

Are Non-Native Gastropods a Threat to Endangered Lichens?

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Cameron, Robert. 2009. Are non-native gastropods a threat to endangered lichens? *Canadian Field-Naturalist* 123(2): 169–171.

Extensive grazing by gastropods was found on endangered Boreal Felt Lichen (*Erioderma pedicellatum*) at Sixth Lake, Nova Scotia, in 2004. At least 80% of arboreal gastropods observed at the site were the introduced species *Arion subfuscus*. Subsequent surveys at five other locations in Nova Scotia showed 90% of arboreal gastropod individuals observed were introduced species. Potential impact on native lichen species, and in particular on rare and endangered species, is discussed.

Key Words: Boreal Felt Lichen, *Erioderma pedicellatum*, gastropods, non-native, Nova Scotia.

Erioderma pedicellatum (Boreal Felt Lichen) is an epiphytic foliose lichen found in the temperate and boreal northern hemisphere. The world population of *E. pedicellatum* has been listed as critically endangered by the International Union for the Conservation of Nature. In Canada, the Atlantic population, occurring in Nova Scotia and New Brunswick, has been listed as endangered under the Canadian Species at Risk Act and provincially under the Nova Scotia Endangered Species Act. In Nova Scotia, the population declined by 90% between the early 1980s and the 1990s (Maass and Yetman 2002*). Researchers have visited the known *E. pedicellatum* localities annually since 2004 to evaluate health and condition. There are 180 thalli in 30 locations known for Nova Scotia (Cameron et al. 2010).

During a re-visit to the Sixth Lake site (44°54'N, 62°43'W) in fall 2004, I found evidence of extensive grazing on the single *Erioderma pedicellatum* thallus at the site. Sixth Lake occurs on the eastern edge of the Tangier Grand Lake Protected Wilderness Area, Halifax County. About 60% of this thallus had been grazed and it appeared that about 80% of trees at the site harboured slugs on the trunks. *Arion subfuscus*, a non-native introduction from Europe, was the dominant arboreal slug found at the site at the time, making up about 80% of individuals found on trees. A voucher specimen was collected and will be deposited in the Nova Scotia Museum of Natural History. The only other species found was a native species, *Pallifera dorsalis*. Other lichen species with evidence of grazing included *Coccocarpia palmicola*, *Hypogymnia physodes* and *Parmelia squarrosa*. *Coccocarpia palmicola* is relatively uncommon in Nova Scotia (Cameron and Neily 2008), while *Hypogymnia physodes* and *Parmelia squarrosa* are very common (Casselman and Hill 1995; Cameron 2004; McMullin et al. 2008).

To help determine the magnitude of the potential threat to rare lichens from this introduced gastropod, subsequent surveys were conducted. Five mixed-wood forest sites in central Nova Scotia were surveyed for arboreal gastropods between 10 October 2005 and 3 September 2006. Locations of survey sites are Tangier Grand Lake Wilderness Area (44°53'N, 62°50'W),

Gully Lake Wilderness Area (44°33'N, 63°42'), Eigg Mountain-James River Wilderness Area (45°41'N, 62°10'W) and MacPhees Corner Hants County (45°07'N, 63°32'W) (2 sites). Site descriptions and location details can be found in Cameron et al. (2007) and Cameron and Richardson (2006). Sites were visited during days when gastropod activity was likely to be the highest, with daytime temperatures of greater than 10°C and an overcast sky with fog, drizzle or rain. One hundred trees (20 per site) of either *Acer rubrum* (Red Maple) or *Abies balsamea* (Balsam Fir) were examined for the presence of gastropods between the ground and 2 m up the trunk. Trees were selected for study by walking into the centre of the stand and choosing the closest trees of suitable species. Gastropod species (slugs and snails) were identified and, if they were actively feeding, the lichen species being grazed was also recorded. Identification of species was done using Burch (1962) and Burch and Jung (1988). There are several cryptic species of the *Arion fuscus/subfuscus* complex (Barr et al. 2009). However, since no collections of *Arion fuscus* in Nova Scotia had been reported in the literature up to Davis (1992), all species keyed to *Arion fuscus* or *A. subfuscus* were considered *A. subfuscus* for this study.

Twenty-one gastropods representing three slug species were found. No snails were found. Over 76% (16 of 21) of gastropods found were non-native *Arion subfuscus*. Four individuals (19%) were *Deroceras reticulatum*, also a non-native slug. Only one native gastropod species (*Pallifera dorsalis*) was found, and it was on *Acer rubrum*. *Arion subfuscus* was found more commonly on *Acer rubrum* (80% of findings) than on *Abies balsamea*. *Deroceras reticulatum* was found only on *Acer rubrum*. Species of lichens grazed included *Lobaria pulmonaria*, *Parmelia squarrosa*, *Parmelia sulcata* and *Platismatia glauca*. *Lobaria pulmonaria* is widespread and common in Nova Scotia (Anderson 2007), as are *Parmelia squarrosa* and *Platismatia glauca* (Casselman and Hill 1995; Cameron 2004; McMullin et al. 2008).

It is notable that 90% of arboreal gastropod individuals found were introduced species. Some caution is needed with this number because many native spe-

cies, which are much smaller than introduced species (Davis 1992), are more difficult to detect. Also, some species forage only at night or at very low light levels (Gauslaa et al. 2006). Nevertheless, under the investigated conditions, there appears to be a very high proportion of non-native arboreal gastropod foragers. Little is known about the distribution and abundance of terrestrial gastropods in Nova Scotia. However, Davis (1992) suggests that *Arion subfuscus* is common and widespread, having naturalized to mixed and deciduous forests. Davis and Browne (1996) suggest that non-native species, like *Arion subfuscus*, have restricted *Pallifera dorsalis* to native forests.

It is uncertain whether the non-native species are out-competing the native species or are filling a previously unfilled niche. The former seems more likely, since native arboreal foragers are present. Non-native gastropods can compete for resources or can prey on native species. Non-native terrestrial gastropod introductions have resulted in the decline of native species diversity and even the extinction of native species in other areas (Hadfield 1986; Proschwitz 1994; Mahtfeld 2000).

The impact of non-native gastropod grazers on native lichens is uncertain. Other studies suggest that lichens can recover from grazing by gastropods (Fröberg et al. 2006; Gauslaa et al. 2006). Asplund and Gauslaa (2008) indicate that grazing by molluscs may limit growth and early development of *Lobaria pulmonaria* in calcareous deciduous forest. However, previous studies have documented only the impacts of grazing by native gastropods. To my knowledge, this is the first documentation of non-native gastropod grazing on lichens.

No grazing animal was found on the *Erioderma pedicellatum* thallus at Sixth Lake. However, the pattern of grazing was indicative of gastropods (Sharnoff and Rosentreter 1998*). The typical gastropod feeding tracks were quite wide, indicating a larger species like *Arion subfuscus*.

The disappearance of two thalli at another site, Jacket Lake (44°45'N, 62°42'W), may also have been caused by grazing. The Jacket Lake site is less than 2 km from the Sixth Lake site. The Jacket Lake site was visited in August 2006, when it was noted that two *Erioderma pedicellatum* thalli were healthy with minimal evidence of grazing. Researchers failed to locate two mature thalli on the same tree at the Jacket Lake site when it was revisited in March 2007. Careful examination of the locations on the tree where the thalli had been revealed small fragments of thalli that showed evidence of grazing. It could not be determined whether grazing was entirely responsible for the loss of these two thalli. It is, however, significant to note the rapid loss in less than 7 months of these two healthy thalli.

Cameron et al. (2009*) found evidence of grazing on *Erioderma mollissimum*, another rare cyanolichen

found in Nova Scotia. Of 96 thalli observed between 2006 and 2008, 12 (13%) showed evidence of grazing. The area of the thalli grazed ranged from 1 to 20%. Most grazing had patterns typical of small invertebrates such as oribatid mites or Collembola. Only 3 thalli had grazing patterns typical of gastropods.

Further research is needed to determine the impact these non-native gastropod species may be having on native lichens and on rare and endangered lichens in particular.

Acknowledgments

Funding was provided in part by the Habitat Stewardship Program, Environment Canada and Nova Scotia Environment. Thanks to Julie Towers and two anonymous reviewers for manuscript reviews.

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Received 27 January 2009

Accepted 7 March 2010