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Review

Invasion dynamics of *Lantana camara* L. (sensu lato) in South Africa

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Abstract

Lantana camara L. (sensu lato) has a wide range of impacts throughout its global invasive range. Here we review the mechanisms driving its invasion dynamics in South Africa at national (biome, habitat) and regional (within a protected area) scales. Although only three introduction events into South Africa have been recorded (the earliest in 1858), as of 1998 *L. camara* was found in over 2 million ha (total area), with a condensed area of about 70,000 ha. Moreover, *L. camara* is present in most of the country's major biomes and a diversity of habitats, confirming its broad ecological tolerance. Using correlative bioclimatic models, we show that under future climate conditions, *L. camara*'s range in South Africa could expand considerably over the coming decades. While human-mediated dispersal and climatic suitability have been crucial in shaping *L. camara*'s current broad-scale distribution in South Africa, dispersal by birds and along rivers are important drivers of invasion at landscape scales. For example, current evidence suggests that in the Kruger National Park, *L. camara* has spread primarily along rivers. We conclude with a discussion on the implications of the different invasion dynamics for biological control and management, and provide recommendations for future research.

Keywords: Biological invasions; Geographic distribution; Kruger National Park; Management

Contents

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1. Introduction

Plant invasions are mediated by a combination of invasiveness (i.e. species traits), invasibility (i.e. characteristics of receiving habitats), and the history of introduction (e.g. propagule pressure and residence time) (Foxcroft et al., 2011; Lockwood et al., 2005; Richardson and Pyšek, 2006; Wilson et al., 2009). Certain intrinsic factors predispose particular plant species to becoming invasive (Sakai et al., 2001). For example, Baker (1965) suggested that weedy plant species tend to reproduce both sexually and asexually, have rapid growth from seedling to sexual maturity, and show high adaptability to environmental stress and heterogeneity, i.e. possess a broad ecological amplitude. Further examples of plant species characteristics that have been linked with invasive potential include plant height, life form (Goodwin et al., 1999), seed size (Rejmánek and Richardson, 1996), polyploidy (Pandit et al., 2011; te Beest et al., 2012) and the ease with which a species hybridizes (Ellstrand and Schierenbeck, 2000).

Similarly, habitats vary in the degree to which they can be invaded. In particular, at a local scale habitats that are frequently disturbed (such as riparian areas or those subject to human activities) are often inherently more prone to invasion than others (Fridley, 2011; Richardson et al., 2007). However, identifying and measuring variation in invasibility across landscapes can be difficult, particularly if key factors (e.g. disturbance rates and fluctuating resource levels) vary over short geographic distances (Fridley, 2011).

Additionally, the origin of introduced propagules and the number, timing, and geographic location of introduction events act to determine both the success of an introduction and the rate of spread of an invasion (Lockwood et al., 2005; Wilson et al., 2009).

It is therefore evident that no simple predictor of invasion success prevails. Nonetheless, attempting to unravel which factors play a role in the invasion success for a particular invader provides insights that are useful for management (Sakai et al., 2001).

Lantana camara L. (sensu lato), a notorious global invader, has spread rapidly in many of the 60 regions of the world to which it has been introduced by humans (Day et al., 2003) and is listed among the world's one hundred worst invasive species (Lowe et al., 2000). It is considered a Weed of National Significance (WONS) in Australia, meaning that it displays exceptional invasiveness, potential for spread, and potential negative economic and environmental impacts (Clark et al., 2004). In a recent global review of invasive trees and shrubs, *L. camara* was found to be one of the most widespread invasive alien woody shrub species globally, being recorded as invasive in 12 of the 15 regions assessed (Richardson and Rejmánek, 2011). *L. camara* is one of the most conspicuous invaders in savanna ecosystems worldwide (Foxcroft et al., 2010).

Given *L. camara*'s global status as a species of considerable concern, it is not surprising that it has been extensively studied. A search for "*Lantana camara*" in Thomson-Reuters ISI Web of Science for the period 2000–2010 returns 366 publications, of which 174 have "*Lantana camara*" in the title. Much of the available knowledge of the species has accumulated recently, and is predominantly associated with biological control efforts (for a recent South African review see Urban et al., 2011), management (Bhagwat et al., 2012), ethnopharmacology (Ali-Emmanuel et al., 2003; Sathish et al., 2011), and phytochemistry (Kumar et al., 2011; Misra and Laatsch, 2000; Zoubiri and Baaliouamer, 2012). However, despite this wealth of literature and its relevance to the South African situation, there has been no recent assessment of the invasion dynamics of *L. camara* in the region.

This paper reviews *L. camara* invasions in South Africa, with particular reference to known drivers of invasive success. Specifically, we aim to explain the processes and factors that have contributed to the successful invasion of the species, using a framework developed for invasion ecology; and to model distribution patterns across biomes, ecoregions, and under current and changing climate scenarios. We draw on information on *L. camara* invasions from other parts of the world (Day et al., 2003; Sharma et al., 2005) to provide the context within which the South African invasion will be examined. At a more localized scale, we investigate the progression of spread and management of *L. camara* in South Africa's flagship protected area, the Kruger National Park (KNP), a site where the invasion dynamics of *L. camara* have been studied in more detail than elsewhere in the country.

2. *L. camara* L. (sensu lato)

2.1. Origin

L. camara L. (sensu lato) (Verbenaceae), referred to in this paper as *L. camara*, is a complex of many horticultural hybrids