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Invasive alien plants in the Daan Viljoen Game Park

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Abstract

Eight alien plant invaders were identified in the Daan Viljoen Game Park, and their distribution, abundance and population parameters were assessed and related to one another. Alien invaders include four species of the Genus Opuntia *(*Opuntia ficus–indica *(spineless),* Opuntia *cf.* dillenii*,* Opuntia *cf.* vulgaris *and one unidentified species. Other aliens include* Argemone ochroleuca*,* Datura innoxia*,* Nicotiana glauca *and* Prosopis *species (of* P. glandulosa*). Distribution maps are provided for each species. Of all these invasive alien plants,* Opuntia *cf.* dillenii *appears to pose the greatest potential threat*. *The invasiveness of the spiny* Opuntia *spp. is probably mostly attributable to their obvious defence against browsing (spines) and their ability (compared to indigenous succulents at least) to vegetatively propagate. Seed dispersal, through fruit consumption, by baboons, also plays an important role in their success*. *Riverine habitat proved to be the most invasible, with seven of the eight species occurring in it. It is likely that the number of species invading the park will increase, as will the populations of invasive alien species, particularly* Opuntia *cf.* dillenii. *Active management to remove these species is recommended. This will save time, money and biodiversity in the long run.*

Keywords: Invasive alien plants, abundance, distribution, species parameters, Daan Viljoen Game Park, Namibia.

Introduction

Conservation of biotic diversity is one of the main aims of nature conservation authorities, with the existence of invasive alien species within natural parks posing a threat to indigenous communities (Boyer & Boyer 1988). Currently, Namibia has comparatively modest problems with invasive alien plants (Kolberg 1998). This complacent perception of invasive and potentially invasive species has been attributed to Namibia's aridity (meaning that relatively few alien species are likely to become invasive); a lack of research capacity in terms of qualified biological

research personnel and a consequent lack of information available on the recent distribution and population dynamics of invasive species (Bethune *et al.* 2004).

Species that do occur should not be allowed to spread, for various ecological and economic reasons (Brown *et al.* 1985). Early detection and rapid response is the key to successful control of invasive aliens. A sound understanding of the invasiveness of species and the invasibility of habitats is also important.

Although relatively little work has been conducted on invasive alien plants in Namibia, earlier publications include work by Müller (1985), Scheepers (1985) and Macdonald & Nott (1987), while the following species-specific reports have recently been published by Joubert & Cunningham (2002) [*Pennisetum setaceum*], Cunningham *et al.* (2004) [*Dodonaea angustifolia*], Steenkamp & Smit (2002) [information poster] and Smit (2004) [*Prosopis* sp.]. Prior to this, the only detailed studies of invasive alien species have been research by the Department of Water Affairs into the control of the aquatic weed, *Salvinia molesta* since the early 1980's (Bethune 1996, Schlettwein *et al.* 1991, Schlettwein & Bethune 1992, Taylor 1999, Bethune & Roberts 2002). At present nothing is known of any parameter influencing and/or affecting alien invasive plants in the Daan Viljoen Game Park although eradication programmes were initiated in the 1980's (Adank, pers. comm., Ndikwetepo, pers. comm.).

Study area

The Daan Viljoen Game Park (DVGP) is situated 24 km west of Windhoek in central Namibia on the C28 to Walvis Bay at an elevation of approximately 2000 m above sea level. The park falls within the Highland Savannah vegetation type, in what is generally referred to as the Khomas Hochland, and is characterised by trees such as *Acacia mellifera*, *Acacia hereroensis* and *Combretum apiculatum* (Anon n.d., Giess 1971). The DVGP is 3946 ha in size (Anon s.a) and proclaimed during 1968 (Baker 1996). The ephemeral Augeigas and Aretaragas Rivers flow through the park. During summer months, temperatures can rise up to 37°C and during winter temperature can drop below freezing (Anon n.d.). The rainy season lasts from October until April with an average rainfall of 370 mm (Anon n.d.).

This paper deals with the identification, relative abundance, distribution, population structure and mapping of some of the most common and problematic invasive alien plants in the DVGP.

Methods

The study was conducted between August and October 2003 by means of transect walks. The visibility distance/width range during these transects was at least 100-

200 m depending on individual species. In this way, the entire park was covered. Habitats in which individuals were found were broadly categorised as steep slopes, pediments, rivers and cliffs. A GPS was used to plot the position of each plant and hence determine the distribution of each species within each habitat type.

For the relative abundance and distribution of each species, the following formulas were used:

Relative abundance:

(Number of individuals of the species ÷ Total number of individuals of all alien plant species counted) x 100

Relative frequency of occurrence or relative distribution:

Number of Coordinates per individual species ÷ total number of coordinates of all species x 100 (this provided an idea of the relative spread of the species).

Each species has its own invasion potential and rate of invasion. By counting seedlings (young plants), mid age plants and adults per species, a possible "invasion rate" was determined. This was achieved by doing a simple population analysis for each species – i.e. species were divided into population stages – e.g. *Opuntia* by numbers of cladodes (young plants [1–10 cladodes], mid age plants [10–20 cladodes] & adult plants [>20 cladodes]). This was a subjective estimation but allowed a relative population structure to be determined.

Figure 1a & b: Shows two giant spineless *Opuntia ficus–indica* (left) and *Opuntia* cf. *vulgaris* (right) on the bank of Augeigas River [D. F. Joubert & T. N. Shapaka].

Figure 2: *Opuntia* cf. *dillenii* on cliffs (right)
[D. F. Joubert & T. N. Shapaka].

Figure 3a: Unidentified *Opuntia* species on the bank of Augeigas River
[D. F. Joubert & T. N. Shapaka].

Figure 3b:
Unidentified *Opuntia* species on the bank of Augeigas River [D. F. Joubert & T. N. Shapaka].

Results

The most common alien plant invaders identified in the DVGP were: *Opuntia ficus–indica*, *Opuntia* cf. *dillenii, Opuntia* cf. *vulgaris* and one unidentified *Opuntia* species. Other species include *Agermone ochroleuca, Datura* sp. (mainly *D. innoxia*), *Nicotiana glauca* and *Prosopis* species (mainly *P. glandulosa*). The alien invasive grass *Pennisetum setaceum* also occurs within the DVGP (Joubert & Cunningham 2002) but is not commented on further in this paper.

A relative frequency of occurrence or relative distribution and relative abundance of alien plant invaders in the DVGP is indicated in Figure 7. From this it is evident that *Datura innoxia* is abundant as well as fairly widely distributed while *Opuntia* cf. *dillenii* is widely distributed but not as abundant in the DVGP.

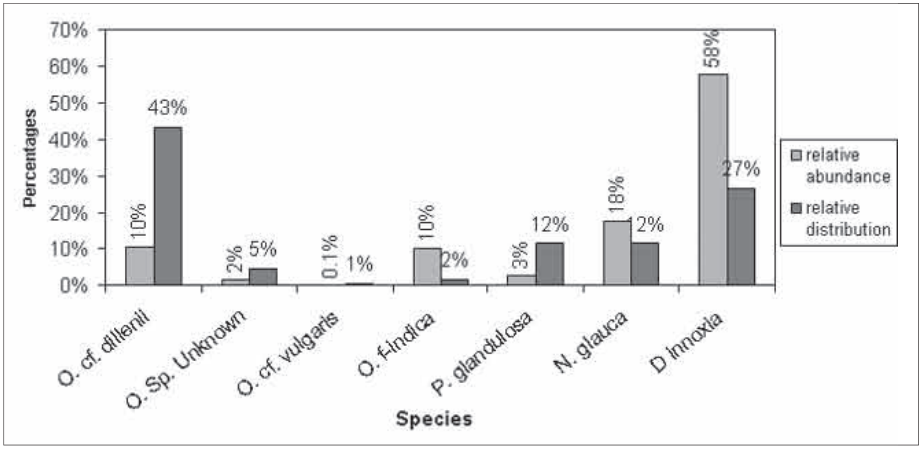


Figure 4. Relative abundance and distribution of alien invasive plant species in the DVGP. *Argemone ochroleuca* excluded.

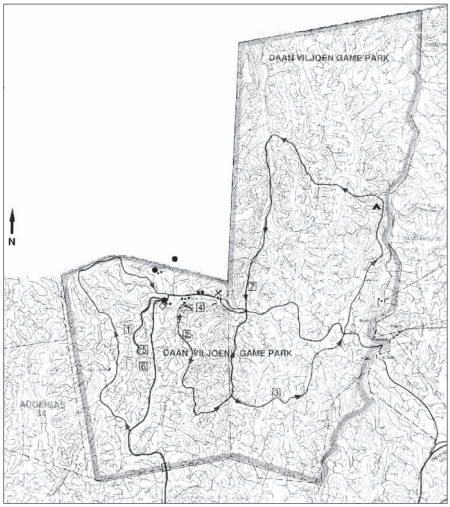
The population sizes for all species are presented in Table 1.

Table 1: Total population sizes of various invasive alien plants in different habitats in DVGP. The total number of alien species in each habitat is also shown.

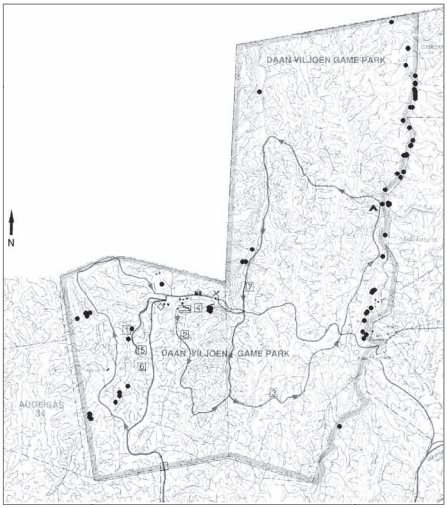
Species	Slopes	River	Cliffs	Pediments	Total
Opuntia cf. *dillenii*	32	24	27	22	105
Opuntia ficus-indica	0	0	0	103	103
Un-ID *Opuntia species*	0	3	13	1	17
Opuntia cf. *vulgaris*	0	1	0	0	1
Datura innoxia	25	47	514	3	589
Nicotiana glauca	0	10	24	60	94
Argemone ochroleuca	0	200	0	0	200
Prosopis glandulosa	3	54	3	11	71
Number of alien species in habitat	3	7	5	6	8

The distribution maps for the various alien plant invaders as identified in the DVGP are presented in Figures 5-10.

No Figures are available for the distribution of *Datura innoxia* and *Argemone ochroleuca*.

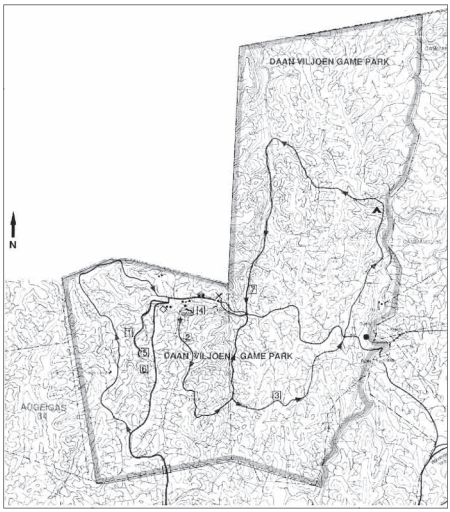


O. f. indica

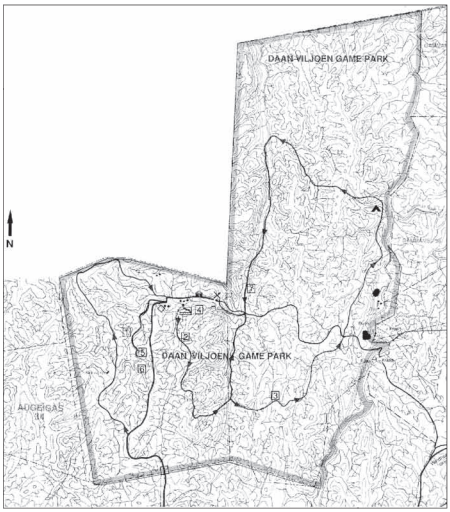


O. cf. dillenii

Figures 5 & 6: Distribution of *Opuntia ficus-indica* (left) and *Opuntia* cf. *dillenii* (right).

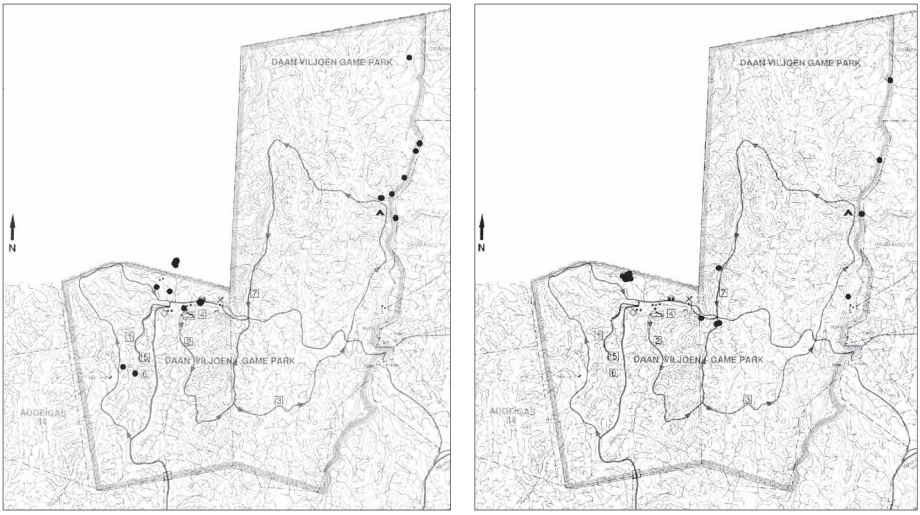


O. cf. vulgaris



O. spp. Unknown

Figures 7 & 8: Distribution of *Opuntia* cf. *vulgaris* (left) and unidentified *Opuntia* species (right).



N. glauca P. glandulosa

Figures 9 & 10: Distribution of *Nicotiana glauca* (left) and *Prosopis* species (mainly *P. glandulosa*) (right).

According to the population stage for *Opuntia* species, *Opuntia ficus-indica* was dominated by young plants, *Opuntia* cf. *vulgaris* dominated by old plants while *Opuntia* cf. *dillenii* and an unidentified *Opuntia* species had a range of population stages with older plants dominating (Figure 11).

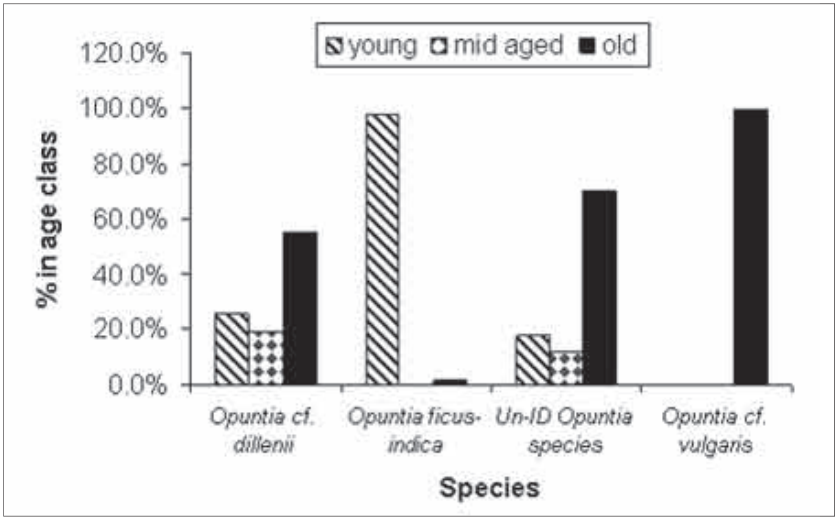


Figure 11. Approximate age classes for the various *Opuntia* species in DVGP.

Discussion

The riverbed habitats contain all but one of the alien species found in DVGP. Riparian habitats are the most susceptible habitats to invasion (Alpert *et al.*, 2000). Since the rivers found in the DVGP run through large parts of Windhoek, there is a very large opportunity for alien invasive seeds and vegetative parts from gardens and dumps to find their way into DVGP.

Opuntia species

Opuntia ficus–indica
Invades many habitats but is mainly associated with dry and rocky places in Savannah and Karoo biomes (Henderson 1995). Van Wyk & Van Wyk (1997) excludes its distribution from Namibia. On the other hand Steenkamp & Smit (2002) include *Opuntia* species as one of the "nasty-nine" invasive alien species in Namibia while Scheepers (1985) lists *O. ficus-indica* as one of the ten most important invasive alien plants in Namibia. Spineless varieties are not declared as weeds in South Africa but may become spiny under certain conditions (Henderson *et al*. 1987). In South Africa, baboons, which love the fruits, are credited with spreading the seeds to inaccessible cliff areas. According to Bromilow (1995) and Henderson, *et al*. (1987) biological control agents such as cochineal and cactoblastis can control it to some degree. This could possibly also be the reason why *Opuntia* species are not as well distributed in the DVGP. On the other hand mechanical control was implemented during the 1980's, which could have resulted in its decline (Adank pers. comm.). *O. ficus-indica* was recorded in rocky/gravel areas in the DVGP (See Figure 5 & Table 1). The species occurring here is spineless (Figure 1 (a) – left). Although relatively abundant (103 individuals), and with a relatively high percentage of young individuals (suggesting a high potential invasiveness) it is restricted to a small portion of the park closely associated with human habitation (Figure 5). The reason for *Opuntia* species not being widely distributed throughout the DVGP could probably be accredited to heavy browsing away from human habitation.

Opuntia cf. *dillenii*
The positive identification of this species is problematic (Obermeyer 1976) and it is referred to as *O.* cf. *dillenii* in this text (Figure 2). *Opuntia* cf. *dillenii* is the most widely distributed invasive alien species with a total of 106 individual plants recorded in the DVGP (See Figure 6). High concentrations are found along the Augeigas River on the eastern border area, which is joined by the Aretaragas River flowing from the Goreangab Dam. It mostly occurs on rocky/cliffs, in watercourses and also associated with the dams in the Choub River in the western section of the DVGP (Table 1). This would suggest that the species requires a moist habitat or that distribution occurs along these watercourses. *Opuntia* cf. *dillenii*, being the most widespread invasive alien species found in the DVGP, suggests that this species may pose a severe threat to the indigenous vegetation communities if not

kept in check. According to Adank (pers. comm.) mechanical control measures implemented in the 1980's effectively reduced all the *Opuntia* species in the DVGP with consequent infestations occurring since then due to the abandonment of such control measures. Since then *O.* cf. *dillenii* has reinfested and spread widely. Its relative success as an invader, when compared to *O. ficus-indica*, is most likely due to its very spiny nature.

Opuntia cf. *vulgaris* and unidentified *Opuntia* species
Opuntia cf. *vulgaris* as well as the unidentified *Opuntia* species was located in the eastern section of the DVGP along the Augeigas River (See Figures 1(b), 3(a/b) & 7). Their overall numbers are currently low (18 individual plants), but the fact that they are located in the inaccessible cliffs and drainage lines make it potentially problematic, especially to eradicate. The as yet unidentified *Opuntia* species is widespread and common within the city of Windhoek, particularly in the Aloe Trail greenspace area adjacent to the National Botanical Research Institute. Its extreme spiny nature and its distribution and abundance outside the park suggest that it is likely to be the most problematic of the *Opuntia* species in the future.

Vegetative propagation from cladodes provides the *Opuntia* genus with a unique feature, probably contributing greatly to their invasiveness. The *Opuntia* genus is also dispersed rapidly by baboons, which are attracted to, and consume, the edible fruit and although no seedlings were observed and confirmed being propagated in this way, it is expected. Baboons may also distribute cladodes during foraging for fruit.

The total eradication of all *Opuntia* species is suggested whilst the populations are relatively small – either mechanically (proved successful in the past), or by employing biological control measures such as cochineal and cactoblastis (also successful – e.g. Farm Lichtenstein).

Other species

The most widely distributed and abundant invasive alien species, other than the *Opuntia* species, are *Datura* species (mainly *Datura innoxia*), which is common throughout the DVGP (See Figure 4). Although all the invasive alien species were actively eradicated during the 1980's they have since re-established in the absence of active management (Adank pers. comm.). All of the following species are widespread in Namibia with both Scheepers (1985) and Steenkamp & Smit (2002) including them as the most important invasive alien plants in Namibia.

Datura innoxia
D. innoxia is poisonous and being a deep germinator, it is not easily controlled by pre-emergence herbicides (Bromilow 1995). Although poisonous, cases of livestock poisoning are rare due to animals being able to tolerate high levels of atropine (one of the main ingredients) without ill effect (Van Wyk *et al.* 2002). A total

count of 597 individual plants was identified mainly in habitats such as rocky/cliffs (86%) and drainage lines (Table 1) throughout the DVGP. Seed dispersal takes place during flood events (Kolberg 1998) and although suspected, it is not known if baboons and birds are also responsible for seed dispersal. *D. innoxia* is an annual and the fact that it can drastically increase and occurs often on inaccessible cliffs will make eradication complex. Eradication programmes should focus on clearing the plants before the onset of fruits. However, seed production is high and the seeds probably persist in the soil for many years, and so the results of such a programme may only manifest after many years.

Argemone ochroleuca
A. ochroleuca are widespread throughout South Africa, but were not initially declared a noxious weed (Bromilow 1995). Van Wyk *et al*. (2002) state that the plant is unpalatable to livestock and being poisonous (contains the toxic isoquinoline alkaloids berberine and propane) has resulted in human fatalities. An estimate of at least 200 individual plants was recorded mainly on the western boundary, Augeigas River and Choub River up to Augeigas Dam. Its annual nature and prodigious seed production would make combating problematic. A similar programme as advocated for *Datura* species should be conducted for all annual species.

Nicotiana glauca
N. glauca is a widespread invasive alien species throughout South Africa and Namibia (Coats Palgrave 1983; Van Wyk & Van Wyk 1997) and thought to have been introduced to Namibia in horse fodder (Bromilow 1995). Other than being common in drainage lines and tolerant of arid conditions it is poisonous to humans (Van Wyk *et al.* 2002) and occasionally to game and livestock when browsed and should be removed when young (Bromilow 1995). A total of 184 *N. glauca* individuals (2nd highest abundance of all alien invasive species) were located mainly in the eastern and western sections along the drainage lines (See Figures 4 & 9). This species is highly visible and should be eradicated when encountered.

Prosopis species (mainly *P. glandulosa*)
Introduced to Namibia in 1897 (Bromilow 1995), *Prosopis* spp. are now widespread in the arid western parts of southern Africa (Coats Palgrave 1983; Van Wyk & Van Wyk 1997) and Namibia (Smit 2004). Control is difficult due to their coppicing ability (Bromilow 1995). *Prosopis* species have been targeted for elimination from the park since the early 1980's therefore probably resulting in the current low numbers (26 individuals) in the DVGP (Adank pers. comm.). Although not currently abundant they are widespread (See Figures 4 & 10) and due to their known invasiveness should be eradicated further so as to prevent spreading, especially in the drainage lines.

This project serves as a baseline study to the understanding of the dynamics and potential problem that invasive alien plants pose in a protected area such as the DVGP. The DVGP faces a real threat from invasive alien plant species as most of

these species have fruits (e.g. *Opuntia* and *Prosopis*) that are favoured by animals such as baboons that can spread them throughout the general area. It is well known that prevention of invasions is much less costly than post-entry control (Mack *et al.* 2000) and the DVGP being a relatively small park, with most of the infestations in their infancy, it should be possible to eradicate these aliens and thus serve as an example that such problems can be dealt with effectively. The close proximity of DVGP to a rapidly growing Windhoek indicates that invasions from outside will increase, particularly along rivers entering the park. The situation in DVGP is by no means unique for Namibian protected areas, as aliens are known to occur in other parks (e.g. *Lantana camara*, *Opuntia* spp. and *Pennisetum setaceum* in the Waterberg Plateau Park – See Macdonald & Nott (1987), Joubert & Cunningham 2002) throughout Namibia. The Ministry of Environment and Tourism should revive their commitment to invasive alien control, particularly in protected areas.

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