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Terrestrial dispersal of juvenile Mink Frog (*Lithobates septentrionalis*) in Algonquin Provincial Park, Ontario

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Abstract
Dispersal following metamorphosis is critical for sustaining anuran metapopulations. Mink Frog (*Lithobates septentrionalis*) is a primarily aquatic species that is common in eastern Canada. The species is not well studied, and little is known about the terrestrial dispersal of recently metamorphosed individuals. Here we present our observations on the phenology of terrestrial activity in recently metamorphosed Mink Frogs in Algonquin Provincial Park, Ontario, Canada. Despite a sampling effort of over 26 000 trap nights over two years (2010 and 2011) in an area with a known population of Mink Frogs, we observed only 35 individuals, all of which were recent metamorphs, in late summer 2011, suggesting annual variability of recruitment. Because all Mink Frogs were observed in a riparian area, it is likely that this species uses riparian corridors to disperse toward other wetlands, thus avoiding forested areas.

Key words: Mink Frog; *Lithobates septentrionalis*; dispersal; riparian habitat; Algonquin Provincial Park; Ontario

Introduction
Amphibians often occur in metapopulations, defined as a grouping of local populations inhabiting specific patches of habitat which are prone to extinction and colonization events (Hanski 1998; Marsh and Trenham 2001). The sustainability of metapopulations depends on distances between habitat patches, connectivity, and the number and quality of habitat patches (Howell *et al.* 2018; Fahrig 2020). Maintaining connectivity requires that patches are within an organism's dispersal or migratory ability or that a suitable corridor exists to link them (Fahrig *et al.* 1983). However, many amphibian populations experience localized extinctions despite assumed connectivity in their natural environment (Hecnar and M'Closkey 1996; Green 2003). For instance, the ability of recently metamorphosed individuals to disperse several hundred metres in a short period can sustain "sink" populations (Sinsch 1997) that experience greater mortality than recruitment (Krebs 2001). Furthermore, gene flow between patches allows for genetic diversity to be maintained over time in the face of habitat fragmentation which contributes to the long-term survival of a population (Lesbarrères *et al.* 2003, 2006). Although dispersal to new habitat patches is undertaken by both adults and newly metamorphosed individuals, those in the latter life stage tend to move much greater distances from natal ponds (Preisser *et al.* 2000). Therefore, post-metamorphic dispersal is critical to long-term survival and persistence of regional populations for many species (Sinsch 1997). Yet, amphibian dispersal events remain difficult to assess because of their small size and unpredictable timing.

Mink Frog (*Lithobates septentrionalis*) has an extensive distribution in eastern Canada and the Great Lakes area of the United States (Dodd 2013). This species is highly aquatic, rarely venturing overland, making use of large permanent ponds and lakes, but also occurring in bogs, beaver ponds, and even rivers and streams (Dodd 2013). Mink Frogs typically have a minimum year-long larval period, and froglets metamorphose by mid to late summer the year following hatching (Harding 1997; Dodd 2013; Mills 2016).

Despite being widespread and common throughout much of its range, Mink Frog is not well studied. Compared with other sympatric species in the same genus, such as Green Frog (*Lithobates clamitans*), American Bullfrog (*Lithobates catesbeianus*), and Northern Leopard Frog (*Lithobates pipiens*), little has been written about the post-metamorphic dispersal of Mink Frog. In particular, little has been reported on the terrestrial activity of recently metamorphosed individuals, leading to speculation on the role of this life-history stage in the persistence of local populations and metapopulations in general (Hedeen 1986; Schueler 1987). Here, we present observations on the phenology of terrestrial dispersal of Mink Frogs in Algonquin Provincial Park.

Methods

The study site is in western Algonquin Provincial Park (Ontario, Canada), Hunter Township, on the shore of Brown Lake (45.615°N, 78.854°W). The forest is typical of the area, composed primarily of Sugar Maple (*Acer saccharum* Marshall). Brown Lake is small (66.1 ha) with extensive riparian vegetation. A small creek flowing through a large beaver meadow empties into the lake at the southwest end of the study site.

Drift fence and pitfall trap arrays were used to sample dispersing individuals on the road and forested habitat at varying distances from Brown Lake (LeGros *et al.* 2014, 2017). Two 200-m drift fences were installed on an unused forest road with 26 pitfall traps on each side of the fences ($n = 104$); an additional 54 traps divided among six X-shaped drift fence arrays were placed in the adjacent forest (Figure 1). The road and forest arrays were 97–150 m and 60–175 m from the shoreline of Brown Lake, respectively. Pitfall traps were 19-L white plastic buckets (ICL Canada, Toronto, Ontario, Canada) buried flush with the soil surface next to the drift fence. A moistened sponge was placed in the bottom of the traps to allow animals to hide under it to prevent drying or sit on top in wet conditions. A 3-mm hole was drilled in the bottom of each bucket to allow rainwater to drain. No sticks were placed in the trap to allow bycatch to escape, as we were sampling other amphibians as well that could have escaped.

Traps were checked every morning from May to September in 2010 and 2011, and all captured animals were processed within 1–2 minutes and released on the opposite side of the fence. Snout-to-urostyle length (SUL) was measured to the nearest 0.5 mm using vernier calipers, and mass was measured with a spring scale (model no. 10020 [20 g] and model no. 10100 [100 g], Pesola, Präzisonswaagen, AG, Switzerland), by placing the animal in small plastic bag and subtracting the mass of the bag. To avoid counting recaptured animals as new captures, frogs were marked using a simple toe clip. All capture dates were converted to Julian dates. Trap-nights were calculated by counting the number of sampling nights multiplied by the number of traps in operation. Catch-per-unit-effort (CPUE) was calculated by dividing the number of frogs captured by trap nights.

Results

Mink Frogs were captured in only six of the 104 traps on the road, and five of the 54 traps in the adjacent forest. All six of these road traps were located closest to the stream in the beaver meadow (within 4–10 m); however, they were 97–150 m from the lake. A total of 35 Mink Frogs were captured in all pitfall traps, with only one recapture. Mink Frogs represented 0.84% of the 4260 anurans of eight species captured. Most captures (33 of 36) were on the east side of the drift fence (proximal to Brown Lake), with only three on the west side (coming from upstream of the beaver meadow). We sampled for a total of 26 159 trap nights (11 917 in 2010 and 14 242 in 2011), but Mink Frogs were captured only in 2011. Captures occurred between 24 July and 3 September with two waves of captures during 30 July to 10 August (14 individuals) and 18–27 August (18 individuals). In particular, nights with precipitation yielded many individuals the following day. In 2010, CPUE was 0.25, requiring 395.69 trap nights to capture one individual. All Mink Frogs were recent metamorphs and could not be sexed. Their size range was 30–39 mm SUL (mean 34.47 mm, SE 0.38, $n = 35$) and their mass 2.8–5.9 g (mean 4.04 g, SE 0.12, $n = 34$).

Discussion

Despite an extensive sampling period over two field seasons, Mink Frogs were only captured during a specific period corresponding with metamorphosis (Hedeen 1972) in late summer 2011. Like many ranid frogs, Mink Frog exhibits dramatic fluctuations in population size over time and among sites (Shirose and Brooks 1997). Based on previous studies (Wright and Wright 1949; Hedeen 1972; Gilhen 1984; Leclair and Laurin 1996), all individuals encountered were recent metamorphs (under 39 mm SUL). Although Mink Frogs were captured in pitfall traps only in 2011, adults were heard calling during daylight hours nearby in both 2010 and 2011. Although it is possible that adult frogs could escape from pitfall traps, the large 19-L buckets (38 cm deep) likely prevented such escapes, as many adult and immature Green Frogs ($n = 2311$) and American Bullfrogs ($n = 72$) were also captured (LeGros 2012). In addition, Mink Frogs are noted for being late-night callers (Bishop *et al.* 1997; Lepage *et al.* 1997) and may have been even more abundant in the area than daytime calling would suggest.

The activity period for this cold-adapted species is surprisingly short, ceasing by 30 September in

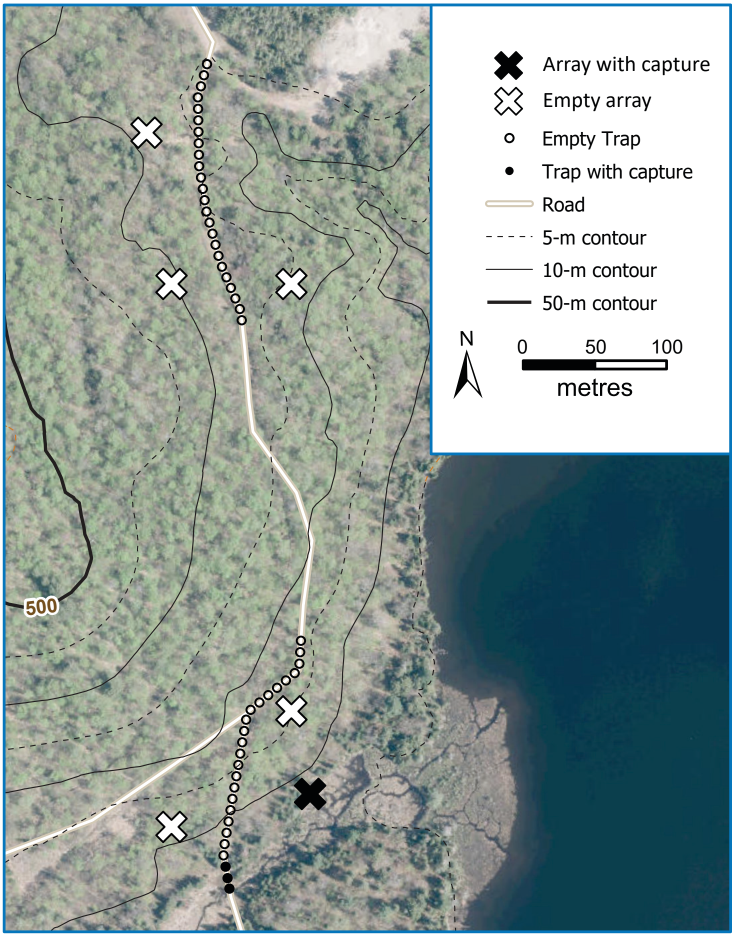

Figure 1. Pitfall traps at the Brown Lake study site, Hunter Township, Algonquin Provincial Park, Ontario, Canada. Circles and Xs indicate paired pitfall traps and arrays, respectively, installed on the unused forest road and in the adjacent forest. Filled symbols represent traps in which Mink Frogs (*Lithobates septentrionalis*) were captured in 2011.

Nova Scotia (Gilhen 1984) and the end of October in Ontario (iNaturalist.org 2020). In Algonquin, our final capture was recorded on 4 September 2011, suggesting a relatively brief period of terrestrial activity for post-metamorphic individuals (42 days between 24 July and 3 September) followed by hibernation. However, Schueler (1987; pers. comm. 10 September 2020) noted that some Mink Frogs were found moving overland in several Ontario locations late in the active season, and many individuals found in October had empty stomachs, suggesting that they were moving to hibernation sites.

Juvenile amphibians are important in maintaining metapopulations, although there are limitations to their ability to disperse long distances, such as small size and a predisposition to rapid water loss and predation (Rothermel and Semlitsch 2002; Lemckert 2004; Smith and Green 2005; Howell *et al.* 2018). Anuran species with short larval periods and small body sizes at metamorphosis, such as American Toad (*Anaxyrus americanus*) and Wood Frog (*Lithobates sylvaticus*), require a pre-dispersal period to improve metabolic function to sustain dispersal activity (Pough and Kamel 1984). In contrast, anurans with longer larval periods and large metamorphic body sizes, such as Green Frog, are capable of near immediate dispersal at metamorphosis (Pough and Kamel 1984). Given that Mink Frogs are particularly prone to desiccation, more so than other immature frogs (Schmid 1965), it is likely that their dispersal is limited to riparian and aquatic habitats to prevent water loss.

The distance between habitat patches and the quality of those patches can also influence rates of dispersal and colonization of amphibians (Howell *et al.* 2018). In our observations, it appears that recently metamorphosed Mink Frogs use riparian habitats, such as streams and beaver meadows, that connect aquatic habitats as corridors for dispersal, as they were not captured at other locations, particularly inland. In the beaver meadow, the stream did have deeper pools that frogs could occupy before hibernation, and if frogs followed the creek upstream 1.7 km, they would encounter another small lake. The use of riparian corridors may not only reduce mortality from desiccation but also provide more feeding opportunities for Mink Frogs, as this species feeds primarily on aquatic prey (Hedeen 1972). By staying close to aquatic habitats, Mink Frogs may also reduce contact with other hazards, such as roads.

Conclusion

Although many species of ranid frogs make overland movements through forest habitats (Lamoureux *et al.* 2002), Mink Frogs rarely do so. However, overland movements may occur at specific times and in concentrated locations, particularly along riparian habitat. Therefore, efforts should be made to maintain connectivity among aquatic habitats to minimize impacts on dispersing amphibians and other wildlife reliant on riparian corridors. In addition, Mink Frogs may not be as affected by road mortality as other ranid frogs because of their habitat preferences during dispersal; however, road construction near riparian corridors and their associated water crossings should be designed to avoid sensitive areas and allow wildlife to follow natural corridors, contributing to the ecological integrity of a site, especially those within protected areas.

Author Contributions

Writing – Original Draft: D.L.L.; Writing – Review & Editing: D.L.L., D.L., and B.D.S.; Conceptualization: D.L., B.D.S., and D.L.L.; Investigation: D.L.L.; Methodology: D.L.L., D.L., and B.D.S.; Formal Analysis: D.L. and D.L.L.; Funding Acquisition: B.D.S., D.L., and D.L.L.

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