

RESEARCH NOTES

J. Parasitol., 96(2), 2010, pp. 429–430
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Horsehair Worms (*Gordius robustus*) in Nests of the Western Bluebird (*Sialia mexicana*): Evidence for Anti-Predator Avoidance?

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ABSTRACT: Hairworms (Nematomorpha: Gordiida) are internal parasites that alter the behavior of their terrestrial insect host, forcing it to enter the water to reach its reproductive habitat. After reproduction of the free-living adults, the larvae encyst in aquatic insects and are retained upon metamorphosis of the insect into an adult fly. This paratenic host links the aquatic and terrestrial environments after its consumption by omnivorous or predatory insects. Therefore, hairworms are usually only associated with invertebrates, and few reports discuss hairworm interactions with vertebrate species. Here, we report on the finding of horsehair worms in nests of a cavity-nesting bird species in Los Alamos County, New Mexico. From 2004 to 2008, 7 nests within nest boxes occupied by the western bluebird (*Sialia mexicana*) contained 8 hairworms that were identified as *Gordius robustus*. All of the nest boxes with worms were less than 100 m from stagnant or low-flowing streams. The most likely explanation for the presence of the worms in the nests is that worms engaged in anti-predator avoidance after their insect hosts were collected and before digestion by nestling birds.

Hairworms (Phylum *Nematomorpha*) are internal parasites of insects such as crickets, cockroaches, grasshoppers, mantids, and beetles that can manipulate the behavior of their terrestrial insect host, forcing it to enter water to reach its reproductive habitat (Thomas et al., 2002; Sanchez et al., 2008). Adults are free living and lay millions of eggs in water, from which larvae hatch within several weeks. Once larvae are consumed by aquatic insects such as midges and mayflies, migration within the host occurs in the form of gut penetration into the body cavity, where the larvae encyst (Hanelt and Janovy, 2004; Hanelt et al., 2005). The life cycle is completed when metamorphosed insects, infected with cysts, are consumed by the definitive host (Hanelt et al., 2005).

Gordian worms, or hairworms, are usually only associated with their invertebrate hosts and few reports discuss hairworm interactions with vertebrate species. Several reports indicate that hairworms are consumed by fish and frogs (Cochran et al., 1999; Kinziger et al., 2002; Ponton, Lebarbenchon, Lefèvre, Thomas et al., 2006). Field and laboratory studies suggest that fish consume, and partially digest, free-living hairworms (Cochran et al., 1999; Kinziger et al., 2002). More recently, it was reported that frogs and fish prey on insect hosts during worm release, a process lasting as long as 10 min (Ponton, Lebarbenchon, Lefèvre, Biron et al., 2006; Sato et al., 2008). Reports of non-aquatic vertebrates interacting with hairworms are much rarer. Notman and Yeates (1992) described the unusual case of a South Island (New Zealand) tomtit bird (*Petroica macrocephala*) killed by entanglement with a horse hairworm. Here, we report on the finding of hairworms in the nests of a cavity-nesting bird species in New Mexico.

From 1997–2008, we conducted nest-box monitoring for cavity-nesting birds at multiple locations on the Pajarito Plateau in Los Alamos County in north-central New Mexico (see Fair et al., 2003, for project description). This area consists of mountainous regions with ponderosa pine (*Pinus ponderosa*) forests as well as canyons and mesas with pinyon pine trees (*Pinus monophylla*) and several species of juniper. The climate is temperate and montane with annual precipitation ranging around 48 cm. The study site contains 8 canyons with ephemeral streams that flow in the spring and early summer. Over 700 nest boxes are monitored and maintained almost daily during the nesting season (May–July).

The western bluebird (*Sialia mexicana*) is a secondary cavity-nesting species that readily uses nest boxes. It is widely distributed, sexually dichromatic, and is a socially monogamous species (Guinan et al., 2008).

The western bluebird is also insectivorous during the breeding season and uses a small amount of grit in its gizzard.

Prior to spring nesting, all nest boxes were cleared of rodent nests and other debris, including nesting material. Within 1 wk of fledging, nests were collected and stored in plastic bags in a freezer until sifting. Nests were searched thoroughly for pupae of *Protocalliphora* species and dietary items. While sorting the nests, hairworms were located on the top section, where food items are usually found. The hairworms were separated and later identified to species and sex.

From 2004 to 2008, we collected 439 nests, 7 of which contained 8 adult hairworms, 4 males and 4 females. Most nests contained a single worm, but 1 nest possessed both a male and a female worm. Worms were identified as *Gordius robustus* based on published descriptions and a key (Schmidt-Rhaesa et al., 2003). All of the nest boxes with worms were less than 100 m from stagnant or low-flowing streams, which could provide hairworm habitat, although sampling of these streams was not attempted.

This is the first report of hairworms associated with the nests of birds. Their presence in this ‘unnatural’ habitat can be explained in three ways. First, infected crickets could have crawled into the nest and released their worms. However, hosts must be immersed in water for worms to begin host emergence (B. Hanelt, unpubl. obs.), and the humidity of the nests is likely not high enough to trigger this behavior. Second, worms could have been collected by birds to feed to their nestlings but were subsequently ignored as a food source. Worms may have been collected directly or indirectly through secondary predation, within the body of an insect from which they subsequently emerged. The diet of the western bluebird is mainly insectivorous during the breeding season, and we are unaware of reports of birds seeking out, collecting, and bringing worms back to the nest as food items. However, there are reports of bluebirds provisioning nestlings with larger vertebrate food items. This includes eastern bluebirds (*Sialia sialis*), one of which was found to provide nestlings with a dead flat-head snake (*Tantilla gracilis*) (Braman and Pogue, 2005), although there was no evidence to suggest it was consumed by the nestlings. Another report (Stern, 2007) notes that a western fence lizard (*Sceloporus occidentalis*) was captured by a western bluebird during the winter. However, we believe that birds may avoid use of hairworms as a food resource. Hairworms are large, extremely strong, and capable of entangling each other, and other objects, an action which has led to the death of an adult bird (Notman and Yeates, 1992). In addition, vertebrates appear to be unable to completely digest hairworms (Cochran et al., 1999; Kinziger et al., 2002; Sato et al., 2008) and, thus, appear to provide very limited nutritional benefits. This tangling behavior and low nutritional benefit likely makes hairworms difficult for nestling birds to consume and may lead to some birds becoming conditioned to avoid hairworms as prey.

The final explanation for the presence of worms in these nests is that birds collected insects containing adult worms and returned with them to the nest. Upon arriving at the nest, or upon feeding the prey to the nestlings, the worms actively avoided the bird predators and found refuge in the nesting material, where the humidity was just high enough to avoid desiccation. The escape of hairworms from predators, or their prey, has been documented in frogs and fish (Ponton, Lebarbenchon, Lefèvre, Thomas et al., 2006). Worms fed to these aquatic predators, while inside an insect host, were able to escape from their host, and from the predator, through the mouth or gills (Ponton, Lebarbenchon, Lefèvre, Biron et al., 2006). This raises the intriguing possibility that the worms found within bird nests escaped either before, or just after, the feeding of their hosts to the nestlings. Although Ponton, Lebarbenchon, Lefèvre, Biron et al. (2006) considered hairworm anti-predator behaviors in aquatic hosts to be an important life history strategy, in which worms could ‘reclaim’ their

reproductive potential, the significance of this strategy in bird nests is less clear. Although worms may be able to escape death, their reproductive potential could not be reclaimed, as they were isolated away from their normal breeding environment.

We thank the following people for excellence in the field: C. Hathcock, D. Keller, L. Maestas, E. Powell, R. Robinson, and S. Sherwood. We are grateful to Orrin Myers for establishing the avian nest box monitoring network. This research was funded by the Environmental Restoration Program through Los Alamos National Security, LLC, operator of the Los Alamos National Laboratory under Contract No. DE-AC52-06NA25396 with the U.S. Department of Energy. Finally, we would like to thank two anonymous reviewers for providing helpful comments.

LITERATURE CITED

- BRAMAN, S. C., AND D. W. POGUE. 2005. Eastern bluebird provisions nestlings with flat-headed snake. *Wilson Bulletin* **117**: 100–101.
- COCHRAN, P. A., A. P. KINZIGER, AND W. J. POLY. 1999. Predation on horsehair worms (Phylum: Nematomorpha). *Journal of Freshwater Ecology* **14**: 211–218.
- FAIR, J. M., O. B. MYERS, AND R. E. RICKLEFS. 2003. Immune and growth response of western bluebird and ash-throated flycatchers to soil contaminants. *Ecological Applications* **13**: 1817–1829.
- GUINAN, J. A., P. A. GOWATY, AND E. K. ELTZROTH. 2008. Western bluebird (*Sialia mexicana*). In *The birds of North America*, A. Poole (ed.). Cornell Lab of Ornithology, Ithaca, New York.
- HANELT, B., AND J. JANOVY JR. 2004. Life cycle and paratenesis of American gordiids (Nematomorpha: Gordiida). *Journal of Parasitology* **90**: 240–244.
- , F. THOMAS, AND A. SCHMIDT-RHAESA. 2005. Biology of the phylum Nematomorpha. *Advances in Parasitology* **59**: 243–305.
- KINZIGER, A. P., P. A. COCHRAN, AND J. A. COCHRAN. 2002. Additional cases of predation on horsehair worms (Phylum Nematomorpha), with a recent record for Missouri. *Transactions of the Missouri Academy of Science* **3**: 1–11.
- NOTMAN, P. R., AND G. W. YEATES. 1992. Tomtit killed by a worm. *Notornis* **39**: 16.
- PONTON, F., C. LEBARBENCHON, T. LEFÉVRE, D. G. BIRON, D. DUNEAU, D. P. HUGHES, AND F. THOMAS. 2006. Parasitology: Parasite survives predation on its host. *Nature* **440**: 756.
- , ———, ———, F. THOMAS, D. DUNEAU, L. MARCHE, L. RENAULT, D. P. HUGHES, AND D. G. BIRON. 2006. Hairworm anti-predator strategy: A study of causes and consequences. *Parasitology* **133**: 631–638.
- SANCHEZ, M. I., F. PONTON, A. SCHMIDT-RHAESA, D. P. HUGHES, D. MISSE, AND F. THOMAS. 2008. Two steps to suicide in crickets harbouring hairworms. *Animal Behaviour* **76**: 1621–1624.
- SATO, T., M. ARIZONO, R. SONE, AND Y. HARADA. 2008. Parasite-mediated allochthonous input: Do hairworms enhance subsidized predation of stream salmonids on crickets? *Canadian Journal of Zoology* **86**: 231–235.
- SCHMIDT-RHAESA, A., B. HANELT, AND W. REEVES. 2003. Redescription and compilation of Nearctic freshwater Nematomorpha (Gordiida), with the description of two new species. *Proceedings of the Academy of Natural Sciences of Philadelphia* **153**: 77–117.
- STERN, C. A. 2007. Western bluebird captures a western fence lizard. *Wilson Journal of Ornithology* **119**: 128–129.
- THOMAS, F., A. SCHMIDT-RHAESA, G. MARTIN, C. MANU, P. DURAND, AND F. RENAULT. 2002. Do hairworms (Nematomorpha) manipulate the water seeking behaviour of their terrestrial hosts? *Journal of Evolutionary Biology* **15**: 356–361.