



SHORT NOTE

A Southern Record of the Xenobiotic Ant *Formicoxenus quebecensis* from Eastern Wisconsin

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Abstract

The ant genus *Formicoxenus* is notable for the fact that all its species are xenobiotic and live inside or in close association with the nests of other ant species. Here, we report the occurrence of a colony of *Formicoxenus quebecensis* and its host, *Myrmica alaskensis* from the eastern side of the Door peninsula in Wisconsin. Both species are new records for the state, and *F. quebecensis* was previously known only from boreal habitats much farther north in Canada. We also provide some observations on this colony's nest demography, morphology, and feeding behavior and discuss the ant community of this biogeographically interesting location.

Xenobiosis is a symbiotic interaction in which two ant species live together in the same nest but rear brood in separate chambers. Often, one of the partners in this relationship is completely dependent upon the other for nest construction (Lenoir et al., 2001). Beyond shared nest space, xenobiotic interactions are often broken into several subcategories based upon foraging behavior, ranging from food solicitation from the free-living species by the dependent species (cleptobiosis) to co-foraging along trails scouted by the independent species (parabiosis) to only casual nest associations and uncertain foraging interactions (plesibiosis). While xenobiotic interactions resemble social parasitism in some cases, these may be context-dependent. Most have not been evaluated regarding potential fitness costs to the free-living partner (Rabeling, 2021). Only a handful of species are known to be definitively xenobiotic (Weber, 1943; Buschinger, 2009; Adams et al., 2013; Powell et al., 2014; Kvifte et al., 2017). Among these, the myrmicine genus *Formicoxenus* currently contains seven extant species, all of which are exclusively xenobiotic

(Wilson, 1971; Francoeur, 1985; Hölldobler & Wilson, 1990; Martin et al., 2007). Colonies of *Formicoxenus* are typically made up of fewer than 100 workers, and they establish their nests within or in close proximity to the much more populous nests of *Formica*, *Myrmica*, and *Manica* species.

In North America, the species *Formicoxenus quebecensis* Francoeur, 1985 is associated with the host ant *Myrmica alaskensis* Wheeler, 1917 and is thus far known only from boreal habitats in Canada. *Formicoxenus quebecensis* is infrequently collected and is considered rare (Lenoir et al., 1997). New occurrence records that lie outside of the recognized ranges of uncommon xenobiotic or socially parasitic species can provide useful information about their natural history (Buschinger et al., 1994; Buschinger & Schumann, 1994; Antonova, 2009; Kiran et al., 2021). We recently collected a colony of *F. quebecensis* along with workers of its host *Myrmica alaskensis* at the Ridges Sanctuary, which is a private nature reserve located on the Door Peninsula of eastern Wisconsin (Figure 1, Figure 2A). This location is



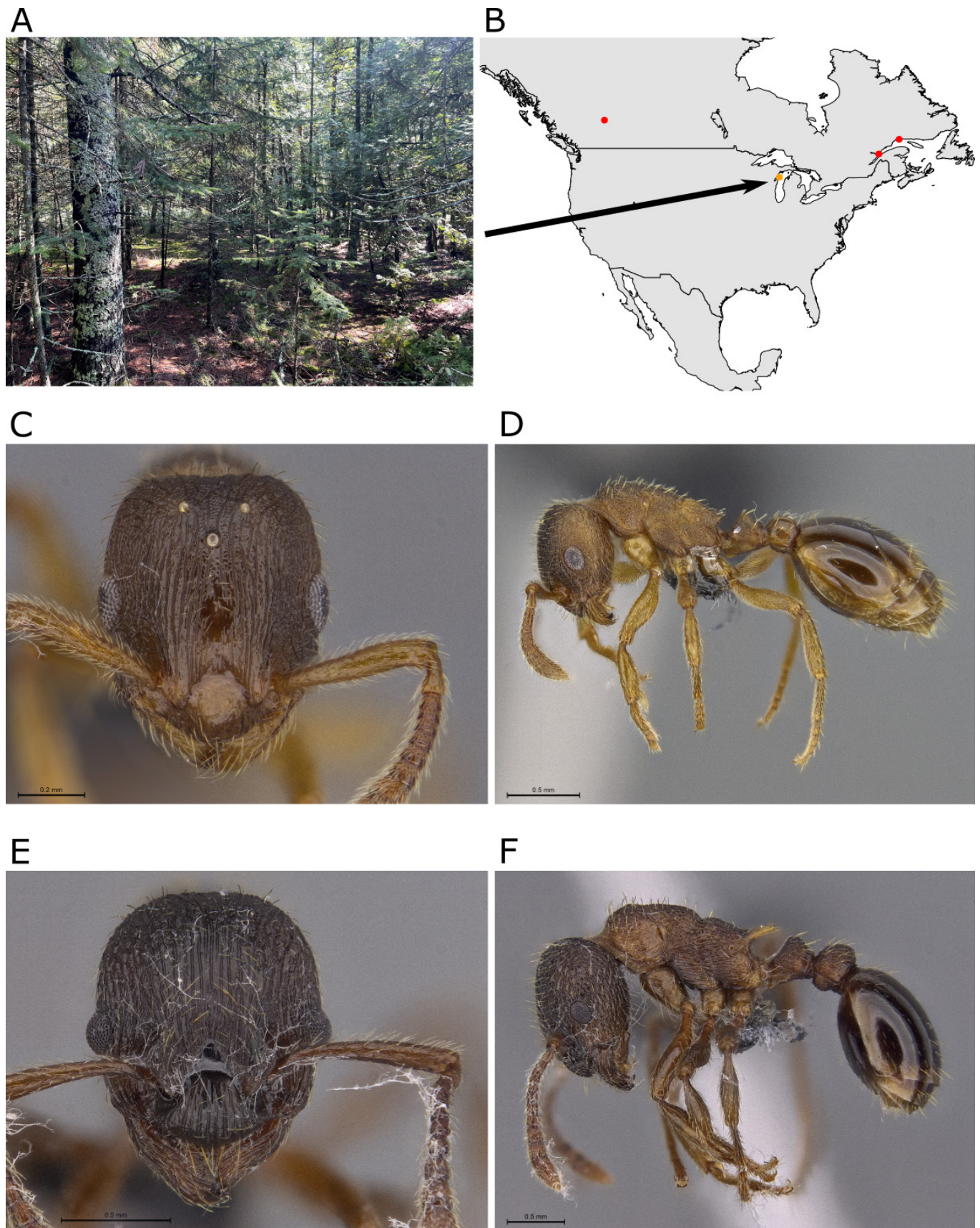


Fig 1. A photograph of the collection locality (A), and a map (B) pinpointing the origin of our colony of *F. quebecensis* (orange dot) relative to previous records (red dots) of *F. quebecensis* whose coordinates are provided on AntWeb (<https://www.antweb.org>). Head (C) and profile (D) view of a *F. quebecensis* intermorph taken from the collected nest. Head (E) and profile (F) view of a *M. alaskensis* worker taken from the collected nest. The map was generated using the R packages “maps” and “mapdata”.

unusual in that is considered to have a boreal climate and has cooler summer temperatures than the areas adjacent to it (Curtis, 1959).

We made three ant collecting trips (one each in 2019, 2021, and 2022) to the Ridges Sanctuary, Door County, Wisconsin [Coordinates of sanctuary: 45.068372, -87.123751]. During these trips, we searched for ant colonies by hand collecting, breaking open rotting sticks, and looking under small stones. Although we did not collect specimens from all encountered colonies, our impression during our hand collecting efforts is that colonies of the species *Stigmatomma pallipes* Haldeman, 1844 and *Leptothorax canadensis* Provancher, 1887 appear to be especially common at this locality. *Leptothorax canadensis* is apparently a species complex (Prebus in prep., see also Schär et al. (2018)), and the *Leptothorax canadensis* found here comprise at least two species: *L. AF-can* and *L. AF-erg* (Ellison et al., 2012). *Leptothorax AF-erg* has also previously been found on the western side of the Door Peninsula inhabiting acorn nests (Doering et al., 2022). The colony of *F. quebecensis* was collected on September 7th, 2021, from a rotting stick. This colony was nesting alone; a colony of its host *M. alaskensis* was not present in the same stick, but four *M. alaskensis* workers were found alongside the *Formicoxenus* workers within the nest. Neither species has previously been recorded in Wisconsin. Voucher specimens of *F. quebecensis* and *M. alaskensis* from this nest will be deposited in the Arizona State University Natural History Collections (institutional collection code: ASUHC) (unique specimen identifiers for *F. quebecensis*: CASENT4011002; CASENT4011005; CASENT4011008; CASENT4011009. *M. alaskensis*: CASENT4011007).

We counted the approximate number of *Formicoxenus* larvae and pupae by photographing the colony after transferring it into an artificial nest (Figure 2B) made from balsa wood and two glass microscope slides (75 x 50 mm). We looked for eggs in this image and by manual visual inspection, but due to their small size and tendency to clump together, we did not count the number of eggs. We inspected all collected adults from the colony individually under a dissecting scope to assess the demographic makeup of the colony. In addition to the worker caste, *Formicoxenus quebecensis* exhibits two distinct queen morphs (Francoeur, 1985; Buschinger et al., 1994). Queens can be either gynomorphs (winged individuals that are larger than workers) or intermorphs (worker sized individuals that have ocelli and sutures between sclerites on the mesosoma). Male polymorphism occurs in this species, and males can be either winged or wingless (Francoeur, 1985; Buschinger et al., 1994). We also used a digital caliper to measure the width and approximate length of the different chambers that made up the original stick nest that the colony was living in.

In addition to the four workers of *Myrmica alaskensis*, we counted a total of 62 *Formicoxenus* adults in the colony. Several individuals in our *Formicoxenus* colony were indeed intermorphs (Fig 1C, D). Based on our morphological assessment,

the colony consisted of 15 putative intermorphs and 47 workers. Six adults that we classified as workers appeared to have very small ocelli but lacked any obvious mesosomal sutures. These individuals thus do not seem to be intermorphs. No males or gynomorphic queens were present. The colony had approximately 35 larvae, did not appear to have any pupae, and eggs were present. The original stick nest of the colony contained at least three clearly identifiable chambers. The colony spread its brood between multiple chambers (Figure 2A). The width of the chambers ranged from 3.4-6.5 mm, and the length of each chamber ranged from 37.2-58.3 mm.

In addition to being a more southern record for *F. quebecensis*, this is the first documented instance of this species situated between the currently known disjunct eastern and western populations in Canada (Buschinger et al., 1994). This new record of *F. quebecensis* also sheds some additional light on its natural history. Our measurements of the colony's nest indicate that this species' nests can consist of multiple chambers similar to free-living ants from the genera *Leptothorax* (Francoeur, 1986; Heinze & Ortius, 1991), which belongs to the same genus group as *Formicoxenus* (Blaimer et al., 2018). The size of our colony does not appear substantially different from prior records of *F. quebecensis* (Francoeur, 1985; Buschinger et al., 1994). The presence of intermorphs also appears to be typical for this species; intermorphs can comprise nearly half of the adult population of a nest in some populations (Buschinger et al., 1994). The lack of a *Myrmica* colony living in the same stick as the *F. quebecensis* suggests that this species may sometimes nest alone in the wild. However, the presence of *Myrmica* workers may indicate that this is a satellite nest of the main *Myrmica* colony. It is possible that solitary nesting may occasionally occur in its close relative *F. provancheri* (Cole, 1954). However, we cannot rule out the possibility that the colony we found might have been nesting nearby a host colony in a separate stick.

We provided our colony with honey and dead fruit files while it resided in the artificial nest, but the ants were only ever observed eating honey. This matches reports of captive *F. provancheri*, which will forage on sugar sources but do not retrieve dead insect prey (Kannowski, 1957). However, we did observe workers eating pieces of Spam (Hormel Foods, Minnesota) that were left in the colony's nestbox, indicating that *Formicoxenus* workers might sometimes forage for protein on their own as well.

Lastly, the locality where we collected the *Formicoxenus* is likely a promising location for a comprehensive ant survey. Due to the effect of on-shore winds from Lake Michigan, the eastern side of the Door Peninsula has a microclimate that resembles the North American boreal forest biome (Curtis, 1959). The *Myrmica alaskensis* and *Formicoxenus quebecensis* found here are thus surrounded by warmer deciduous forest habitats that appear unsuitable for these species. The eastern Door Peninsula might thus act as a refugium that harbors other ant taxa that are typically restricted to higher latitudes in North America.

A



B



Fig 2. A photograph of one side of the stick nest that the *F. quebecensis* colony was inhabiting (A). Multiple chambers containing workers and brood can be seen. A photograph of the colony residing in the artificial nest (B). Several individuals were exploring outside the nest at the time this image was taken.

Authors' Contribution

GND: Conceptualization, Investigation, Visualization, Writing-original Draft, and Writing-review & Editing.

MMP: Investigation, Writing-review & Editing.

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