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Short communication

Repeated monitoring as an effective early detection means: first records of naturalised *Solidago gigantea* Aiton (Asteraceae) in southern Africa

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ABSTRACT

Early detection of emerging invasive plants depends on maximizing the probability of detecting new populations. Repeated surveys along a gradient of environmental conditions or in areas exposed to high propagule pressure provide a potentially efficient strategy for early detection of alien species. The long-term monitoring of such an area resulted in the documentation of the first naturalised *Solidago gigantea* Aiton (Asteraceae) population for southern Africa. This population consisted of *c.* 45 individuals growing in two locations on unmanaged grassland in the Drakensberg Mountains at an elevation of 1619 m a.s.l. *Solidago gigantea* readily invades unmanaged European grasslands, altering biomass and transforming habitats. Moreover, since goldenrods (*Solidago* spp) are perennial species reproducing through a large number of wind-dispersed seeds and belowground rootstocks, these species appear well pre-adapted to the fire-prone grassland biome of South Africa. We therefore suggest early-stage eradication of *S. gigantea* before it potentially becomes an unmanageable and costly invasive species in this region. This study supports long-term monitoring programmes as an effective means for early detection of new invasive species.

1. Introduction

The early detection of emerging invasive species is an effective means to stop potential invaders at an early stage, while eradication is still achievable (Wilson et al., 2013). To date, however, few early detection and eradication efforts have been successful (de Lange and Van Wilgen, 2010). A reason for this lack of success is that detecting range expansion of invasive species is challenging due to their low densities at the invasion front (Huang et al., 2012; Leung et al., 2010). To optimise detection probability, resources are thus best concentrated on habitats or regions that are susceptible to invasion; either due to high propagule pressure or due to high environmental heterogeneity offering a diversity of environmental conditions. Road reserves are ideal for the establishment of many invasive species because of their disturbed and open character and the relatively high probability of propagule transport from other regions (Procheş et al., 2005). Repeated monitoring of road reserves, especially in areas of pronounced environmental heterogeneity may therefore provide early warning of emerging invaders (Becker et al., 2005; Carbutt, 2012). Although the value of such repeated studies is widely acknowledged, long-term ecological studies are still scarce (Lindenmayer et al., 2012).

South Africa has several biodiversity hotspots that are affected by invasive alien species (Mgidi et al., 2007; Richardson and Van Wilgen, 2004). The Drakensberg Alpine Centre is such a hotspot and, as a result, an a priori list of emerging weeds has been proposed for this region to aid early detection of likely plant invaders (Carbutt, 2012). One of Carbutt's proposed monitoring sites is the Sani Pass road, a mountain pass covering an altitudinal range of 1527–2874 m a.s.l. This road has been annually monitored for the presence of all exotic species since 2007 (details in Kalwij et al., 2008), enabling the detection of potentially invasive species at a very early stage of their colonisation process. A recently observed species is *Solidago gigantea* Aiton (Asteraceae); a weed native to North America that is a major transformative invader in European unmanaged grasslands (Weber and Jakobs, 2005). Here, we provide the first documentation of a naturalised *S. gigantea* population in southern Africa and discuss its potential threat to the grasslands of this region.

2. Materials and methods

2.1. Study area

The Sani Pass road is situated in the Cobham region of the uKhahlamba Drakensberg Park (29°17–39′ E, 29°35–39′ S) and is an important access road to eastern Lesotho (Fig. 1). This road is 33 km long and rises from an altitude of 1527 to 2874 m a.s.l. The vegetation of

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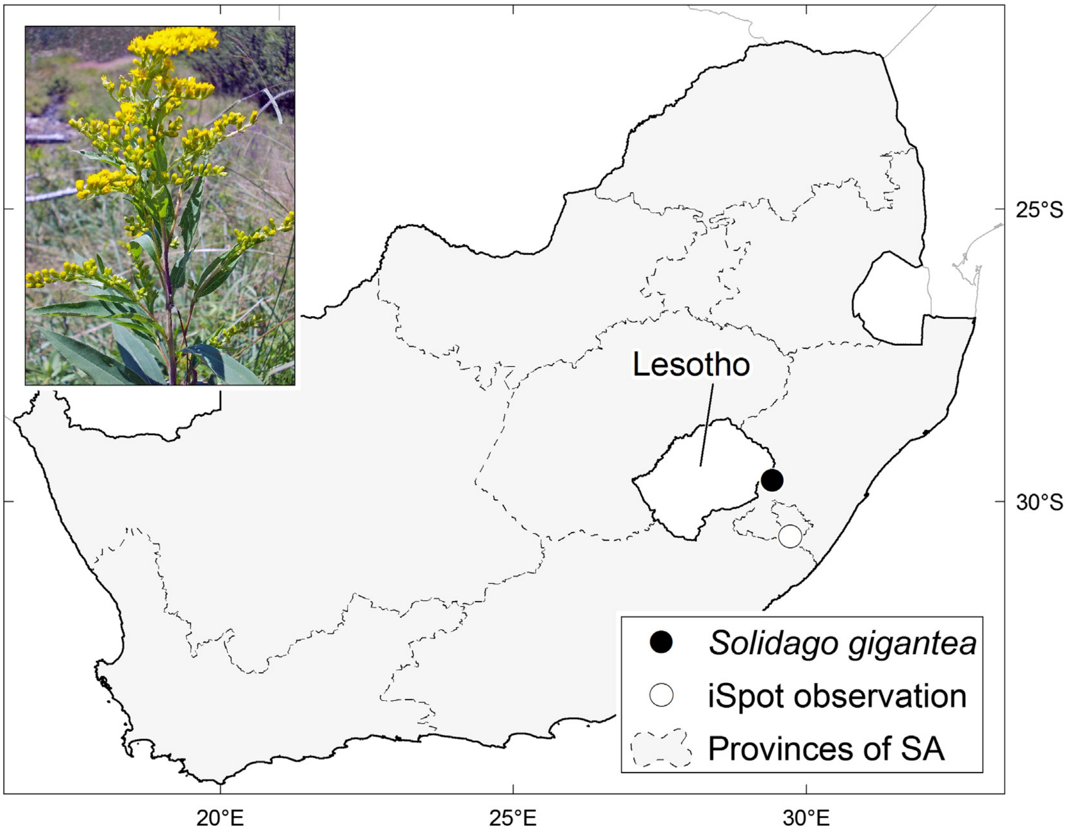

Fig. 1. Location of the *Solidago gigantea* population is denoted with a filled circle (●), on the border of South Africa and eastern Lesotho at the bottom of the Sani Pass road in the uKhahlamba Drakensberg Park. The location of a previously mis-identified population is denoted with an open circle (○). Provincial boundaries of South Africa are indicated with a dashed line. The inset photograph shows the inflorescence of an *S. gigantea* specimen at the Sani Pass location.

the uKhahlamba Drakensberg Park is grassland with scattered pockets of Afromontane forests in fire-protected rocky outcrops and gullies (Mucina and Rutherford, 2006). Summer rainfall typically varies between 990 and 1130 mm per annum (Kalwij et al., 2008), with regular frost and snowfall in the higher altitudinal zones during winter. Due to its attractive scenery and unique biodiversity the area was inscribed on the UNESCO World Heritage List in 2000.

2.2. Sampling strategy

The 20-km gravelled section of Sani Pass road has been monitored annually for the presence of exotics plant species since 2007 (details in Kalwij et al., 2008). In 2014, this monitoring scheme was extended to also survey the lowland exotic plant species pool along the 13-km tarred section of the road (1527–1564 m a.s.l.) by surveying road intersections and the grounds around three clusters of dwellings: site 1 (29°25′7″E; 29°37′52″S; 1619 m), site 2 (29°26′45″E; 29°39′24″S; 1548 m) and site 3 (29°27′24″E; 29°39′44″S; 1557 m). We selected these dwellings because they are frequented by tourists from outside the region, and because the surrounding grounds are, or have been, longstanding cultivated gardens with many introduced ornamental plants. All naturalised exotics were recorded, with a plant considered naturalised when its growth form or location indicated that establishment was spontaneous. To prevent survey-related dispersal events, observers always ensured that footwear and field vehicles were free from propagules.

3. Results

A naturalised *S. gigantea* population was found on the grounds of site 1. This population consisted of two clusters totalling *c.* 45 flowering individuals in unmanaged grassland around large ponds on the premises. The identification of this species was confirmed by Derick B. Poindexter and Alan Weakley (University of North Carolina, Chapel Hill, NC, USA). A herbarium voucher has been formally lodged at the KwaZulu-Natal Herbarium. No other populations of *S. gigantea* were observed at the two other sites, or anywhere else along the road during the 2007–2014 monitoring period. An interview with the land manager of site 1 indicated that this species was not intentionally planted and is likely to have established recently since it had not been noticed on the property before. No management actions had been implemented since the species had not been recognised as an exotic or potentially problematic species.

4. Discussion

Our annual monitoring of exotic plant species documented the first naturalised *S. gigantea* population in southern Africa to date. Neither the online checklist of plants of southern Africa (SANBI, 2013), the checklist of plants of southern Africa (Germishuizen and Meyer, 2003), or in the sub-Saharan checklist (Klopper et al., 2006) indicated previous recordings of any naturalised *Solidago* spp in southern Africa. Moreover, global databases only provide records of *S. gigantea* in the northern hemisphere (e.g., CAB International, 2000; GBIF, 2013). Finally, an extensive literature and internet search (using the keywords "*Solidago*" and "South Africa") suggested that a naturalised *S. gigantea* population had once been observed previously (some 110 km south; iSpot, 2013) but was incorrectly identified and therefore not considered a concern. *Solidago gigantea* does not appear to be cultivated for ornamental or medicinal purposes in South Africa. Therefore, since no earlier formal records of naturalised *S. gigantea* exist for southern Africa, our record is the first documented naturalised population for this region.

Solidago gigantea is a perennial herb native to North America where it is a problematic weed in prairie and open woodland communities (Weber and Jakobs, 2005). The species produces a large number of wind-dispersed seeds allowing it to rapidly disperse across large distances. For example, *S. gigantea* was introduced as an ornamental to London (UK) *c.* 1758, became naturalised around 1850, and reached its current European distribution within only 30 years (Weber, 1998). Once established the species can become dominant due to its clonal growth and its strong competitiveness, invading wetland margins, unmanaged grasslands, roadside verges, afforestations, and riverbanks (Jakobs et al., 2004; Rentch et al., 2005). As a result, *S. gigantea* is a major transformative invader across most of Europe (CAB International, 2000; Schlaepfer et al., 2010).

The invasion success of *S. gigantea* in Europe is in part due to the species being highly plastic and capable of responding to changes in environmental conditions by adjusting its growth patterns (Jakobs et al., 2004; Weber, 1998). Its perennial rhizomes provide the necessary protection from the harsh climate of high-altitude ecosystems (Alexander et al., 2009), allowing, for example, *S. gigantea* to invade semi-natural grasslands in Switzerland as high as 1540 m a.s.l. (Becker et al., 2005). Perennial rhizomes also ensure that this species is fire-resistant and protected against temporarily unsuitable climatic conditions. The invasion success of this species across Europe is a clear indication that *S. gigantea* has the potential to become a widespread and serious new invader in the southern Africa grassland biome, even at high altitudes. We therefore suggest that this species is placed on South Africa's watchlists of emerging invaders (sensu Wilson et al., 2013), and that any cultivated and all naturalised populations are managed accordingly. The Invasive Species programme of the South African National Biodiversity Institute has been informed about these *S. gigantea* records and the species' potential to become a new invader. This programme will evaluate the need to regulate the species and the feasibility of eradicating it from South Africa (Wilson et al., 2013).

This study supports the call to monitor vulnerable ecosystems for new and emerging exotic species (Bradley et al., 2012; Carbutt, 2012; Mgidi et al., 2007). However, long-term ecological monitoring programmes, such as the one underlying our study, are rare and difficult to sustain, both financially and logistically (Lindenmayer et al., 2012). Monitoring selected areas, such as road verges and areas that are otherwise susceptible to invasion (Carbutt, 2012), is thus an effective means to detect new exotics at an early stage of their range expansion. Since the invasion probability of newly arrived exotics is usually unknown, a further challenge may be to convince legislators, land managers and the general public to take timely and appropriate action before such species become new transformative invaders.

5. Conclusion

The presence of a naturalised *S. gigantea* population in South Africa is of great concern since this species is a known transformative invader of unmanaged grasslands in the northern hemisphere. The risk of this species becoming an invader is particularly high for South Africa's grassland biome due to its combination of a perennial life strategy, rhizome rootstocks and the production of many wind-dispersed seeds. We propose that *S. gigantea* is put on South Africa's lists of potentially invasive species, encouraging stakeholders to proactively eradicate this conspicuous and easily identifiable species before it becomes unmanageable. Regardless of the challenges of detecting very recently established exotic species, an early-detection monitoring programme can be an effective means to prevent the establishment of new invasive species.

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