Exotic Species in North American Caves

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Abstract

Exotic species are important threats to endemic fauna in epigean habitats. However, the threat of exotic species to endemic cave fauna has not been the focus of traditional cave management. Several invasive exotic troglophiles are capable of invading cave habitats and might even competitively exclude troglobitic species. Cave resource managers and biospeleologists need to pay attention to several groups with particularly invasive species including ants, centipedes, earthworms, isopods, millipedes, mites, and spiders. In some situations even exotic troglobites and other unlikely invaders are a potential problem.

Current cave faunal records documenting populations of native species in conjunction with exotic species are important in monitoring the progress of invasive species. For example, states like South Carolina have no records of cave millipedes before the introduction of *Oxidus gracilis*, which is now the only millipede known in South Carolina caves. While some exotic species can not be controlled, others may be controlled with new management practices. For example red imported fire ants can forage in caves and decimate endemic troglobite populations. Properly timed fire ant insecticides can be applied, but management must take into consideration the foraging behavior of cave-dwelling crickets and harvestmen. Land management may also influence fire ant foraging in caves.

Other exotic species include the earthworm, *Dendrodrilus rubidus*. *Dendrodrilus rubidus* is the most common earthworm found in many cave surveys and might exclude native species. Native earthworms sometimes use caves as a refuge, and are no longer present in epigean habitats. With the invasion of *Dendrodrilus rubidus* and other exotic species, the native cave fauna may go extinct.

The purpose of this paper is to present the threat of exotic cavernicoles and to suggest studying their impact on cave ecosystems. As world commerce and travel increase so too does the introduction of exotic animals and plants. Exotic species are continuously introduced to the United States by accident or for purposes like biological control, landscaping, agriculture, or the pet industry (Malakoff, 1999). Most species do not survive but others kill or exclude endemic species, sometimes driving them to extinction. According to Enserink (1999), habitat destruction is being replaced by exotic species introductions as the most significant threat to global biodiversity. The U.S. federal government only recently acknowledged the threat of exotic species and stopped federal agencies from actively spreading them (Kaiser 1999). State and private industry will probably take longer to follow.

Not all exotic species compete with their endemic counterparts. Instead some transmit or harbor pathogens. An example is the "brown dog tick," *Rhipicephalus sanguineus,* a vector for several canine and human diseases, which were introduced with the tick from the Old World (Cooney and Hays, 1972). Exotic bat parasites can also import or transmit diseases. For example *Cimex lectularius*, the exotic human bed bug, also feeds on vespertilionid bats and probably transmits *Trypanosoma cruzi* and other bat trypanosomes (Paterson and Woo, 1984). In what seems to be an unlikely relationship several aquatic insects and snails are intermediate hosts for bat helminths (Chen, 1964). With the constant influx of exotic spe-

cies into aquatic habitats, these parasites can be introduced into bat populations.

Caves historically have been expounded as nutrient-poor low-energy systems (Culver 1982). The low-ecosystem productivity probably acts as a mitigating factor in controlling exotic cavernicoles. Exotic species have invaded North American caves. When all invertebrate species (excluding mollusks) from cave surveys in Alabama, Florida, Illinois, Georgia, South Carolina, and Tennessee were counted, 11%, were exotic (Peck, 1970; Holsinger and Peck, 1971; Lewis and Peck, 1978; Peck, 1989, 1995; Reeves, 1999). When individual orders of cavernicoles were examined, some trends were evident. For example, 42% of the terrestrial isopods in caves of Alabama and Georgia are exotic species (Peck, 1989; Holsinger and Peck, 1971). Most exotic isopods are larger than the endemic troglobitic *Miktoniscus* spp. European isopods, including the troglophiles *Cylisticus convexus* and *Porcelio laevis*, are now more common than the native species in some epigean habitats. Both species have symbiotic fungi and nematodes (Lichtwardt, 1986, Reeves unpublished data). In natural situations, symbiotic fungi do not harm their hosts and probably help in nutrient absorption (Lichtwardt, 1986). Symbionts sometimes kill new host species or become parasitic when they are introduced. There are reports of several symbiotic fungi killing their hosts or occluding their guts (Coluzzi, 1966; Sweeney, 1981; Lichtwardt, 1986).

Millipedes are a second group of cavernicoles with a large percentage of exotic species. In Georgia, 50% of the cavernicoles in the orders Julida and Polydesmida are exotic species (Holsinger and Peck, 1971; Reeves, 1999). In Howards Waterfall Cave, both exotic millipedes and endemic troglobites occur sympatricaly and both groups are infected by fungi and nematodes (Reeves, 1999). The most common exotic millipede in many Georgian caves is *Oxidus gracilis* (Reeves, 1999). *Oxidus gracilis* sometimes forms aggregations and releases a noxious compound when disturbed. Hundreds of aggregating *O. gracilis* can move into caves. These millipedes both compete with native species and harbor potential diseases. The ecological effects of these exotic millipedes have not been determined.

Annelids, specifically earthworms, are the third most common exotic cavernicoles. Unlike isopods or millipedes, earthworms are often overlooked by cave biologists. Exotic earthworms have replaced many of the endemic species in epigean habitats (Reynolds, 1998). Caves might represent a refugium for endemic species but in most caves this is not true (McAlpine and Reynolds, 1977; Reeves and Reynolds, 1999). Earthworms are capable of changing the physical and biological components of cave soils. For example, Dendrodrilus rubidus and Aporrectodea spp. can preferentially feed on guano or organic debris with high microbial or fungal activity (Doube and Brown, 1998). Earthworms and their smaller relatives, enchytraeids, can consume and change the soil microbial community once they are established in a cave. Earthworms also transport nematodes and other potential earthworm pathogens.

Not all exotic species that harm cavernicoles live in caves. The red imported fire ant, *Solenopsis invicta*, forages in caves. In Texas, *S. invicta* has had devastating effects on most ground-dwelling wildlife (Allen *et al*, 1994). These ants will forage more than 20 meters from their nests, and colonies are now present in all southern states. The projected range extension of *S. invicta* could make it an important exotic species when managing caves and karst in the United States. *Solenopsis invicta* is common in disturbed areas like high-traffic cave entrances.

Exotic cave species are not limited to caves in the United Sates. Tropical caves are not as well studied as in the United States, but good records exist for some systems. For example, Chilibrillo Cave, Panama, was surveyed by Peck (1971) and among the endemic species collected in the survey were several exotic cavernicoles. These exotic species included a snail (*Subulina octona*), a millipede (*Chrondrodesmus kelaarti*), and possibly the collembolan (*Cyphoderus similis*), which is also known from Africa, California, and Iowa (Peck ,1971).

Exotic species in caves have not attracted attention compared to those in epigean habitats. Some studies have made the distinction between exotic species and endemics (Howarth, 1973), but further research is needed to determine the real significance of exotic species in cave ecosystems. Ecological studies are needed to assess the influences of exotic species on the cave ecosystem. Hundreds of exotic millipedes, earthworms, or isopods probably impact the cave ecosystem. The relationships between native cavernicoles and exotic species have not been well documented. Until the influences of these exotic species are understood, no management practices can be recommended. Simple lists of what species are troglobitic, troglophilic, trogloxenic, and accidental will not suffice to predict the ecosystem-level effect of exotic species, their relative abundance, or parasite-vectoring capacity.

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