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Earthworms as a prey source for the insular snake *Thamnophis sirtalis* (Linnaeus, 1758)

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Abstract

Insular organisms typically evolve in closed, isolated systems; thus, changes caused by introduced species can drastically affect their ecology. Isle Royale National Park (Michigan, USA) is a remote island in Lake Superior that, until relatively recently, was void of earthworms. Its two native natricine snakes are known to feed on earthworms on the mainland; here, we confirm that eastern gartersnakes (*Thamnophis sirtalis*) are also feeding on earthworms on Isle Royale. It is unknown how this new important dietary source will impact the snake ecology on Isle Royale.

Key Words

diet, eastern gartersnake, Isle Royale National Park, redbelly snake, *Storeria occipitomaculata*

Insular organisms have evolved in isolation from conspecifics on the mainland and in sympatry with other species native to that island. Islands are excellent models for more complex ecosystems and allow for a better understanding of predator-prey relationships because of the comparative reduction in species richness (Simberloff 1974).

Many islands around the world have evolved interesting snakes with unique life histories (e.g., King and Lawson 1997; Boback 2003; Shwiff et al. 2010; Portillo et al. 2019). Whether native or introduced, insular snakes can be subject to important ecological dynamics, including the introduction of a new prey source (King et al. 2006). The introduction of invasive alien species often has dramatic effects on the ecosystem, especially on islands (e.g., King et al. 2006; Russell et al. 2017). Earthworms, which have now become well-established, are not native to the upper Midwest and are believed to have arrived in the United States as early as the 1600s in potting soil or ship ballasts (i.e., Gailing et al. 2012). On average, most earthworms move less than 8 m a year, but they are spread readily by humans, ending up in more remote places because of their usage as live bait for fishing or decomposers for gardening. Estimates suggest about 268 worms per square meter of soil and as many as 81.8 billion worms alone in Manistee County (3320 km^2 in size) in the northern lower peninsula of the U.S. state of Michigan (Freley 2021).

Earthworms can have extensive negative impacts in forested environments. They may remove the surface plant litter rapidly, alter the understory vegetation, and disrupt soil physiology (Hendrix and Bohlen 2002; Craven et al. 2017). Such changes drastically alter the ecosystem (Frelich et al. 2006), especially on islands where space is relatively limited.

It can be difficult to identify an earthworm as a species unless you are able to count the segments between the

start of the worm and the clitellum (band), measure the total length of the worm as well as the length from the start of the worm to the clitellum (band), and also examine a picture of the underside of the worm; however, all are introduced species in the Upper Midwest. For example, Minnesota, United States, has at least 15 introduced species of earthworms. Ontario, Canada, has at least 15 confirmed invasive species (Holdsworth et al. 2017). In the upper Midwest, the last locations to experience the invasion of earthworms are often islands, including those in Lake Superior.

Even though earthworms are now widespread in the Upper Midwest and several snakes are known to feed on them, little work has been done to document this prey source. Here we confirm that snakes isolated on an island are utilizing earthworms as prey and establish baseline data for the study of this over the next few years.

Methods

Study site

Isle Royale National Park, Keweenaw County, Michigan, United States (47.9763°N, 88.9313°W), is a relatively remote island in western Lake Superior. It is located 29 km from the Minnesota shore, 90 km from the Michigan shore, and 24 km from the Ontario, Canada, shore. Isle Royale was designated a National Park in 1940, and to this day, 99% of it is federally protected wilderness (NPS 2023). The surrounding waters of Lake Superior are vast and cold, making it impossible for many organisms to immigrate to, or emigrate from, the island.

Study species

Isle Royale has two native species of snakes: *Thamnophis sirtalis* (Linnaeus, 1758), popularly known as the eastern gartersnake, and *Storeria occipitomaculata* (Storer, 1839), popularly known as the northern redbelly snake. It is unclear how they came to the island, though both are well-established and widespread; neither is well-studied in this environment. *Thamnophis sirtalis* is most notable on Isle Royale for its highly variable color morphs (Mooi et al. 2011). It has a wide diet, including frogs and toads, rodents, small fish, and invertebrates such as slugs and earthworms (Mullin and Seigel 2009; Virgin and King 2019). *Storeria occipitomaculata* feeds primarily on slugs and occasionally on earthworms (Virgin and King 2019).

Procedure

The following observation was made while visiting Isle Royale National Park: The snake was not captured or handled, and digital documentation of the event was taken.

Results

On 23 June 2023, at 14:54 h, at the South Lake Descor Campground (47.969099, -80.975028), a small (presumably a 2022 neonate) *Thamnophis sirtalis* was found feeding on an earthworm (Fig. 1). This represents the first photographed event of the consumption by a snake on Isle Royale, even though both native species of snakes are documented to feed on earthworms on the mainland.

There is a single record of an eastern gartersnake (*Thamnophis sirtalis*) consuming a *Lumbricus terrestris* Linnaeus, 1758 in what was previously the Ransom settlement, located on the northwestern side of the island near the present-day Daily Farm campground (Adams 1909). During a visit to Isle Royale in July 2023, two large additional "nightcrawler" earthworms were found near Malone Bay. One was on the concrete platform of the duplex housing, and the other was found under a log on the Ishpeming Trail near Siskiwit Lake.

Discussion

Earthworms, not native to the Upper Midwest of the United States, were presumably introduced to Isle Royale National Park in Lake Superior as byproducts of fishing in the area. At this time, we do not know how the introduction of earthworms and their expansion of range are going to impact the two native species of snakes on Isle Royale. It has been shown in other systems that the introduction of an abundant prey source can lead to increases in body size and thus increased reproductive potential in another natricine snake (King et al. 2006; Llewelyn et al. 2010).

The presence and impacts of earthworms on the nearby Boundary Waters Canoe Area Wilderness on the border of Minnesota, United States, and Ontario, Canada, are well documented (Wellnitz et al. 2020). However, there is little information available on the presence of earthworms on Isle Royale *per se*, as well as when they were originally introduced to the island. Similar observations have been made recently by one of the authors (JMR) in proximate locations (Sand Island in the Apostle Islands, Lake Superior, Wisconsin, United States) while surveying for eastern gartersnakes (*Thamnophis sirtalis*). In that case, JMR recovered an earthworm in the regurgitate from a snake caught during an evening rainstorm. At the time, invasive earthworms had not yet been documented on Sand Island in the Apostle Islands. Given the presence of earthworms on these islands in or near Lake Superior, it is not surprising that earthworms are present on Isle Royale.

As stated by Simberloff (1974), in reference to Isle Royale, it is the isolation of the island that leads to the reduced flora and fauna. This allows for observations to be more easily made in reference to how changes impact the ecosystem. If earthworms are widespread and abundant on Isle Royale, they may constitute an important food source for the snakes. Further studies of the island should make an effort to document the presence of earthworms among species to understand how widespread and abundant the invasive species are.

Figure 1. Sequence of a juvenile eastern gartersnake (*Thamnophis sirtalis*) ingesting a non-native earthworm on Isle Royale National Park, Keweenaw County, Michigan, United States of America.

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