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NATURAL INFECTIONS OF TETRATHYRIDIA OF *MESOCESTOIDES* SPECIES IN DEER MICE, *PEROMYSCUS MANICULATUS*, FROM NEW MEXICO

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Abstract—At Southern Methodist University campus about 6 miles south of Taos, New Mexico,, we recovered tetrathyridia of *Mesocestoides* in five *Peromyscus maniculatus* in the summers of 2008 (3 of 129, 0.023%), 2009 (0 of 98, 0%), 2010 (1 of 112, 0.008%), 2011 (0 of 88, 0%), and 2012 (1 of 86, 0.011%). Tetrathyridia from the body cavity of one of the five infected mice were injected into the peritoneal cavity of laboratory white mice, *Mus musculus*. Our later examination of the laboratory mice revealed heavy infections of tetrathyridia continuing to reproduce asexually. Here we provide important new information on the prevalence of asexuality among tetrathyridia and underscore the need for further study of this variation among metacestodes of this cosmopolitan genus.

Resumen–En el campus de Southern Methodist University, aproximadamente seis millas al sur de Taos, Nuevo México, se colectaron tetrathyridia de *Mesocestoides* en cinco *Peromyscus maniculatus* durante los veranos de 2008 (3 de129, 0.023%), 2009 (0 de 98, 0%), 2010 (1 de 112, 0.008%), 2011 (0 de 88, 0%) y 2012 (1 de 86, 0.011%). Tetrathyridia provenientes de la cavidad corporal de uno de los cinco *P. maniculatus* infectados fueron inyectadas dentro de la cavidad peritoneal de ratones *Mus musculus* del laboratorio. Posteriormente, nuestro estudio de los ratones del laboratorio reveló una fuerte infección de tetrathyridia, las cuales continuaban reproduciéndose asexualmente. Aquí contribuimos información nueva e importante sobre la prevalencia de la asexualidad entre tetrathyridia y señalamos la necesidad de más estudios de esta variación entre metacéstodos de este género cosmopolita.

Adult *Mesocestoides* species are parasites of carnivorous mammals and birds. Although 27 species of Mesocestoides were recognized by Schmidt (1986) the life cycles of none of them are known. Encapsulated and free tetrathyridia are often found in the body cavities and various organs of amphibians, reptiles and rodents Padgett and Boyce (2004). In recent surveys of foxes in New Mexico adult *Mesocestoides* have been reported (Ubelaker et al. 2013; 2014*a*, 2014*b*). Surveys of rodents in the northern mountains of New Mexico have found asexually reproducing tetrathyridia of *Mesocestoides* in a rodent species that we report here.

During the summers of 2008–2012, we collected *Peromyscus maniculatus* from buildings and surrounding grounds on the Southern Methodist University campus in Taos, New Mexico (36°16′27N, 105°34′31.6″W). We collected 129, 98, 112, 88, and 86 mice in 2008, 2009, 2010, 2011, and 2012, respectively. Mice were trapped in Sherman live traps (H. B. Sherman Traps, Tallahassee, Florida) baited with peanuts and examined for parasites under animal protocols SMU 80708 and 80711. We collected parasites as described by Gardner (1996).

Three of 129 deer mice (one adult male collected 24 July 2008, one adult female collected 23 June 2010, and one adult female collected on 8 July 2012) contained actively dividing tetrathyridia of *Mesocestoides* in the body cavity and liver. We collected all infected mice among the foundations of a former saw mill (that operated 1940–1950) in a field dominated by sagebrush (*Artemisia tridentata tridentata*) with clumps of Wood's rose (*Rosa woodsii*) and the grasses wildrye (*Elymus canadensis* and *Elymus longifolius*) June grass (*Koeleria macrantha*) and sleepy grass (*Achnatherum robustum*). We deposited two of the infected mice and their tetrathyridia in the Museum of Southwestern Biology, Department of Biology, University of New Mexico, as MSB PARA 174 and MSB PARA 175.

The morphology of the tetrathyridia we collected was similar to that described by Etges (1991). Tetrathyridia that we observed with a dissecting microscope were

asexually proliferative by means of multiple and binary fission. We observed small numbers (approximately 20) of tetrathyridia free in the body cavity of the male mouse collected in 2008 and they were divided and injected into the peritoneal cavity of four laboratory white mice, *Mus musculus* under SMU animal protocol numbers 30108–30111. Our examination of the laboratory mice 6–9 mo later revealed heavy infections with an estimate of several hundred tetrathyridia continuing to reproduce asexually. They have been maintained in laboratory mice since 2008. A specimen of laboratory-reared *M. musculus* with tetrathyridia present has been deposited in the University of Nebraska State Museum, Manter Laboratory of Parasitology, number HWML 686671.

Kegley et al. (1970) were the first to report that tetrathyridia isolated from *P. maniculatus* in Coos County, Oregon, could be laboratory-propagated by interperitoneal transfer of tetrathyridia in laboratory mice, although they never authenticated their work with voucher specimens or continued propagation. The authors referred to the tetrathyridia as *Mesocestoides corti* although *M. corti* was described as an adult cestode from the intestine of *M. musculus* by Hoeppli (1925) based on specimens collected earlier by Cort. Beaver (1989) questioned that *M. musculus* was the actual host because adult *Mesocestoides* occur in carnivores, and adult *Mesocestoides* have never been recovered from rodents. Conn (1990) stated that asexual reproduction was confirmed by continual propagation of laboratory clones only in tetrathyridia isolated from lizards, as reported by Specht and Voge (1965). Hanson and Widmer (1985) and Widmer et al. (1995) reported asexual proliferation in snakes. Working with the strain isolated by Specht and Voge (1965), Etges (1991) named and described the proliferative tetrathyridia from lizards as *Mesocestoides vogae* (see also Rausch 1994).

Another report of tetrathyridia isolated from rodents in North America is *Mesocestoides carnivoricolus* (Grundmann, 1956). Grundmann (1956) reported finding tetrathyridia in body cavities, liver, and lungs of *P. maniculatus* and *Peromyscus crinitus* from Toole County, Utah (Grundmann 1958; Grundmann and Frandsen 1959, 1960). The presumed adults for these tetrathyridia were found in American badger (*Taxidea taxus*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*) in the same county. Padgett and Boyce (2004) reported that 8% of *P. maniculatus* on San Miguel Island, California, had infections of *Mesocestoides* tetrathyridia and foxes (*Urocyon littoralis littoralis*) contained adult tapeworms. The authors were not successful in infecting ants with eggs from tapeworms taken from the foxes. Shults (1970) reported tetrathyridia of *Mesocestoides kirbyi* in red-backed voles (*Clethrionomys rutilus*) from Alaska and adults in arctic foxes (*Alopex lagopus*). Our report supports the observation by Kegley et al. (1970) that asexually reproducing tetrathyridia occur naturally in deer mice. In New Mexico, *Mesocestoides* species in foxes have been reported. Ubelaker et al. (2013) reported adult *Mesocestoides variabilis* in red foxes (*Vulpes vulpes*). Ubelaker et al. (2014*b*) found *M. variabilis* in swift foxes (*Vulpes velox*) and Ubelaker et al., (2014a) also found *M. variabilis* in kit foxes (*Vulpes macrotis*). Ubelaker et al. (in litt.) report *M. kirbyi* in gray foxes (*Urocyon cinereoargenteus*).

Several researchers have reported nonproliferative *Mesocestoides* tetrathyridia from nonmammalian hosts in North America. This was supported by failure to reproduce asexually in repeated laboratory infections of mice (Conn and Etges, 1984; McAllister and Conn 1990; McAllister et al., 1992) and by lack of morphology consistent with asexual reproduction (see Conn 1986; Conn and McAllister 1990; McAllister et al., 2005). These reports were all documented by deposition of voucher specimens in museums. Conn (1986) and Conn et al. (2002) examined *Mesocestoides* tetrathyridia both morphologically and ultrastructurally and noted marked differences between asexually proliferative and nonproliferative tetrathyridia. They have also reported nonproliferating *Mesocestoides* tetrathyridia from European rodents, although some of these do possess morphological aberrancies (Conn et al., 2010, 2011). The present report provides important new information on the prevalence of asexuality among tetrathyridia and underscores the need for further study of this variation among metacestodes of this cosmopolitan genus.

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