

Uncharismatic Microfauna of the Colorado Plateau: Notes on Distribution and Ecology of an Undescribed, Pothole-Dwelling Ameronothroid (Acari: Ameronothridae) Mite

Tim B. Graham
U.S. Geological Survey
Biological Resources Div.
Forest and Rangeland
Ecosystems Science Ctr.
Canyonlands Field Station
2282 S. West Resources
Blvd.
Moab, UT 84532
tim_graham@usgs.gov

Roy A. Norton
State University of
New York
College of Environmental
Science and Forestry
Syracuse, NY 13210
ranorton@mailbox.syr.edu

Potholes are small basins in bedrock that collect precipitation, forming ephemeral aquatic habitats. They are relatively harsh environments for aquatic organisms, especially when dry.

Potholes range in size from tiny depressions holding less than a liter of water to huge pools, up to 18 m deep and over 20 m across

ABSTRACT

■ Potholes, or rock pools, are common in exposed sandstone on the Colorado Plateau and support a diverse array of aquatic invertebrates. An undescribed species of ameronothroid oribatid mite resides in very small potholes (pans), holding only a few liters of water. This mite has been placed in the genus *Aquanothrus* (Acari: Ameronothridae), which contains only one other species (*A. montanus*), found in ephemeral rock pools in South Africa. *Aquanothrus* n. sp. occupies pans that are extremely short-lived, yet months may pass between rains. It is apparently not cryptobiotic in that it does not tolerate desiccation of its tissues. Morphological characteristics and observations of length of survivability indicate instead that it resists desiccation. While not tested quantitatively, few mites appear able to survive more than a year when stored dry.

This mite has been found across much of the central portion of the Colorado Plateau on sandstone exposures of Permian to Cretaceous age. It is limited to areas where small weathering pits form in the rock, but it is apparently absent from many areas that seem suitable, including many sites that have been examined in the Grand Staircase-Escalante National Monument. It is not clear what makes a pan suitable or unsuitable for mites. We suspect a combination of physical factors and biotic interactions are involved. This mite is a very unusual organism, of interest from evolutionary, physiological, and morphological, as well as biogeographic perspectives. As such, it deserves protection. Further investigations into its ecology are needed if it is to be protected in the Monument and elsewhere on the Colorado Plateau.

(Netoff et al., 1995). Different organisms may occur in pools of different sizes as a result of interactions between life cycle length and pool



longevity (Dodson, 1987), although other factors also play a role in determining pothole community composition.

One of us (TBG) found small mites (Figure 1) in very small potholes in 1988. It is a new species of oribatid mite in the genus *Aquanothrus*, which was erected by Engelbrecht (1975) for the species *Aquanothrus montanus* discovered in ephemeral pools in South Africa. The Colorado Plateau mite represents only the second species in the genus *Aquanothrus*.

Both *Aquanothrus* species are found in ephemeral rock pool microhabitats. They have

been found only on midelevation plateaus in semiarid to arid climates, living in weathering pits formed in late Paleozoic to late Mesozoic sandstones. They have a secondary light receptive organ, called a lenticulus, that resembles the lenticulus of the Hydrozetidae, a common aquatic mite family (Alberti and Fernandez, 1990). Both species of *Aquanothrus* have unusual leg trachea as well (Norton et al., 1997). Herein we discuss the distribution and what little is known about the ecology of the Colorado Plateau species of *Aquanothrus*.

Materials and Methods

Distribution

No systematic surveys have been conducted to determine the distribution of this mite. Rock pools on and near the Colorado Plateau have been examined by the authors during travel; in some cases, looking for mites has been a major function of taking a particular route across the Colorado Plateau. Rock outcrops with exposed relatively horizontal surfaces were examined wherever encountered on the Colorado Plateau; if boulders had depressions that showed evidence of holding water at times (black bathtub ring) and sediment, they were also examined. A small sample of sediment was scooped up with a spoon and wetted to activate mites. Thus far, no attempt has been made to assess habitat quality across the Colorado Plateau by comparing mite populations in different kinds of pools.

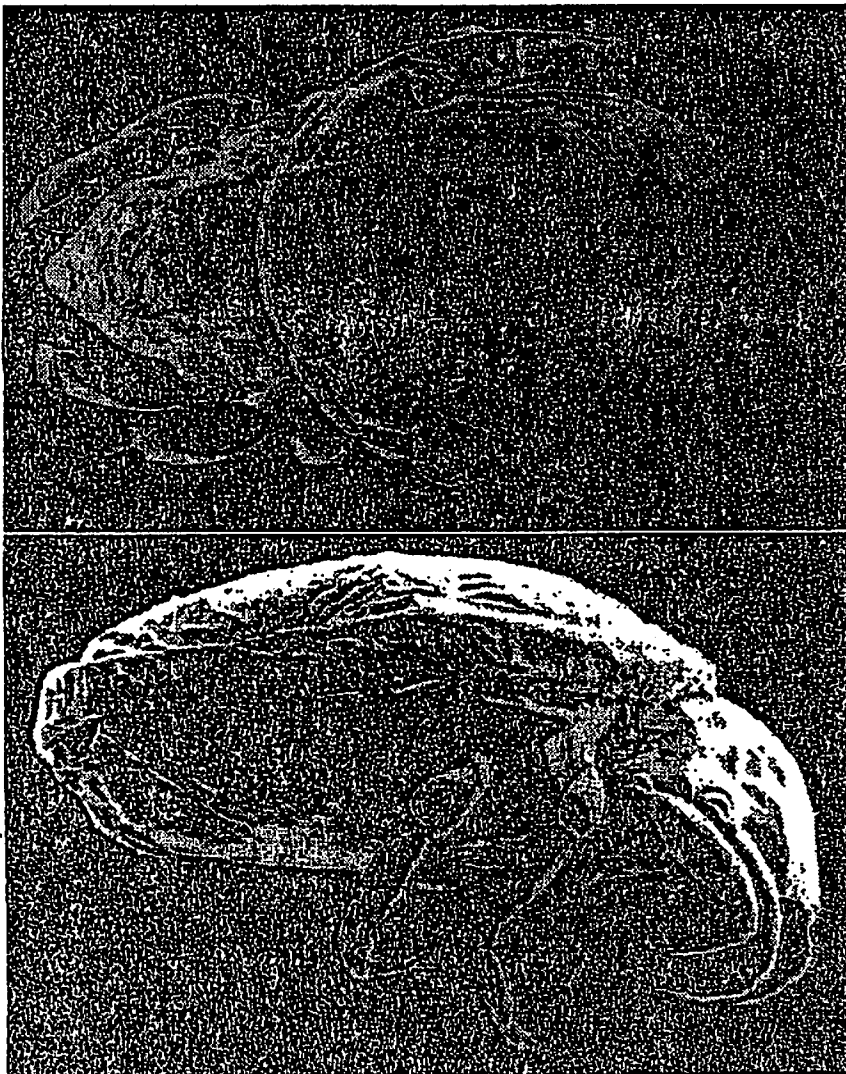


Figure 1. Dorsal and lateral views of an undescribed mite, near *Aquanothrus*, inhabiting very short-lived rock pools on the Colorado Plateau. The mite is approximately 0.77 mm long, the widest part of the abdomen is about 0.38 mm, and the body is roughly 0.15 mm thick. (Scanning electron micrographs by John Gardner, Brigham Young University, Provo, UT.)



Habitat Requirements

Over 60 pools have been characterized near Moab, Utah where the mite was first discovered. Each pool was measured and examined for mites and other organisms. Length, width, and depth were measured, and surface area and volume were estimated. Maximum sediment depth was also measured. Pool sediment was examined for the presence of mites, rotifers, and gnat larvae, and the sediment surface assessed for the degree of cyanobacterial crust development. These data were analyzed using principal components analysis to look for pool characters that may correlate with mite presence or absence.

Results and Discussion

Distribution

The known distribution of this mite is shown in Figure 2. The x's represent locations where mites are present; the dots are locations where pools were examined, but no mites were found. The vast areas with no marks indicate areas that have not been surveyed, and include unsuitable habitat (e.g., most Mancos Shale exposures). We have examined few sites outside Utah; this is a reflection of our travel patterns rather than mite distribution.

Mites have been found across much of the central Colorado Plateau, from 1,060 m to 1,980 m above sea level on sandstones of Permian to Cretaceous age (Figure 2). Only cursory surveys have been made across most of the southern Colorado Plateau (Figure 2), and no work has been done in the northern portion of the Colorado Plateau.

Most mite pools are in fine-grained sandstones such as Navajo and Wingate Sandstones, and coarse-grained sandstone deposits such as the Cedar Mesa, White Rim, and Dakota Sandstones. Some Entrada exposures (e.g., the Moab and Slickrock Members in Arches National Park) also contain many mite pools; however, the mite appears to be absent on Entrada outcrops in the Escalante and Capitol

Reef region. The Entrada is comprised of finer sediments and is softer in central and western Utah than eastern Utah (Baars, 1983). This may play a role in suitability for mites. Mites have not been found in other soft sandstones or siltstones (e.g., Morrison and Moenkopi Formations). More work is needed to determine the full distribution of this mite. Most of the Colorado Plateau has not been adequately surveyed, but even where we have surveyed, it is missing from pools that appear to be suitable.

A combination of biotic and physical interactions probably determine geographic and elevational distribution of this mite. At lower elevations and latitudes, a small pool may not last long enough for mites to replace the energy used in generating and breaking dormancy, but larger pools may support mite predators. At high elevations and latitudes, mites may not have enough time where they are both wet and warm enough for efficient metabolic activity to acquire sufficient energy to successfully reproduce.

Habitat Requirements

Lower pan size limit is predicted to be determined by the minimum amount of time needed to acquire the energy necessary to reactivate metabolic activity following rehydration plus the energy required to resist dehydration again. There could be a minimum amount of sediment needed as well. Sediment may provide protection for mites from wind, and perhaps from exposure to ultra-violet radiation or other stressors. Upper limit on pan size is probably based on biotic interactions, especially predation. Mites move across sand surfaces clumsily, and are probably easy prey for active predators such as gnat larvae and tadpole shrimp.

The attempt to characterize physical parameters of small pools to look for either positive or negative correlations with mite presence has not been very successful to date. A total of 61 pools were described; 42 contained mites, 19 did not. Mites were found in pools throughout the full range of each parameter (Table 1), and there is complete overlap between pools with mites and pools without mites. Principal component analysis indicates

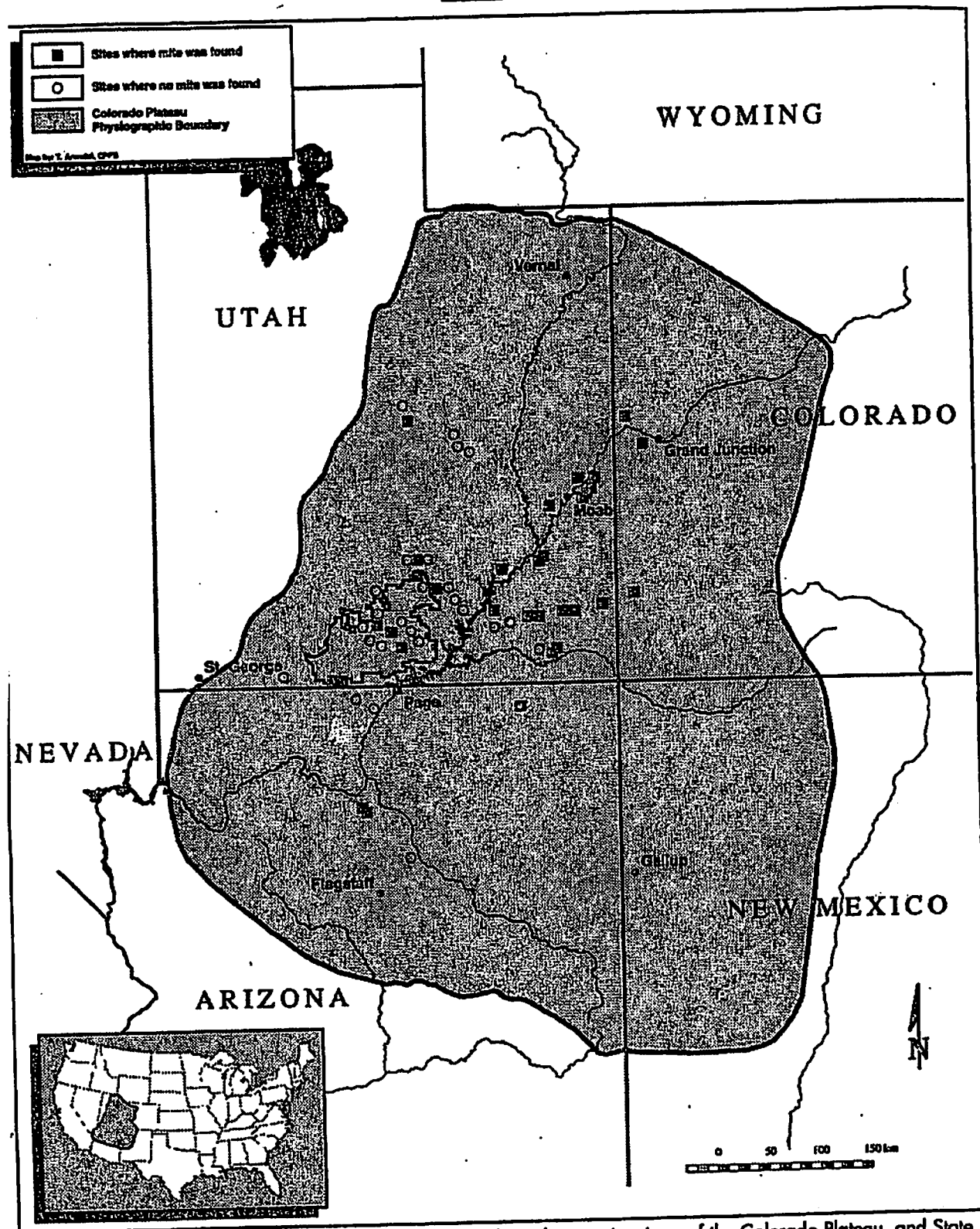


Figure 2. Schematic map showing the Colorado Plateau boundary, major rivers of the Colorado Plateau, and State boundaries. The squares indicate locations where the mite has been found; the circles represent locations that were surveyed for mites, but no mites were found.



Table 1. Ranges for pool characteristics measured in 61 pans in Navajo Sandstone near Moab, Utah. Mites occurred in 42 pans and were absent from 19 pans.

Pool parameter	Pools with mites	Pools without mites
Depth	0.5-10.0 cm	0.65-6.75 cm
Surface area	23.8-24,053 cm ²	50.3-11,216 cm ²
Volume	0.108-40.25 L	0.075-43.9 L
Sediment depth	0.05-7.0 cm	0.01-10.0 cm
Dist. to nearest pool	1.01-4.6 m	0.16-2.86 m
Dist. to nearest pool w/ mites	0.1-9.9 m	0.18-7.0 m

that pool surface area accounts for essentially all of the variability among the pools surveyed, but there was no pattern of mite presence/absence correlated with surface area (Figure 3).

Sediment depth was expected to be correlated with mite presence, since mites retreat into the sediment as pools dry out. They had not been observed on dry rock surfaces exposed to air. But sediment depth was not correlated with mite presence, and a pool with sediment depth of only 0.5 mm had mites.

Surveys appeared to reveal a trend for pools with well-developed cyanobacterial crusts to

be without mites more often than similar-sized pools without a well-developed crust. But at least for the 61 pools surveyed, there is no clear pattern: 23 pools had crust, 38 pools were without crust, 4 of the 19 pools without mites had well-developed crusts, and almost half the pools with mites contained crusts.

Ecology

Aquanothrus sp. is an unusual oribatid mite. Few oribatids are aquatic, nor able to live in the small ephemeral environments these mites occupy. Most oribatid mites feed on fungi and organic detritus. This mite is a predator, feeding on rotifers, although it may also eat diatoms, algae, and detritus. Oribatid eggs are generally unpigmented; this mite's eggs are a bright orange, the same color as the rotifers the mites eat. We don't know if there is a relation between rotifer color and egg pigmentation. Pans can hold surprisingly large mite populations. Over 200 individuals have been counted in pans estimated to contain only 1 L of water.

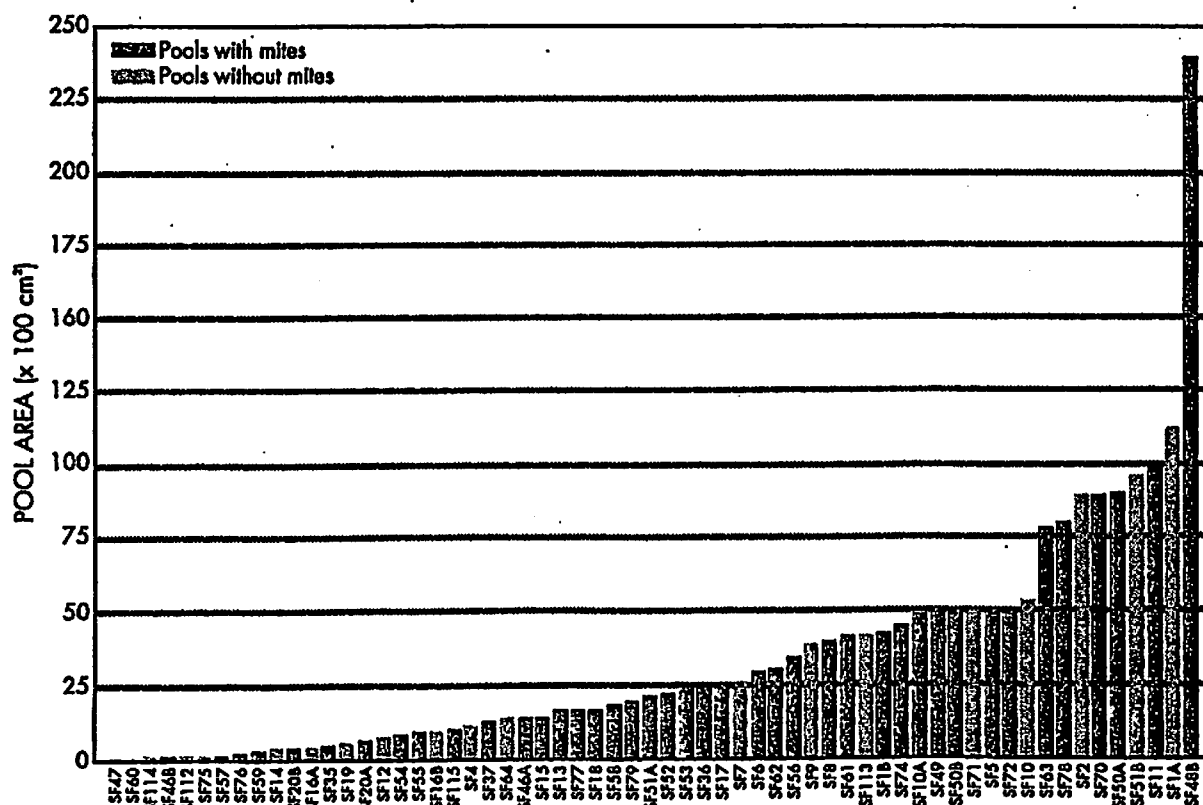


Figure 3. Potential mite pools measured and surveyed in July 1997, sorted by surface area, showing mite pools and pools without mites.



No experimental work has been done on these mites to determine how they survive extended dry periods. They probably do not tolerate desiccation (anhydrobiosis); we suspect they avoid desiccation rather than tolerating water loss. Part of the suite of adaptations that allows them to survive in dry pans may be the unique structure of their cuticle, which is thin but very tight, with little lamination detectable. Their waxy coating is a thin continuous cerotegument, with air-filled chambers connecting to the surface (Norton et al., 1997). The mites are not capable of surviving very long periods without water; samples kept dry over a year rarely contain any live mites (T.B. Graham pers. obs.).

Bright orange patches (up to 30-mm diameter) have been observed in the sediment of some pans, notably those without mites. Examination of these patches revealed they were comprised of thousands of rotifers. These rotifers are present in pans with mites, but at much lower densities. The mite population of one pan was accidentally destroyed in August 1989 and had not been recolonized by October 1993, but the rotifer population became quite dense during that period (T.B. Graham, pers. obs.). Mites did not disperse from the nearest pool with mites (0.61 m) for 7 years (T.B. Graham, pers. obs.). These observations led to the hypothesis that the mites feed on rotifers, and may play a role in rotifer population control. Observations in the lab indicate the mites do indeed feed on rotifers, and can eat all the rotifers in a container in a few days. We have not quantified their impact on rotifer populations in pans yet.

Mites live in shallow depressions rarely recognized as living ecosystems. The mites are limited by availability of suitable habitat of course, but are also impacted by trampling by livestock, vehicles, and other human activities. Near Moab, mites are abundant in areas with little human use over the past 20 years. One area has been used for grazing, off-highway vehicle use, and firewood collecting for many years. I have not seen any mites in hundreds of pans examined here, but many have large

rotifer populations. This may be a reflection of greater human use in this area.

Recreational activity is increasing on the Colorado Plateau, and many areas are receiving very intense use. Human use of some areas currently occupied by mites has increased exponentially over the past decade. Land managers have traditionally encouraged use of slickrock areas to protect the fragile soil and plant communities on the Colorado Plateau. There are few potential indicators on slickrock to monitor recreational pressure. Mite populations may be a useful indicator for this purpose. Comprehensive surveys are needed to document baseline mite populations, and protocols should be developed to monitor impacts as use increases on the Colorado Plateau, including within the Grand Staircase-Escalante National Monument.

These mites are important from a scientific perspective and deserve protection. The disjunct distribution of the genus *Aquanothrus* is intriguing, and may provide valuable insights on dispersal mechanisms and biogeography. They can contribute information on evolutionary ecology, the morphology and physiology of desiccation resistance, and other ecological and evolutionary questions. Research into anhydrobiosis of rotifers and tardigrades has led to a number of applications, particularly in processing and storing biological tissues and other substances (Crowe and Crowe, 1990; Crowe et al., 1987). The mites seem to have solved the problems of surviving in a dry environment differently, and they may hold alternative answers to problems of tissue storage and maintenance of molecular structure.

We hear a lot about the charismatic megafauna, and know the emotional and political power members of this elite club wield. *Aquanothrus* mites are not cuddly, cute, or fuzzy (Figure 1). They are tiny, inconspicuous, and have twice as many legs as the organisms most people envision when they hear the word animal. They still deserve protection. Please tread lightly on the rocks of the Colorado Plateau and stay out of even the smallest depressions in the rock.



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