FIRST RECORDS OF *LEPTOTHORAX RUGATULUS* (HYMENOPTERA: FORMICIDAE) WITH CYSTICERCOIDS OF TAPEWORMS (CESTODA: DILEPIDIDAE) FROM THE SOUTHWESTERN UNITED STATES

J. HEINZE,[1,2] O. RÜPPELL,[2] S. FOITZIK[1,2] AND A. BUSCHINGER[3]
[1]Zoologie I, Universität Erlangen-Nürnberg, Staudtstr. 5
D-91058 Erlangen, Germany

[2]LS Verhaltensphysiologie und Soziobiologie, Biozentrum, Universität Würzburg
D-97074 Würzburg, Germany

[3]Zoologisches Institut, TH Darmstadt, Schnittspahnstr. 3
D-64287 Darmstadt, Germany

Ants of the myrmicine tribe Formicoxenini may serve as intermediate hosts of immature stages (cysticercoids) of two genera of dilepidid cestodes. The parasites are thought to enhance the transmission to their final hosts, piciform, galliform or passeriform birds (Gabrion et al. 1976, Péru et al. 1988, 1990) and also shrews (Sawada & Harada 1995), by modifying the behavior and the pigmentation of their hosts. Infected *Leptothorax* are yellowish rather than brown or black as are their unparasitized nestmates, and they also do not flee when the nest is disturbed (Plateaux 1972, Buschinger 1973, reviewed in Moore 1995), thus increasing the probability that they are eaten. The tapeworms mature and reproduce in the intestine of the final host (Péru et al. 1990), and the eggs are still contained in parts of the tapeworm's uterus or in complete proglottids when released with the bird's feces. Ants collect the protein-rich pieces and feed them to their larvae (Gabrion et al. 1976, Péru et al. 1988).

Ants of the subgenus *Leptothorax* (s.str.) infested with *Choanotaenia* cysticercoids and *Leptothorax* (*Myrafant*) infested with *Anomotaenia* cysticercoids have been reported from various parts of Europe and Northern Africa (Germany, Hungary, Italy, France, Spain, Algeria, Morocco, Ukraine (Crimea); Plateaux 1972, Buschinger 1973, Espadaler Gelabert & Riasol Boixart 1983, A. Buschinger, unpublished data) and eastern North America (Illinois, Michigan, Ohio, Quebec; Stuart & Alloway 1988). Here we report on the occurrence of cysticercoids in several populations of *Leptothorax* (*Myrafant*) *rugatulus* in the Chiricahua, Huachuca, and Mimbres Mts. in southern Arizona and New Mexico.

Infested ants were easily recognized by their yellowish coloration, whereas typical *L. rugatulus* workers are reddish brown. Dissection of 24 yellowish workers revealed the presence of one to 28 cysticercoids (mean 7.8, median 6), closely associated with the midgut of the ants (Fig. 1a). A single cysticercoid was found in a worker with normal, reddish brown coloration. Eleven "normally" colored workers from the same colony, 5 "normally" colored workers from five other colonies with yellowish ants, and 18 from colonies without yellowish ants were not infected.

Whereas *Leptothorax* infested with tapeworms occasionally show morphological aberrations, such as a broadened postpetiole, a stronger petiolar spine etc. (Plateaux 1972, Buschinger 1973, Stuart & Alloway 1988), yellowish *L. rugatulus* were not conspicuously different in morphology from their uninfested nestmates.

By gently squeezing cysticercoids under a microscope, the rostrum evaginated and the number of mouth hooks could be counted (Fig. 1b). Cysticercoids found in *L. rugatulus* had between 18 and 21 hooks in two circles (28 cysticercoids, mean 19.9, me-

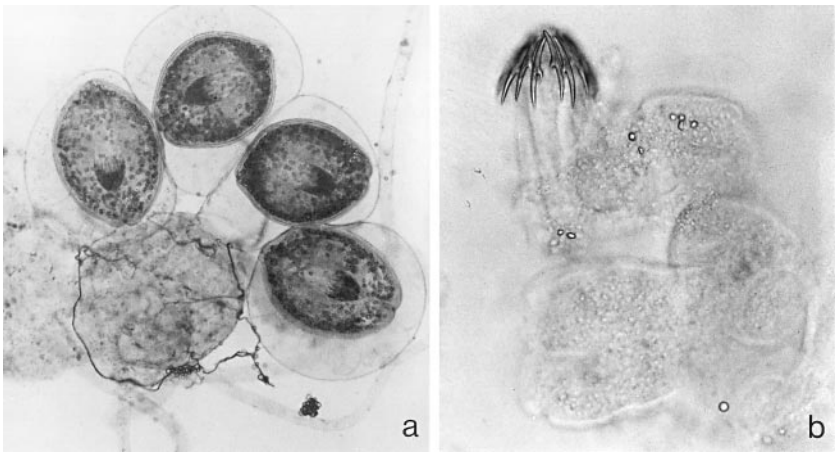

Fig. 1. a) Four cysticercoids of a dilepidid cestode associated with the midgut of a worker of the ant *Leptothorax rugatulus*. b) Cysticercoid after devagination of the rostrum. The hooks are clearly visible.

dian 20; compared to *Anomotaenia brevis* with 17 to 22, rarely 26 hooks, and *Choanotaenia* with 18 to 27 hooks, Buschinger 1973, Gabrion et al. 1976). One exceptional cysticercoid from *L. rugatulus* had one circle consisting of 18 large hooks and a second circle of 13 small hooks. Cysticercoids from *L. rugatulus* were similar in size to those from Europe (48 cysticercoids in *L. rugatulus*: mean 224 µm, median 216 µm, range 180-290 µm; compared to A. brevis 220-250 µm and *Choanotaenia* 170-210 µm, Buschinger 1973, Gabrion et al. 1976), but the average length of the hooks by far exceeded that of European specimens (in *L. rugatulus*: 60 µm; compared to A. brevis 23.5-28.5 µm and *Choanotania* 40-45 µm). Overall, cysticercoids from *L. rugatulus* appear to belong to a taxon different from both European species, but closer related to *Anomotaenia* than to *Choanotaenia*. The final host of the tapeworm is unknown.

In addition to yellowish workers, several colonies also contained yellowish dealate queens (Table 1). None of 12 dissected yellowish queens was found to be inseminated, and none of approximately 90 dissected, inseminated queens was infected, suggesting that infestation somehow interferes with the queens' sexual behavior. The ovaries of five yellowish virgin queens contained 1 to 3 developing eggs, but according to the absence of corpora lutea, they had only recently become fertile.

In the Chiricahua, Huachuca, and Mimbres Mts., between 5% and 20% of the inspected colonies contained yellowish workers (Table 1), and in single colonies, up to 50% of the workers were infected (mean appr. 10%). Infestation by tapeworm cysticercoids thus appears to be a rather common phenomenon in the mountain ranges of Southern Arizona and New Mexico. No cysticercoids, however, were found in *L. rugatulus* from several other populations in Arizona, New Mexico, and Colorado. Similarly, a species of *Leptothorax* (s.str.), regularly co-occurring with *L. rugatulus* in Southern Arizona and New Mexico (an as yet undescribed member of the *L.* (s.str.) *muscorum* complex referred to as *Leptothorax* (s.str.) F, Heinze 1989), was never found infested with cysticercoids. The apparent restriction of the *Anomotaenia*-like cysticercoids to *L. rugatulus* is consistent with the hypothesis that cysticercoids of dilepidid tapeworms are limited to host species from a single *Leptothorax* subgenus (Buschinger 1973, Péru et al. 1990).

TABLE 1. OCCURRENCE OF *LEPTOTHORAX RUGATULUS* ANTS INFECTED WITH CYSTICERCOIDS OF A DILEPIDID TAPEWORM. THE TABLE GIVES THE RATIOS OF YELLOWISH DEALATE QUEENS AND WORKERS PER COLONY TO THE TOTAL NUMBER OF DEALATE QUEENS AND WORKERS, AND OF COLONIES CONTAINING INFECTED INDIVIDUALS TO THE TOTAL NUMBER OF COLONIES COLLECTED PER POPULATION.

Mountain Range, County, State	Collecting Site, Elevation	yellowish individuals per colony		colonies with yellowish individuals
		queens	workers	
Chiricahua Mts., Cochise Co., AZ	Barefoot Lookout, 2630m	0/2	4/18	
		0/16	14/174	4/30
		3/25	16/137	
		0/3	6/62	
	FSR 40, 0.8km W of Onion Saddle, 2200m	17/19	0/51	1/13
	FSR 40, 1.5km W of Onion Saddle, 2100m	0/1	3/139	2/25
		0/18	3/115	
	Pinery Campground, 2100m	42/43	49/156	1/5
	Onion Saddle, 2280m	0/5	8/104	
		0/1	4/33	
		0/1	3/21	4/84
		0/0	1/31	
	Rustler Park, 2580m	0/7	1/46	1/5
	Morse Canyon Trailhead, 1980m	1/4	10/342	1/11
Huachuca Mts., Cochise Co., AZ	Carr Canyon Road, 2400m	0/2	1/79	1/20
Mimbres Mts., Grant Co., NM	4.8km west of Emory Passm 2200	0/1	2/30	
		0/1	6/17	3/12
		5/6	1/17	
total number, including additional populations of *L. rugatulus* in New Mexico, Arizona, and Colorado				18/523

Field work in the USA was supported by the Deutsche Forschungsgemeinschaft (Heisenberg-grant He 1623/6-1 and Graduiertenkolleg "Arthropodenverhalten"). The studies were performed in part in the Southwestern Research Station of the American Museum of Natural History, Portal, AZ.

SUMMARY

Cysticercoids of a dilepidid cestode were found by dissection of aberrant yellowish workers and virgin queens of the ant *Leptothorax rugatulus* from several mountain ranges in the southwestern United States. The cestode was not positively identified, but cysticercoids are similar to those of the genus *Anomotaenia* previously found in related ants.

REFERENCES CITED

BUSCHINGER, A. 1973. Ameisen des Tribus Leptothoracini (Hym., Formicidae) als Zwischenwirte von Cestoden. Zool. Anz. 191: 369-380.

ESPADALER GELABERT, X., AND J. M. RIASOL BOIXART. 1983. Cisticercoides de Cyclophyllidea en hormigas *Leptothorax* Mayr. Modificaciones morfologicas y etologicas del huesped intermediario. Rev. Ibérica Parasitol. 43: 219-227.

GABRION, C., L. PLATEAUX, AND C. QUENTIN. 1976. *Anomotaenia brevis* (Clerc, 1902) Fuhrmann, 1908 Cestode Cyclophyllide, parasite de *Leptothorax nylanderi* (Forster) Hyménoptère, Formicidé. Ann. Parasit. 51: 407-420.

HEINZE, J. 1989. A biochemical approach toward the systematics of the *Leptothorax* "*muscorum*" group in North America (Hymenoptera: Formicidae). Biochem. Syst. Ecol. 17: 595-601.

MOORE, J. 1995. The behavior of parasitized animals. BioScience 45, 89-96.

PÉRU, L., L. PLATEAUX, A. PERRAMON, AND J.-C. QUENTIN. 1988. Utilisation de la caille (oiseau galliforme) et d'une fourmi *Leptothorax* (Hymenoptère Myrmicidae) comme hôtes de laboratoire pour l'élevage de cestodes Cyclophillidea d'oiseaux. Bull. Soc. Zool. France 114: 27-34.

PÉRU, L., L. PLATEAUX, A. BUSCHINGER, P. DOUWES, A. PERRAMON, AND J.-C. QUENTIN. 1990. New records of *Leptothorax* ants with cysticercoids of the cestode, *Choanotaenia unicoronata*, and the rearing of the tapeworm in quails. Spixiana 13: 223-225.

PLATEAUX, L. 1972. Sur les modifications produits chez une fourmi par la présence d'un parasite cestode. Ann. Sci. Nat., Zool. 12e sèr. 14: 203-220.

SAWADA, I., AND M. HARADA. 1995. Cestode parasites from some Nepalese mountain shrews. Japanese J. Parasitol. 44: 196-209.

STUART, R. J., AND T. M. ALLOWAY. 1988. Aberrant yellow ants: North American *Leptothorax* species as intermediate hosts of cestodes, pp. 537-545 in J. Trager [ed.], Advances in myrmecology. E. J. Brill, Leiden.