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SHORT COMMUNICATIONS

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Helminths of the Ocelot from Southern Texas

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ABSTRACT: In the USA, the ocelot (*Leopardus pardalis*) is a highly endangered felid found only in a few remaining vestiges of native thornshrub brushland in the Lower Rio Grande Valley (LRGV) of extreme southern Texas. From 1987–1998, carcasses of 15 adult ocelots that died of vehicular accidents or natural causes were examined for helminths. All cats had 1–8 (mean=3) helminth species. All were infected with 1–101 (mean±SE=32±7) *Toxascaris leonina.* Other helminths from these ocelots were *Alaria marcianae, Brachylaima* sp., *Mesocestoides lineatus, Taenia rileyi, Oncicola canis, Dirofilaria immitis, Physaloptera rara, Ancylostoma tubaeformae, Cylicospirura chevreuxi, Vogeloides felis,* and *Metathelazia californica.* Additionally, two cats had scarring of the aorta with lesions typical of those caused by *Spriocerca lupi,* although larval nematodes were not seen. A clinal variation in size of nearly three orders of magnitude was noted in the diplostomatid trematodes in the small intestine of one adult male ocelot. Despite the differences in size, all specimens appeared morphologically identical and were regarded as *A. marcianae.* Helminth prevalences and abundances, including those of potentially pathogenic species like *D. immitis,* were low. Although a single heartworm infection may have contributed to the death of one ocelot, helminth infections in general seemed to be of no great consequence to this endangered ocelot population. The helminth fauna of ocelots in the LRGV is reflective of that from wild felids in general; all have been reported previously from the bobcat (*Lynx rufus*) and mountain lion (*Puma concolor*) elsewhere in Texas.

Key words: *Alaria marcianae,* helminth survey, *Leopardus pardalis,* ocelot, *Toxascaris leonine,* trematode size variation.

The ocelot (*Leopardus pardalis*) is a bobcat-sized, long-tailed, spotted cat that originally occurred from the southern United States to Argentina; now it is mostly distributed in tropical Latin America and ranges into extreme southern Texas (USA)(Tewes and Schmidly, 1987). The ocelot's preferred habitat of dense chaparral that once blanketed the Lower Rio Grande Valley (LRGV) has been reduced to <5% of the area. Thus, there remains only a remnant of the original ocelot population, from 80–120 individuals (Tewes and Everett, 1986). In the USA, it is considered highly endangered. In most of Latin America, the ocelot is considered endangered because it has been hunted extensively for its commercially valuable spotted pelt (Tewes and Schmidly, 1987).

Helminths of ocelots, many from captive individuals, are listed in Tewes and Schmidly (1987) and more recently in Murray and Gardner (1997). There are 19 identified helminth species reported (Murray and Gardner, 1997), but these records represent isolated necropsies. There has been no survey examining multiple specimens from the same locality or repeated sampling over a long period of time.

From 1987 to 1998 the carcasses of 15 adult ocelots were recovered from southern Texas and were in sufficiently good condition that they could be necropsied for helminths. Herein, we document and evaluate the importance of the helminth fauna of this endangered cat in the LRGV of Texas.

Ocelots examined in this study came from Cameron, Willacy, and Kenedy counties, Texas (25°84′ to 27°64′N, 97°15′ to 98°06′W). Carcasses were collected between 22 October 1987 through 20 October 1998. The majority (n=11) of these

TABLE 1. Prevalence, intensity, and abundance of helminths of the ocelot from southern Texas.

Species (location)[a]	Prevalence		Intensity mean ± SE[c]	Abundance mean ± SE	Range	Total[d]
	NI/NE[b]	%				
Alaria marcianae (SI)	4/15	27	47.8 ± 19.0	12.7 ± 7.4	5–87	191
Brachylaima sp. (SI)	1/15	7	4.0 ± 0	0.3 ± 0.3	0	4
Taenia rileyi (SI)	7/15	47	5.7 ± 1.4	2.7 ± 1.2	1–17	40
Mesocestoides lineatus (SI)	1/15	7	3.0 ± 0	0.5 ± 0.4	0	3
Oncicola canis (SI)	3/15	20	1.3 ± 0.2	0.3 ± 0.2	1–2	4
Toxscaris leonina (SI, LI)	15/15	100	31.7 ± 7.3	31.7 ± 7.3	1–101	475
Ancylostoma tubaeformae (SI)	2/15	13	3.0 ± 0.8	0.4 ± 0.3	2–4	6
Physaloptera rara (S)	2/15	13	6.5 ± 2.5	0.9 ± 0.7	3–10	13
Cyathospirura chevreuxia (S)	1/15	7	43.0 ± 0	2.9 ± 2.8	0	43
Vogeloides felis (L)	2/15	13	7.0 ± 2.1	0.9 ± 0.7	4–10	14
Metathelazia californica (L)	1/15	7	8.0 ± 0	0.5 ± 0.5	0	8
Spirocerca lupi[e] (A)	2/15	13	0	0	0	0
Dirofilaria immitis (H)	1/15	7	1.0 ± 0	0.1 ± 0.1	0	1

[a] Location in the host: A, aorta; H, heart; L, lung; LI, large intestines; S, stomach; SI, small intestines.
[b] Number of hosts infected/number of hosts examined.
[c] Mean ± standard error.
[d] Total number of specimens collected.
[e] Lesions only; No nematodes found.

animals died as a result of traumatic injuries from vehicular accidents. The others died from the effects of notoedric mange (n=1), bobcat or ocelot predation (n=1), aspiration pneumonia with lung abscess from inhalation of a cocklebur (*Xanthium* sp.) (n=1), and unknown (n=1), but possibly exacerbated by a heartworm infection. There were 13 male and two female ocelots; all were mature individuals. Activities related to movement and handling of these carcasses were under the authority of Federal Fish and Wildlife Permit PRT-676811 for endangered/threatened species (US Fish and Wildlife Service, Region 2, Albuquerque, New Mexico, USA) and Texas Parks and Wildlife Department Scientific Permit SPR0190-600 (Texas Parks and Wildlife Department, Austin, Texas).

The carcasses were frozen and stored at −5 C at Texas A&M University-Kingsville (Kingsville, Texas) or at Laguna Atascosa National Wildlife Refuge (Rio Hondo, Texas). They were then transported to Texas Tech University (Health Sciences Center, Lubbock, Texas) where they were thawed and necropsied. Procedures and techniques used in necropsy and in the collection, preservation, preparation, examination, measurement, and illustration of helminths followed those outlined in Waid and Pence (1988). Tongues from four of 15 ocelots were examined for *Trichinella* spp. as previously described (Posio et al., 2001). Helminths were identified by comparison with voucher specimens from the previous studies on the helminths of bobcats by Stone and Pence (1978) and mountain lions by Waid and Pence (1988) and using Yamaguti (1958–63). Representative species of helminths collected from ocelots in this study are deposited in the US National Parasite Collection (Beltsville, Maryland, USA; USNPC Assession numbers 092444.00–092454.00). Terminology used herein to describe ecologic relationships of parasites follows that outlined in Bush et al. (1997).

Ocelots from southern Texas were infected with 12 helminth species (Table 1). Additionally, lesions typical of those caused by *Spirocerca lupi* in other carnivores in southern Texas were found in the aortas of two ocelots, but neither larval nor adult nematodes were found in the aorta or esophagus, respectively. Ocelots were infected with from 1−8 (mean=3) helminth species. Four, four, five, one, and one ocelots had one, two, three, five, and eight helminth species, respectively. Eight hundred sixty individual helminths were collected. An acanthocephalan (*Oncicola canis*), two cestodes (*Taenia rileyi, Mesocestoides lineatus*), two trematodes (*Alaria marcianae, Brachylaima* sp.), and six nematodes (*Toxascaris leonina, Anclyostoma tubaeformae, Dirofilaria immitis, Physaloptera rara, Vogeloides felis, Metathelazia californica, Cyathospirura chevreuxi*) were recorded (Table 1). *Toxascaris leonina* was the only common helminth species in ocelots from the LRGV; its prevalence was 100%. All of the remaining helminth species occurred in <50% of the sampled hosts.

The most abundant helminth species in ocelots from the LRGV also was *T. leonina.* All 15 hosts were infected with from 1−101 (mean±SE=31.7±7.3) *T. leonina.* In addition to domestic dogs and cats, many wild carnivores are infected with *T. leonina* by ingesting eggs with infective second stage larvae from feces-contaminated soil, or probably most commonly by ingesting arrested third stage larvae in the tissues of paratenic rodent hosts (Anderson, 2000). In the ocelot, adult and immature nematodes were found only in the lumen of the large intestine and/or in the middle to posterior part of the small intestine. Even in the hosts infected with the highest intensity of nematodes observed in this study, their numbers were insufficient to evoke an evident pathologic response or result in an observable clinical condition. Unlike *Toxocara cati* which has a predilection toward infecting kittens, *T. leonina* is usually found in greater numbers in older cats (Bowman, 1999). This further indicates little impact on the ocelot population by this nematode.

Although the small diplostomid trematode we identified as *A. marcianae* occurred in only four hosts, it was still the second most abundant helminth in these ocelots (Table 1). Intensities ranged from 5−87 (47.8±19.0) adult trematodes in infected hosts. All specimens were attached to the duodenal mucosa. Our specimens from three cats were within or just short of the range of body length measurements (1.66–2.06 mm) for *A. marcianae* verses the larger (2.47−2.71 mm) *A. americana* as proposed by Pearson and Johnson (1988). The only other structure these authors could find to differentiate the adults of these species was thickness of the ejaculatory duct wall (23–39 μm in *A. americana* and <20 μm in *A. marcianae*). This structure was not discernible in many of our specimens. However, in the smallest specimen we measured (1.41 mm long mature specimen with several viable eggs in the uterus), the thickness of the ejaculatory duct measured 26 μm. Obviously, the size of this structure depends on the degree of relaxation at the time of fixation and on the state of preservation of the specimens. Thus, we regard the measurement of the thickness of the contractile muscular wall of the ejaculatory pouch as too variable to provide a reliable means for species differentiation. Although, Pearson and Johnson (1988) proposed other differences in the sporocyst, cercariae, mesocercariae, and metacercariae of *A. americana* and *A. marcianae,* there remains no reliable way to separate the adults of these proposed species. Therefore, we have identified all specimens found in the ocelots from southern Texas as *A. marcianae* because this name takes nomenclatural precedence. According to Pearson and Johnson (1988), *A. marcianae* is the species usually found in mustelids and felids, whereas *A. americana* usually occurs in canids. However, the species that commonly infects the coyote (*Canis latrans*) across most of Texas (see Pence and Windberg, 1984) appears identical with the specimens from wild felids and also is identified as *A. marcianae.* As in domestic cats (Shoop and Corkrum, 1984), transmammary transmission is suggested as an important means of transmission of *A. marcianae* in domestic dogs (Shoop and Corkum, 1987) and coyotes (Pence et al., 1988).

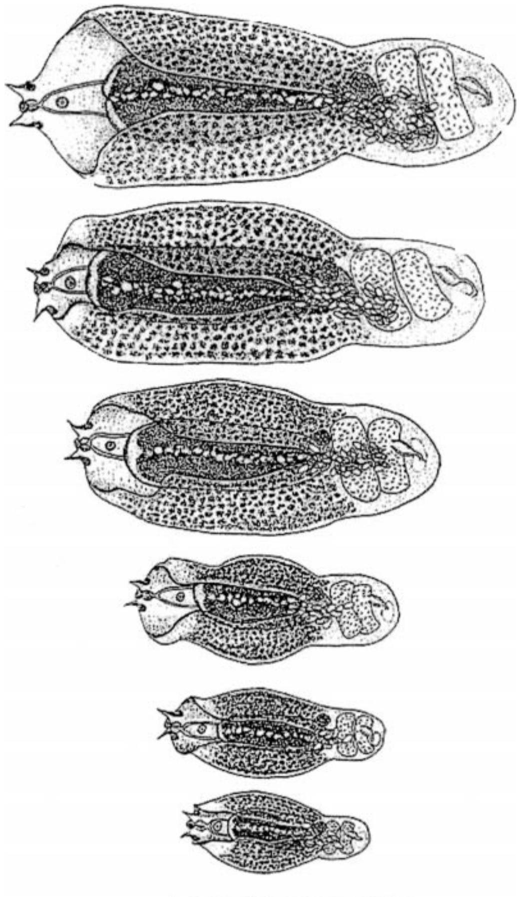

FIGURE 1. Clinal variation in *Alaria marcianae* from the small intestine of a single adult male ocelot from southern Texas. Bar=2 mm.

As a corollary to the above, we found a highly variable diplostomid infection in the most heavily infected cat, a large adult male ocelot. Here, there was a clinal variation in the body size of the trematodes representing nearly three orders of magnitude. Trematodes in this host ranged from 1.41–4.14 mm long. Although dimensions of most body structures varied according to overall length and width, certain structures such as oral suckers and eggs remained constant in size from smallest to largest specimens (Fig. 1). Other than size, the trematodes were identical morphologically. A similar phenomenon has been noted in *A. marcianae* from some coyotes in southern Texas (D. B. Pence, unpubl. data). The cause of this clinal variation in size of *A. marcianae* in some host individuals is unknown, but the different sizes may represent different generations of the parasite acquired across the age of the host as reflected by the host's immune status. The longevity of *A. marcianae* is unknown, but it is thought to be years (D. B. Pence, unpubl. data). Alternatively, perhaps the different sizes of the adult parasites are reflective of age of the parasites as observed in successive generations in some other trematode infections (Ostrowski de Nuñez, 1978). There appeared to be an insufficient number of individuals in this infection for them to be affected by crowding as seen in some tapeworm infections (Roberts and Janovy, 2000). Size differences across individuals could result from different strains of mesocercariae that develop in different intermediate hosts (Watson and Pike, 1993). Similar variation in body size has been reported in many other trematode genera, such as *Stomylotrema* (Macko et al., 1999) and *Apatemon* (Bell et al., 2002). Whatever the cause, this intraspecific morphometric variation further confounds species differentiation in all the genera where it occurs, including *Alaria.*

The adults of *A. marcianae* seem to do little harm to the host, although they are attached to the duodenal mucosa. But, they are very small. It would probably take hundreds of individuals to evoke clinical disease, even in young kittens. However, it is the tissue-migrating mesocercariae that may cause clinical illness (Bowman, 1999). In felines, *A. marcianae* mesocercariae are transmitted by a lactating queen to the kittens (Shoop and Corkum, 1984). The mesocercariae develop to diplostomulae in the lungs and these migrate up the trachea and develop to adults in the small intestine (Shoop and Corkum, 1984). While the effects of *A. marcianae* on ocelot kittens remains unknown, the relatively small numbers of individual trematodes (<100) in only a few infected hosts (27% prevalence) indicates that this species probably has little if any effect on this host population.

The second most prevalent and third most abundant helminth in this ocelot population was the large taeniid tapeworm *T. rileyi.* However, prevalence of infection in the ocelot did not approach that of the 91% seen in the normal definitive bobcat host in west Texas (Stone and Pence, 1978). Because *T. rileyi* is a common helminth of bobcats in the LRGV (D. B. Pence, unpubl. data), they undoubtedly are the primary reservoir for the maintenance of the infection. Ocelots are secondary reservoirs infected by ingesting the strobilocercus in rodents such as the cotton rat, *Sigmodon hispidus* (Mollhagen, 1979).

Ocelots from the LRGV were infected with several additional potentially pathogenic helminth species including the aortic and esophageal spirocercid, metathelazid lungworms, spiruroid stomachworms, hookworms, heartworms, and an acanthocephalan. But pathogenicity of helminth infections is usually density-dependent, and the respective species have to be present in sufficient numbers to have any kind of negative affect on the host individual.

Pence and Stone (1978) described aortic scarring and esophageal lesions of *S. lupi* in coyotes (*Canis latrans*), red wolves (*Canis rufus*), and bobcats in Texas. These lesions were regarded as pathognomic for spirocerciasis in wild canids and felids in Texas (Pence and Stone, 1978). In only two ocelots, we saw minor aortic scars attributable to *S. lupi.* These were old lesions with no larval nematodes present.

Heartworm is a very common pathogen of wild canids on the Gulf coastal prairies of Texas (Custer and Pence, 1981). *Dirofilaria immitis* also is known to occasionally infect wild and domestic felids and as few as one heartworm can result in the death of a domestic cat (Bowman, 1999). The effect of the single canine heartworm found in the LRGV ocelot is unknown, but it may have contributed to the loss of this individual.

Metathelazid lungworms, *V. felis* and/or *M. californica,* are very common parasites of bobcats (Stone and Pence, 1978) and mountain lions (Waid and Pence, 1988) in Texas. At high intensities they are pathogenic in bobcats (Pence and Stone, 1977) and perhaps also in mountain lions (Waid and Pence, 1988). Because lungworms occur in such low abundances, they probably have little impact on this endangered population.

Finally, the remaining gastrointestinal helminth species found in the LRGV ocelots were not present in sufficient numbers to affect these hosts. The hookworm, *A. tubaeformae,* and stomachworm, *C. chevreuxi,* occur in bobcats (Stone and Pence, 1978) and mountain lions (Waid and Pence, 1988). *Mesocestoides lineatus* (=*M. corti* of Stone and Pence, 1978), *O. canis,* and *P. rara* are found in bobcats and coyotes (Pence and Eason, 1979). As previously reported by Posio et al. (2001), *Trichinella* spp. was not found in the four ocelots that were examined.

At least 19 species of helminths have been reported previously from captive and wild ocelots (see review by Murray and Gardner, 1997; Yepez-Mulia et al., 1996; de Mendes-Mendes and Vasconcellos, 1987; Patton et al., 1986). Mostly, these represent generalist species reported from numerous carnivores in Central and South America. In contrast, of the 13 helminth species reported from ocelots in the LRGV, only *T. leonina, A. tubaeformae,* and *D. immitis* were reported previously from this host. Apparently, our collections of *O. canis, T. rileyi, M. lineatus, A. marcianae, Brachylaima* sp., *P. rara, V. felis, M. californica, C. chevreuxi,* and *S. lupi* represent new host records. The three previously reported species are widely dispersed in carnivores from both continents of the Western Hemisphere, while the remaining 10 helminth species in ocelots from the LRGV are mostly parasites of bobcats and other carnivores in North America. Thus, the helminth fauna of the ocelot is not unique to this host across its range in the Americas. Rather, it appears to be comprised of components from abundant helminths found in other carnivores in a given geographic locality. *Toxascaris leonina* is the only locally abundant species in the LRGV that seems to be distributed universally across the entire range of this host.

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