

Note

First report of Eastern Red-backed Salamander (*Plethodon cinereus*) on Newfoundland

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Abstract

The island of Newfoundland has no native amphibian taxa, although six species of Anura (i.e., frogs and toads) have been introduced since European colonisation, four of which have established self-sustaining populations. Here, we document Eastern Red-backed Salamander (*Plethodon cinereus*) on Newfoundland for the first time, in what appears to be a self-sustaining population near Conception Bay South. This is the first species of Caudata (i.e., newts and salamanders) to have been introduced to the island, as well as the first occurrence of Eastern Red-backed Salamander establishing a population outside its native range. The impact that this non-native species might have on forest ecosystems on Newfoundland is unclear and further study is required to determine whether eradication of the species from Newfoundland is necessary or feasible.

Key words: Caudata; introduced species; invasion biology; island biology; new distribution record; non-native; Plethodontidae

The introduction and subsequent spread of non-native species can often result in negative ecological (Elton 1958; Bellard *et al.* 2016; Duenas *et al.* 2021) and economic consequences (Hoffmann and Broadhurst 2016; Paini *et al.* 2016). However, not all non-native introductions become invasive (i.e., either having negative effects on native flora and fauna or expanding their extralimital range beyond their initial colonisation site). Ecological and socioeconomic impacts of non-native introductions vary greatly and depend on the species, ecosystem, and other context-dependant factors (Hawkins *et al.* 2015; Bacher *et al.* 2018).

The assessed impacts of 126 species of non-native amphibians have ranged from minimal concern to massive, irreparable effects (Kumschick *et al.* 2017; Measey *et al.* 2020). Although there are currently no known introductions of amphibians to Canada from outside the country, a number of domestic invasives have been introduced to novel regions within Canada. For example, American Bullfrog (*Lithobates catesbeianus*), native to southeastern Canada, was introduced into British Columbia in the 1930s and is negatively impacting native amphibians and invertebrates (Govindarajulu *et al.* 2006; Monello *et al.* 2006; Jancowski and Orchard 2013; Novak and Goater 2013).

Although Labrador supports seven species of native amphibians—two salamanders (Blue-spotted Salamander [*Ambystoma laterale*] and Northern Two-lined Salamander [*Eurycea bislineata*]), four frogs (Mink Frog [*Lithobates septentrionalis*], Northern Leopard Frog [*Lithobates pipiens*], Spring Peeper [*Pseudacris crucifer*], and Wood Frog [*Lithobates sylvaticus*]), and one toad (American Toad [*Anaxyrus americanus*]; Notzl *et al.* 2013)—the adjacent island of Newfoundland had no native amphibians, but now supports the densest assemblage of introduced amphibians in Canada (Buckle 1971; Warkentin *et al.* 2003). Since European colonisation, six anurans have been introduced, four of which have established self-sustaining populations (Maret 1867; Buckle 1971; Warkentin *et al.* 2003). Green Frog (*Lithobates clamitans*) arrived in Newfoundland during the mid-1800s, presumably via unintentional introductions associated with the transport of agricultural products, such as hay, imported from Nova Scotia to the St. John's area (Maret 1867; Warkentin *et al.* 2003). Since then, Green Frog has spread broadly across the island. During the 1960s, American Toad, Chorus Frog (*Pseudacris*

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triseriata), Northern Leopard Frog, and Wood Frog were intentionally introduced from southern Ontario to western Newfoundland, predominately around the Corner Brook area (Buckle 1971). Of these, only American Toad and Wood Frog have established resident populations. Toads have been steadily spreading eastward across the island (Warkentin *et al.* 2003). In the early 2000s, Mink Frog was also found to be breeding in Newfoundland in the Corner Brook area (Warkentin *et al.* 2003). Here, we document another non-native amphibian and the first salamander, Eastern Red-backed Salamander (*Plethodon cinereus*), introduced to Newfoundland and note potential implications and possible actions.

On 18 May 2021, while clearing piles of old, degraded, timber from around a building and yard during renovations, L.K. discovered five Eastern Red-backed Salamanders on a single property in Conception Bay South, Newfoundland (47.4858°N, 52.9758°W, ~530 km east of the closest native population in Cape Breton, Nova Scotia). Habitat at the site consisted of large spruce (*Picea* sp.) and birch (*Betula* sp.) woodlots with open agricultural fields nearby and is similar to some of the species' native deciduous, coniferous, and mixed-wood forest habitats from eastern Nova Scotia to northwestern Ontario (Gilhen 1984). Human disturbance is generally low in the area where L.K. observed the salamanders. Two additional

individuals were observed on 23 May 2021: a juvenile (snout–vent length [SVL] = 21 mm; Figure 1a) and an adult (SVL = 41 mm; Figure 1b). All individuals were found within 100 m of each other, although adjacent properties have not yet been searched. The chance observations and lack of permits prevented the collection of specimen vouchers; however, photo vouchers are presented (Figure 1). Four of the seven specimens were of the red-backed (striped) colour phase and three were the lead-backed (unstriped) colour phase (Table 1), the two most common phenotypes for the species (Moore and Ouellet 2014). Using ImageJ (version 1.53; Schneider *et al.* 2012), we estimated SVL (± 1 mm), the distance from the tip of the snout to the inferred vent location at the posterior of its pelvic girdle, based on photographs that included a coin for scale. These measurements were used to differentiate adults from juveniles. Sexual maturity for males and females is attained at 36.5 and 41 mm, respectively (Leclair *et al.* 2006). Based on where the observations occurred, the individual colour patterns (Table 1), and the species' small home range (24 m²; Kleeberger and Werner 1982) and high site fidelity (Placyk and Graves 2001), we presume that all seven salamanders are distinct individuals. Furthermore, the presence of a juvenile suggests that this non-native population may be reproducing. L.K. has a 25-year history with this property and the surrounding



FIGURE 1. a. A juvenile Eastern Red-backed Salamander (*Plethodon cinereus*; estimated snout–vent length, SVL = 21 mm) discovered under a pile of timber. b. An adult Eastern Red-backed Salamander (estimated SVL = 41 mm) discovered under a piece of degrading and weathered particle board, both near a property in Conception Bay South, Newfoundland, Canada. Photos: L. King.

TABLE 1. Red-backed Salamanders (*Plethodon cinereus*) observed in 2021 in Conception Bay South, Newfoundland.

ID no.	Date found	Anthropogenic cover	Life stage	Colouration phase	SVL, mm
1	18 May	Degrading, wet lumber	Adult	Lead-backed	N/A
2	18 May	Degrading, wet lumber	Adult	Lead-backed	48
3	18 May	Degrading, wet lumber	Adult	Red-backed	34
4	18 May	Degrading, wet lumber	Adult	Lead-backed	N/A
5	18 May	Degrading, wet lumber	Adult	Red-backed	N/A
6	23 May	Degrading, wet lumber	Juvenile	Red-backed	21
7	23 May	Degrading, wet particle board	Adult	Red-backed	41

Note: SVL = snout to vent length, measured on photographs.

landscape and is unaware of any local knowledge of previous observations of these animals or how they were introduced.

The ability to survive and reproduce in a novel landscape is critical if non-native introduced populations are to successfully establish, spread, and become invasive (Williamson 1996). Invasive species are those that can overcome the challenges posed by novel ecosystems and sustain multigenerational populations in areas well beyond their initial site of introduction (see Richardson *et al.* 2011). Because the initial introduction site in Newfoundland is unknown, we cannot determine if the species is currently invasive, as defined by Richardson *et al.* (2011). Yet, ecological conditions across the island seem favourable for these salamanders. Moore *et al.* (2018) examined the current climatic niche of Eastern Red-backed Salamander across its native range and modelled how the species' distribution could shift in response to climate change. They noted that although the species was not yet present on Newfoundland, the current available climatic niche was suitable (Moore *et al.* 2018). Furthermore, being a generalist invertebrate predator (Maglia 1996) allows Eastern Red-backed Salamander to consume a wide array of potential prey items. Also, unlike many other species of Canadian salamander, it reproduces terrestrially using direct development, with eggs deposited in moist microenvironments under woody debris or rocks. Thus, this species does not require standing bodies of water to produce young (Montgomery 1901; Wake and Marks 1993). Newfoundland, therefore, represents a landscape that is quite suitable for this species to survive and propagate.

Eastern Red-backed Salamander has a slow dispersal rate (<2 m per year; Ousterhout and Liebgold 2010), only traversing an average of 90 m annually within the home range (Kleeberger and Werner 1982). However, larger, one-off dispersal events have been observed (e.g., 143 m through a forested habitat [Sterrett *et al.* 2015] or 300–500 m through open areas to colonize recently restored habitat [Smith and

Smith 2017]). Thus, if this species is able to establish self-sustaining populations, they possess a reasonable capacity to spread elsewhere in the Conception Bay South area and to other localities on Newfoundland.

The discovery of this salamander on Newfoundland raises several questions surrounding (1) its invasion pathway and route (i.e., how they got there and from where), (2) the extent and status of the current Conception Bay South population (i.e., established or ephemeral), (3) whether the species is established elsewhere on Newfoundland, and (4) the impact this non-native species may have on local ecosystems.

Although there are no clear answers to these questions, we can use prior knowledge of this species and previous amphibian introductions to Newfoundland to speculate about likely outcomes. First, the invasion pathway for the Conception Bay South population is unknown. The most likely source is accidental transport, similar to the Green Frog introduction (Maret 1867; Warkentin *et al.* 2003). However, the source may also be related to escaped/released pets or an intentional release, as, globally, these are two of the most common invasive pathways for non-native amphibians (Hulme *et al.* 2008) and would be similar to the American Toad and Wood Frog introductions to Newfoundland (Buckle 1971). Genetic investigations from across the species broad distribution may determine the source population. The cryptic nature may have allowed this salamander to remain undetected for longer than other non-native anuran species that have been introduced to Newfoundland. For example, Mink Frog on Newfoundland was detected by frog-call monitoring (Warkentin *et al.* 2003). As salamanders do not vocalize to the same extent as most frogs and toads, it is possible that Eastern Red-backed Salamander has been present on Newfoundland for some time and may be more widely distributed than our few specimens from a single locality indicate.

Finally, it is important to consider the potential impacts this amphibian may have on Newfoundland ecosystems. Given that it was not recognized as an amphibian species with non-native/invasive

populations during global reviews by Kumschick *et al.* (2017) and Measey *et al.* (2016, 2020), our observation may be the first account of this species establishing a population outside its native range and, thus, the impacts of its introduction have not been previously studied. Within its native range, Eastern Red-backed Salamander is considered one of the most abundant vertebrates in deciduous forests, achieving densities up to 2.8 individuals/m² (Burton and Likens 1975; Mathis 1991) and the species is a significant predator of forest floor invertebrate decomposers (Walton 2013). Research has demonstrated agonistic intraguild interactions between Eastern Red-backed Salamanders and native spiders, relating to cover objects and competition, that can drive altered spatial distribution of these arthropod predators on the landscape (Hickerson *et al.* 2012, 2017). As such, the presence of this salamander in Newfoundland could result in novel trophic interactions and potential shifts in nutrient cycling and ecosystem energy flow.

In conclusion, we have documented the presence of a likely breeding non-native population of Eastern Red-backed Salamander on Newfoundland. There is ample opportunity for future research to determine how this introduction occurred and how this widespread and common North American salamander behaves and impacts other wildlife when introduced to a novel ecosystem. Studies such as these will be necessary in determining whether eradication of the species from Newfoundland is warranted, necessary, or achievable.

Author Contributions

Writing – Original Draft: J.B.G.; Writing – Review & Editing: J.B.G., L.K., and J.L.R.; Conceptualization: J.B.G., L.K., and J.L.R.; Observation: L.K.

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