Nest Guests: Water bears inhabit vole nests in Douglas-fir canopies

Alex Young, Jesse Miller, John Villella, Andrew Emanuels, Greg Carey, William R. Miller

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Figure 1. An adult red tree vole (*Arborimus longicaudus*)

Introduction

Interspecific interactions are an excellent starting point for analyzing community ecology. Due to the recent finding of a tardigrade from Argentina in the forests of Northeastern Kansas (Tibbs, Emanuels, and Miller, 2016), dispersal patters of tardigrades with respect to animal vectors have become a great interest.

Red tree voles (*Arborimus longicaudus)* (Figure 1, 4.2) live their exclusively in the upper canopy of old growth Douglas-fir trees (*Pseudotsuga menziesii*). They build intricate nests of discarded resin ducts (Figure 4.1) derived from their sole source of food, conifer needles. We ask if nest age, nest height, DBH of tree, or regional precipitation impact tardigrade communities.

Figure 2. Range wide transect in Southwest Oregon

Materials & Methods

Forty-three Red Tree Vole nest samples gathered from the canopy of Douglas firs were sent to Baker University for analysis. One gram of each sample was soaked in 20 mL of spring water for 24 hours (Miller 1997). Tardigrades found in each sample under a dissecting scope (20-30x magnification) were mounted on slides in polyvinyl alcohol (Salmon 1951). A glass cover slip was placed on the slide which was sealed with fingernail polish 3-5 days later. The animals were identified to species under a differential interference microscope (400x magnification).

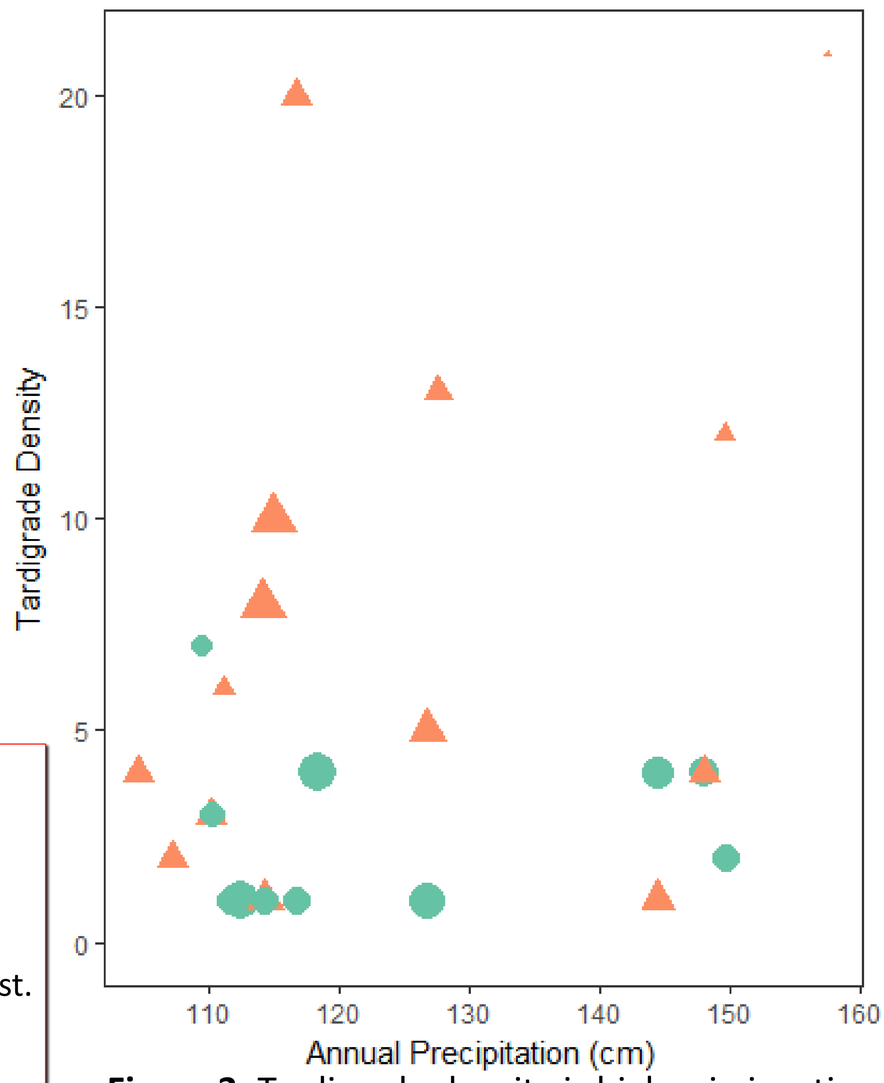

Figure 3. Tardigrade density is higher in inactive nests, in larger diameter trees.

Results

A total of 167 tardigrades were extracted from the nest collections. 65% of the nest samples contained at least one tardigrade. Higher tardigrade density in inactive nests (figure 3)

Twelve species of tardigrades were found in the nests, representing two classes, three orders and seven genera: *Echiniscus*, *Milnesium*, *Hypsibius*, *Ramazzottius*, *Pilatobius*, *Macrobiotus*, and *Murrayon* (Table 1). Seven of the species are new records for the state of Oregon (Table 1), raising the known tardigrade species diversity by 30% from 23 to 30.

Nest height ranged from 1.5 to 40 meters making these collections some of the highest tardigrades have been recorded above the ground.

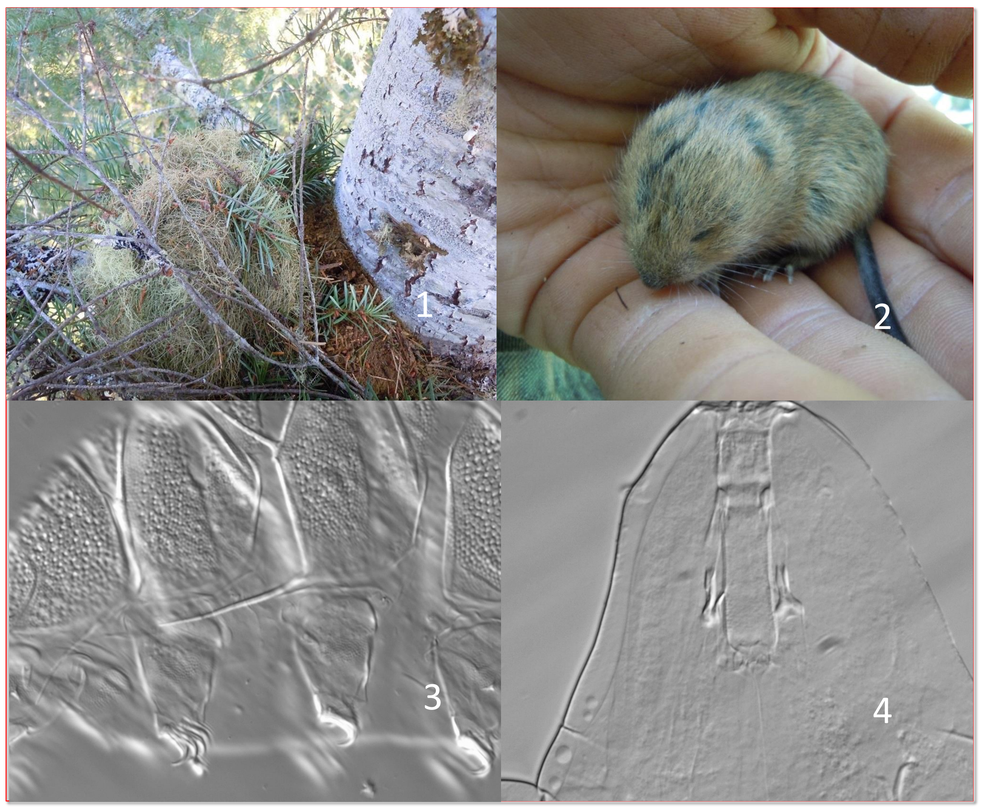

Figure 4. (1) A red tree vole nest, (2) a red tree vole nestling, (3) *Echiniscus merokensis,*(4) *Milnesium granulatum*

Kinchin, I.M.., 1994, *The Biology of Tardigrades*, Portland Press. pp. 186.

Miller, W.R., 1997, *Bears of the Moss*, The Kansas School Naturalist, Vol. 43, No. 3. pp. 16.

Salmon, J.T. 1951. Polyvinyl Alcohol as a Mounting Medium in Microscopy. The Microscope 8:139-142.

Tibbs, L., Emanuels, A., and Miller, W.R. 2016. Tardigrades of the Canopy: Argentine species *Milnesium beatae* Roszkowska, Ostrowska and Kaczmarek, 2015 (Eutardigrada, Milnesidae) discovered in the trees of Kansas, U.S.A. Transactions of the Kansas Academy of Science 119(2): in press.

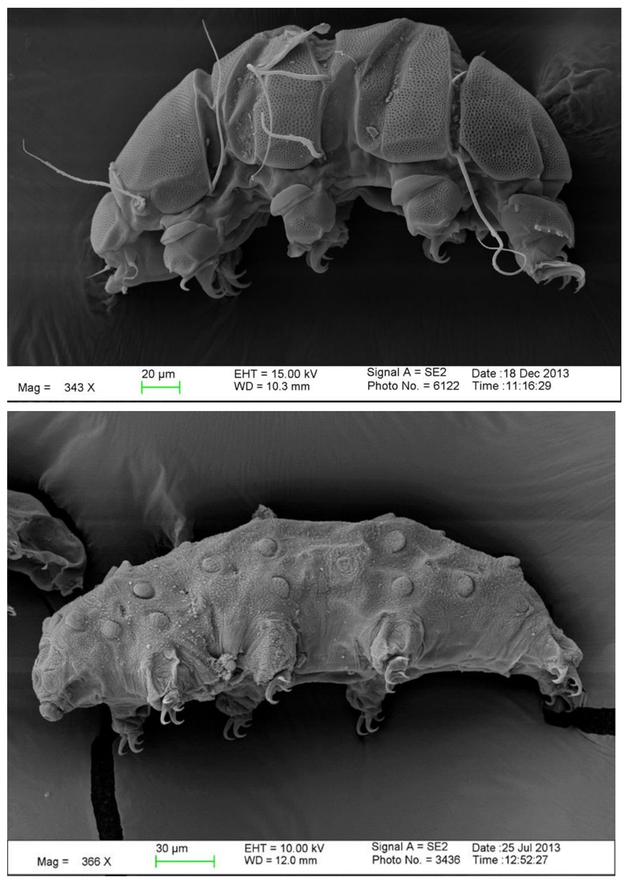

Figure 4. Phylum Tardigrada has two classes: *Heterotardigrada (top), Eutardigrada* (bottom).

Class, Order, SuperFamily, Family Genus species	A	B	C	D	E	F
Heterotardigrada, Echiniscoidea, Echiniscoididae						
Diploechiniscus oihonnae (Richters, 1903)		X				
Echiniscus blumi Richters, 1903		X				
Echiniscus horningi Schuster & Grigarick, 1971			X			
Echiniscus mauccii Marcus, 1930				X		
Echiniscus merokensis Richters, 1904						X*
Echiniscus quadraspinosus Richters, 1902				X		
Echiniscus trisetosus (Cuénot, 1932)		X			X	
Echiniscus wendti Richters, 1903				X		X
Hypechiniscus gladiator (Murray, 1905)		X				
Multipseudechiniscus raneyi (Grigarick, Mihelčič & Schuster, 1964)	X	X				
Pseudechiniscus goedeni Grigarick, Mihelčič & Schuster, 1964	X	X				
Pseudechiniscus victor (Ehrenberg, 1853)		X				
Eutardigrada, Apochela, ,Milnesiidae						
Milnesium cf. *tardigradum* Doyère, 1840		X		X	X	
Milnesium granulatum Ramazzotti, 1962						X*
Eutardigrada, Parachela, Hypsibioidea, Hypsibiidae						
Adropion scoticum (Murray, 1905)		X				
Pilatobius nodulosus (Ramazzotti. 1957)						X*
Pilatobius oculatus (Murray, 1906)		X				
Pilatobius recamieri (Richters, 1911)				X		
Hypsibius calcaratus Bartoš, 1935		X				
Hypsibius convergens (Urbanowicz, 1925)		X				X
Hypsibius microps Thulin, 1928						X*
Hypsibius pallidus Thulin, 1911						X*
Eutardigrada, Parachela, Isohypsibidea, Isohypsibioiidae,						
Isohypsibius marcellinoi Binda & Pilato, 1971					X	
Isohypsibius sattleri (Richters, 1902)		X				
Platicrista angustata (Murray, 1905)		X				
Ramazzottius baumanni (Ramazzotti, 1962)				X		
Ramazzottius oberhaeuseri (Doyère, 1840)		X			X	X
Eutardigrada, Parachela, Macrobiotoidea, Macrobiotidae						
Macrobiotus hufelandi C.A.S. Schultze, 1834		X				X
Macrobiotus islandicus Richters, 1904		X		X		
Macrobiotus spectabilis Thulin, 1928						X*
Mesoobiotus harmsworthi Murray, 1907		X				X
Paramacrobiotus areolatus (Murray, 1907)		X				
Paramacrobiotus richtersi (Murray, 1911)		X				
Eutardigrada, Parachela, Macrobiotoidea, Murrayidae						
Murrayon cf. *hibernicus* Murray, 1911						X*
Total species = 34	2	19	1	7	4	12

A. Grigarick et al. 1964, B. Schuster and Grigarick 1965, C. Schuster and Grigarick 1971, D. Meyer and Hinton 2012, E. Young and Clifton 2015, F. this report. * = New record for the state of Oregon.

Discussion

These data suggest red tree voles disperse tardigrades by their annual nest building behavior.

Collections of other migratory animal habitats may help explain regional and intercontinental dispersal.

This study contributes to dispersal mechanisms, biogeography, and biodiversity of phylum Tardigrada.