The even darker side of the eastern gray squirrel (*Sciurus carolinensis*): a review of global introductions, invasion biology, and pest management strategies

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Abstract

The eastern gray squirrel, *Sciurus carolinensis*, is one of the world's most recognized sciurids and a highly successful human commensal. Historically restricted to eastern North America, gray squirrel populations are now established in Italy, U.K., South Africa, and Australia, and squirrels continue to expand their geographic range globally. Successful introductions of *S. carolinensis* often result in significant negative impacts on native ecosystem integrity. As a result, countries have devised and implemented unique pest management strategies to reduce or eradicate *S. carolinensis* populations, but with differing levels of success. We review accounts of historical global introductions of *S. carolinensis*, discuss its invasive biology and impacts in non-native habitats, and recommend specific management strategies that should successfully curtail establishment of this species in non-native habitats.

Keywords: establishment, introduction, management, non-native, *Sciurus carolinensis* G.

Introduction

The eastern gray squirrel (*Sciurus carolinensis* G.) is a highly adaptable arboreal sciurid native to eastern North America (Flyger, 1999). It is also a successful human commensal, and has established populations in non-native habitats around the world as a result of introductions by people (Bertolino, 2009). Here, we review its historical introductions, comment on why it has been such a successful invasive species, and recommend possible strategies and plans for effectively managing introduced populations of this species.

Materials and Methods

Historical accounts from publications and reports were reviewed for data pertaining to *S. carolinensis* introductions around the world. Life history information was used to make inferences on the invasive species biology of gray squirrels, and to determine why they are such successful alien species. Current management plans were also reviewed to determine what elements of control were most effective.

Results and Discussion

Introductions of *S. carolinensis* into non-native habitats around the world have occurred since the early 1800s. In North America, regional introductions were made into previously unoccupied Canadian provinces (e.g., Nova Scotia; Huynh et al., 2010) and numerous western U.S. states, while introductions also occurred in South Africa (Davis, 1950) and Australia (Peacock, 2009). The U.K. (Lloyd, 1983) and Italy (Currado et al., 1987) have had multiple introduction events associated with the successful establishment of *S. carolinensis*. Hence, it appears that successful establishment of *S. carolinensis* is partly dependent on high propagule pressure generated by repeated introductions by people.

Trophically, gray squirrels are ecological generalists. Their highly adaptable nature in terms of resource exploitation provides them with intrinsic advantages that promote population establishment and growth. For example, though *S. carolinensis* primarily inhabit broad-leaved, mixed deciduous woodlands with mast species, they are able to thrive on food sources found in conifer-dominated stands (Koprowski, 1994). Such adaptable foraging behavior on the part of *S. carolinensis* can significantly increase survival and reproductive success, especially in the context of interspecific interactions with native species (e.g., competition – Gurnell et al., 2004; disease transmission – Sainsbury et al., 2000).

Though the availability of trees (mast, shelter) appears to be a limiting factor in restricting population expansion, the ability of *S. carolinensis* to thrive in human-modified landscapes facilitates the species establishment in introduced environments. Urban areas in particular often have high population densities of *S. carolinensis* and can function as refugia and patch sources in dispersal dynamics.

Gray squirrels are often considered attractive and benign by local communities, which may enhance the probability of successful establishment. Indeed, human enamorment with gray squirrels appears to be an important factor in determining the fate of an introduced population – the novelty of introduced *S. carolinensis* along with the associated emotional attachment generated by their charisma may function as intractable hindrances to development and proper implementation of pest management and eradication programs (e.g., Bertolino et al., 2000).

Effective management plans for introduced gray squirrels should include: detection and monitoring of introduced *S. carolinensis* (Tattoni et al., 2006); understanding the ecological interactions and impacts of *S. carolinensis* in non-native habitats (Gurnell et al., 2004); collating spatial data on the environment (i.e., landscape structure, connectivity and composition; Lurz et al., 2001); and eradication of potential founders before population establishment (Tattoni et al., 2006).

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