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The abundance of an invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) in the Nseleni River, South Africa

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The invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) was first reported in South Africa in 1999 and it has become widespread across the country, with some evidence to suggest that it reduces benthic macroinvertebrate biodiversity. The current study aimed to identify the primary abiotic drivers behind abundance patterns of *T. granifera*, by comparing the current abundance of the snail in three different regions, and at three depths, of the highly modified Nseleni River in KwaZulu-Natal, South Africa. *Tarebia granifera* was well established throughout the Nseleni River system, with an overall preference for shallow waters and seasonal temporal patterns of abundance. Although it is uncertain what the ecological impacts of the snail in this system are, its high abundances suggest that it should be controlled where possible and prevented from invading other systems in the region.

Keywords: distribution, invasion, Mollusca, physicochemical drivers, Quilted Melania

Introduction

Tarebia granifera (Lamarck, 1822) (Gastropoda: Thiaridae) is a freshwater prosobranch gastropod commonly referred to as the 'Quilted Melania'. Although originally from South-East Asia, it has become an invasive snail on at least three continents, including North and South America and Africa (Appleton et al. 2009). *Tarebia granifera* was first reported in South Africa in 1999, established in a concrete lined reservoir in Mandeni, northern KwaZulu-Natal (Appleton and Nadasan 2002). Presumably introduced via the aquarium trade (Madsen and Frandsen 1989; Appleton et al. 2009), it has since become widespread in the eastern half of South Africa, particularly in the provinces of KwaZulu-Natal and Mpumalanga (Appleton et al. 2009). Kruger National Park, South Africa's flagship national park, has also seen recent invasions with spread of *T. granifera* increasing substantially between 2001 and 2006 (Wilmsrans and de Kock 2006). Although predominantly a freshwater snail, *T. granifera* has also established populations in several South African estuaries (Appleton et al. 2009; Miranda et al. 2011b), showing tolerance for wide ranges of both, salinity and temperature (Miranda et al. 2011b). According to the unified framework proposed by Blackburn et al. (2011), *T. granifera* can be classified as fully invasive in South Africa (category E), 'with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence', because it has spread over approximately five degrees of latitude (25 °S–30 °S) since its discovery in 1999 (Appleton et al. 2009).

The spread of *T. granifera* in South Africa has been rapid and both passive (e.g. dispersal through aquatic weeds attached to boats or trailers, or via water transfers) and active (e.g. via attachment to feathers or droppings of waterfowl) pathways have been proposed for its swift dispersal (e.g. Gittenberger et al. 2006; Appleton et al. 2009; van Leeuwen et al. 2012; Reynolds et al. 2015). Its broad physiological tolerances and reproductive strategies, including parthenogenesis and ovoviviparity, have resulted in population explosions of the *T. granifera* in South African ecosystems (Miranda et al. 2011b). Reported population densities of >1 000 individuals/m^2 makes this invader the dominant component of local invertebrate macrofauna in many localities (Miranda et al. 2011b).

Tarebia granifera is a microphagous feeder and despite minimal evidence for direct food resource competition with indigenous benthic macroinvertebrates (Miranda and Perissinotto 2012; Hill et al. 2015), high densities may indirectly limit energy transfers within a food web (Moslemi et al. 2012; Hill et al. 2015), and in the case of nutrient limitation, may also result in reduced growth rates for coexisting macroinvertebrates (Connor et al. 2008; Riley et al. 2008; Riley and Dybdahl 2015). In addition, there is some evidence to suggest that the establishment of *T. granifera* populations may be followed by the extirpation of indigenous snails (Chaniotis et al. 1980; Prentice 1983; Samadi et al. 1997; Pointier et al. 1998; López-López et al. 2009). Comparatively, the effects of *T. granifera* invasions on aquatic ecosystem biodiversity have been

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