N
L06	15920	N						Y	0	Y	N	Y	N
L07	15924	Y	N	N	N	N	N	Y	3	Y	Y	N	N
L08	15235	Y	N	N	N	N	N	Y	4	Y	N	Y	N
L09	15244	Y	Y	N	N	N	N	N	0				
L10	15243	Y	Y	N	Y	N	N	Y	3	Y	N	N	Y
L11	15242	Y	Y	N	Y	N	N	Y	2	Y	Y	N	Y
L12	15241	Y	N	N	N	N	N	Y	3	Y	Y	N	Y
P01	12466	N						Y	X	Y	Y	Y	Y
P02	13636	N						Y	X	Y	N	Y	N
P03	13641	N						Y	3	Y	N	N	Y
P04	13638	Y	N	N	N	N	N	Y	X	Y	N	Y	N
P05	13635	Y	N	N	N	N	N	Y	2	Y	Y	N	N
P06	13639	Y	N	N	N	N	N	Y	2	N	N	N	N
P07	13640	Y	Y	N	N	N	Y	Y	3	Y	Y	N	Y
P08	15237	Y	Y	N	Y	N	N	N	0				
P09	15238	Y	N	N	N	N	N	Y	1	N	N	N	N
P10	15239	N						Y	1	N	N	N	N

Appendix A. continued

ID	ASK	Ectoparasites							Endoparasites				
		Checked	Found	Flea	Lice	Mite	Tick	Checked	GI Cond	Found	Acanthocephalan	Cestode	Nematode
P11	15250	Y	Y	Y	N	N	N	Y	5	Y	N	Y	Y
P12	13787	Y	N	N	N	N	N	Y	2	N	N	N	N

Appendix B. Spotted skunk (*Spilogale*) host collection data. ID is the necropsy number specific to our study, with the first letter representing the species (I01 = interrupta01, L01 = leucoparia01, P01 = putorius01, etc.). ASK = Angelo State tissue number, ASNHC = Angelo State Natural History Collections

ID	ASK	Museum Deposit	State	County	Location	Date
I01	12461	ASNHC 18195	South Dakota	Brule	Ola, 2.5mi W HWY 50	Fall 2015
I02	12462	ASNHC 18196	South Dakota	Brule	I90/HWY 50 Intersection	Fall 2015
I03	11929	ASNHC 18961	Iowa	Sac	2.8mi W Sac City	Apr 2016
I04	11873	ASNHC 19172	Texas	Wichita	Burkburnette I44 overpass	16 Apr 2017
I05	13200		Arkansas	Madison	Pettigrew	16 Feb 2017
I06	11881	ASNHC 19229	Nebraska	Cherry	Valentine National Wildlife Refuge	20 Feb 2017
I07	11870	ASNHC 19227	South Dakota	Brule	Smith Township	27 Mar 2017
I08	11871	ASNHC 19228	South Dakota	Brule	Smith Township	2 Apr 2017
I09	11872	ASNHC 19230	South Dakota	Brule	Smith Township	27 Mar 2017
I10	15026		Texas	Harris	Hockley	9 Oct 2019
I11	13637		Texas	Burleson	Cooks Point	12 Nov 2018
I12	15020		Texas	Harris	Hockley	22 Sep 2019
I13	15019		Texas	Harris	Hockley	11 Sep 2019
I14	14274	ASNHC 20000	Texas	Coleman	8.5km SW Burkett	1 Feb 2020
I15	15009		Texas	Harris	Hockley	27 May 2019
I16	15006		Texas	Waller	Waller, HWY 290	5 Apr 2019
I17	15025		Texas	Harris	Hockley	9 Oct 2019
I18	15023		Texas	Harris	Hockley	5 Oct 2019
I19	15628		South Dakota	Brule	Pukwana Twp Sec. 11	20 Jan 2020
I20	15627		South Dakota	Brule	Chamberlain	28 Sep 2019
I21	13424	ASNHC 20232	South Dakota	Brule	Union Platt Township	Nov 2018
I22	13423	ASNHC 19396	South Dakota	Brule	Union Platt Township	Nov 2018
I23	14004		Texas	Harris	Hockley	30 July 2019
I24	15626		South Dakota	Brule	Chamberlain	28 Oct 2019
I25	15008		Texas	Harris	Hockley	17 May 2019
I26	15923		Arkansas	Scott	Forest Service Rd 235	10 Jan 2019
I27	15923		Arkansas	Scott	2km SW Tate	29 Feb 2020
I28	15161		Texas	Harris	Hockley	22 Dec 2020
I29	15921		South Dakota	Brule	Cleveland Township	Nov 2020
I30	15922		South Dakota	Gregory	North Gregory	24 Jan 2021
I31	15926		Arkansas	Scott		
I32	15928		Arkansas	Scott		18 Mar 2005
I33	15927		Arkansas	Scott		29 Jul 2007
I34	15929		Arkansas	Scott		23 Sept 2006
I35	15180		Texas	Harris	Hockley	19 Feb 2021
I36	15192		Texas	Harris	Hockley	2 Mar 2021
I37	15218		Texas	Harris	Hockley	20 Apr 2021
I38	15236		Texas	Parker	3.5km N Cresson on US377	6 Apr 2020
I39	15248		South Dakota	Edmunds	Ipswich	4 Aug 2021
I40	15246		South Dakota	Faulk	Saratoga Township	Apr 2020
I41	15245		South Dakota	Edmunds	Cleveland Township	Nov 2020
I42	15249		South Dakota	Edmunds	Ipswich	4 Aug 2021
I43	15021		Texas	Harris	Hockley	6 Oct 2019
I44	15065		Texas	Harris	Hockley	6 Jan 2020
I45	15083		Texas	Harris	Hockley	19 Feb 2020
I46	15147		Texas	Harris	Hockley	25 Nov 2020
I47	15085		Texas	Harris	Hockley	24 Feb 2020
I48	15211		Texas	Harris	Hockley	12 Apr 2021
I49	15091		Texas	Harris	Hockley	10 Mar 2020
I50	15205		Texas	Harris	Hockley	20 Mar 2021
I51	15119		Texas	Harris	Hockley	15 Jun 2020
I52	15159		Texas	Harris	Hockley	16 Dec 2020
I53	15224		Texas	Harris	Hockley	9 Jun 2021
I54	15150		Texas	Harris	Hockley	2 Dec 2020
I55	15196		Texas	Harris	Hockley	18 Mar 2021
I56	15207		Texas	Harris	Hockley	2 Apr 2021
I57	15170		Texas	Harris	Hockley	19 Jan 2021
I58	15203		Texas	Harris	Hockley	19 Mar 2021
I59	15183		Texas	Harris	Hockley	25 Feb 2021
I60	15208		Texas	Harris	Hockley	2 Apr 2021
I61	15209		Texas	Harris	Hockley	6 Apr 2021
I62	15213		Texas	Harris	Hockley	13 Apr 2021

Appendix B. continued

ID	ASK	Museum Deposit	State	County	Location	Date
I63	15216		Texas	Harris	Hockley	18 Apr 2021
I64	15219		Texas	Harris	Hockley	22 Apr 2021
I65	15212		Texas	Harris	Hockley	12 Apr 2021
I66	15182		Texas	Harris	Hockley	25 Feb 2021
I67	15195		Texas	Harris	Hockley	18 Mar 2021
I68	15215		Texas	Harris	Hockley	18 Apr 2021
I69	15223		Texas	Harris	Hockley	9 Jun 2021
I70	15705	ASNHC 20257	Arkansas	Scott	Ouachita National Forest	22 Aug 2005
L01	15654		Texas	Tom Green	Dove Creek	22 Dec 2020
L02	13408	ASNHC 20032	Texas	Burnet	Marble Falls	3 Feb 2019
L03	7157	ASNHC 13003	Texas	Tom Green	San Angelo State Park	10 Nov 2005
L04	9965	ASNHC 16125	Texas	Val Verde	Devils River State Natural Area	10 Feb 2013
L05	12465		Texas	Comal	Gruene	24 Jul 2014
L06	15920		Texas	Tom Green		25 Sep 2021
L07	15924		Texas	Sutton	Sonora; Old Juno Rd	3 Sep 2021
L08	15235		Texas	Tom Green	Miles; 11454 S Douglas Loop	3 Mar 2022
L09	15244		Texas	Tom Green	1.3km N 0.8km E San Angelo	12 Sep 2020
L10	15243		Texas	Jeff Davis	HWY-118 McDonald Observatory	26 Jul 2014
L11	15242		Texas	Tom Green	1.2mi S Junction FW584 and US277	14 Jul 2019
L12	15241		Texas	Tom Green	San Angelo State Park	9 Sep 2019
P01	12466		Alabama	Cleburne	Talladega National Forest	7 Feb 2015
P02	13636	ASNHC 20037	Florida	Collier	HWY 41, Port of the Islands	30 Dec 2014
P03	13641		Florida	Okaloosa	3mi S Laurel Hill	13 Dec 2018
P04	13638		Virginia	Tazewell	901 Fincastle Turnpike	12 Dec 2015
P05	13635	ASNHC 20036	Alabama	Fayette	Rt 102 near Waller Co. line	23 Oct 2018
P06	13639		Virginia	Smyth	Rt 16	3 Dec 2013
P07	13640		Virginia	Washington	Rt 762	16 Oct 2015
P08	15237		Florida	Santa Rosa	HWY 90 W of S Airport Rd	28 Feb 2022
P09	15238		Florida	Collier	Naples	18 Mar 2022
P10	15239		Florida	Columbia	I75 SW Lake City	11 Jan 2020
P11	15250		Florida	Claiborne	Canemount WMA	10 Feb 2022
P12	13787	ASNHC 19242	Alabama	Tallapoosa	Piedmont Research Unit	1 Jul 2019