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Distribution of *Iris pseudacorus* (Linnaeus, 1753) in South Africa

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Abstract

The yellow flag iris, *Iris pseudacorus* L., was recorded for the first time outside of cultivation in South Africa along the Vaal River in Gauteng Province in 2004. The yellow flag iris is native to Eurasia and North Africa and was probably introduced to South Africa as an ornamental plant. We recorded *I. pseudacorus* in four of the nine provinces of South Africa, with naturalised populations at 24 localities covering an estimated area of about 0.4 ha around rivers, streams, dams and wetlands. While we found it at multiple sites (suggesting the species should be classified as category E in South Africa under the Blackburn scheme), the current planted and naturalised distribution throughout South Africa and neighboring countries is likely to be substantially higher than reported here. Infestations are likely to cause substantial negative impacts as seen elsewhere in the world. The species is currently listed as an eradication target under South African regulations, but the feasibility of control still needs to be determined and given its popularity, eradication from the region looks unlikely.

Key words: alien species, escape cultivation, Iridaceae, ornamental, yellow flag iris

Introduction

There are about 1036 species of the family Iridaceae native to the southern African region (van Kleunen et al. 2007). *Iris* is the largest genus with more than 250 species, with no representative species in southern Africa. The genus is distributed across the north temperate zones to North America, and is most diverse in Asia (Goldblatt 2000; Goldblatt et al. 2003; Wilson 2003).

Iris pseudacorus (Linnaeus, 1753); yellow flag iris, pale yellow iris) is a popular plant used in water gardens and in other ornamental plantings. It has a wide native distribution from North Africa to Siberia (Morgan 2011) and has escaped cultivation in many regions of the United States of America, Canada and New Zealand (Cody 1961; Sutherland 1990; Katharine 2009; USDA 2010). The species was probably introduced to South Africa as an ornamental plant (Jaca 2012).

Iris pseudacorus is a nitrophile in that it can live in oxygen-poor soils. It frequently invades the banks of streams and wetlands and can form dense clumps (Sutherland 1990; Figure 1). *I. pseudacorus* is easily spread by water where broken rhizomes may be transported downstream and establish new populations (Kratschmer 2009; Jaca 2013). In its native region, this species is reported to be poisonous to grazing animals as it contains glycosides (Ramey 2001). Sutherland (1990), mentioned that *I. pseudacorus* has been shown to decrease soluble organics by 25% in a year. The aim of this study was to examine the distribution of *I. pseudacorus* in South Africa.

Description

Although South African *Moraea* species (Goldblatt et al. 2003) were treated in the same genus, the native range of *Iris* L. is now restricted to the northern hemisphere, with no native representatives in South Africa. *I. pseudacorus* is a herbaceous perennial, semi-aquatic plant (Jacobs et al. 2010), that may superficially resemble some indigenous species in South Africa, for example *Moraea huttonii* (Baker) Oberm. and *Typha capensis* (Rohrb.) N.E.Br. (when not in flower). However, *I. pseudacorus* differs from *M. huttonii* in that its root stock is

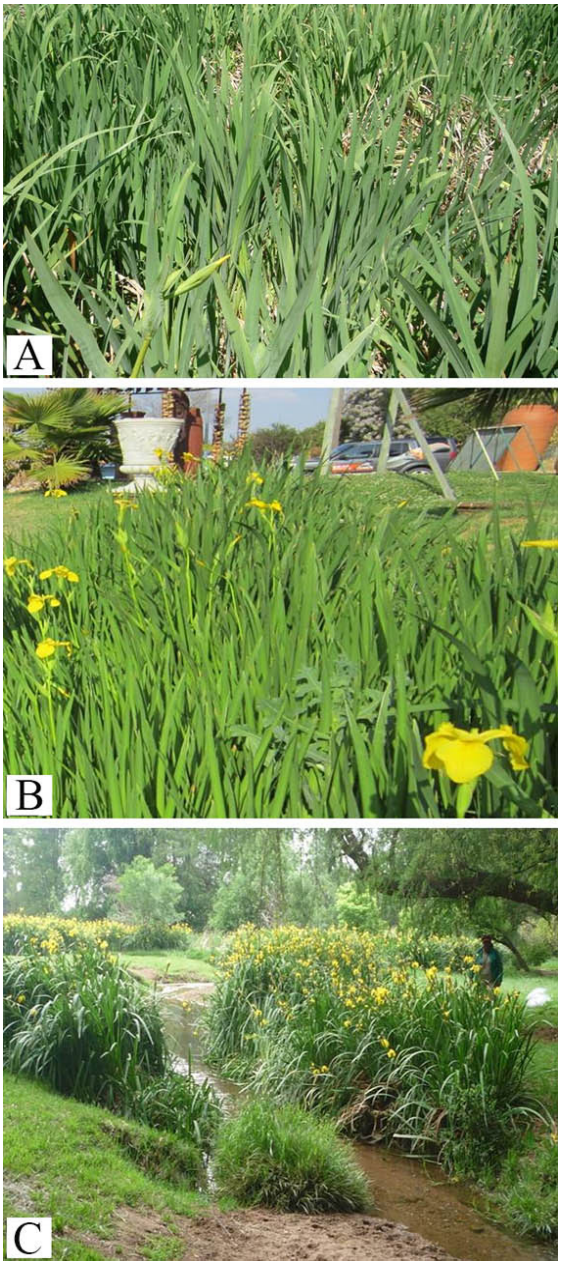

Figure 1. *Iris pseudacorus* infestation along a stream in Pretoria, Equistria (a), Witkoppen Road in Johannesburg (b) and along a river bank at the Johannesburg Botanical Garden (c). Photographs by Thulisile P. Jaca.

a pink creeping rhizome (Figure 2), whereas *M. huttonii* has a corm. At a distance these species look similar as they both have yellow flowers and the flower structure is similar. *I. pseudacorus* differs from *T. capensis* in that the leaves have a raised midrib while in *T. capensis* the midrib is not raised.

Figure 2. *Iris pseudacorus* rhizomes forming mats. Photograph by Thulisile P. Jaca.

Materials and methods

The distribution of *I. pseudacorus* in South Africa, during the period 2004–2014 was determined using data from the Southern African Plant Invaders Atlas (SAPIA) supplemented by records from field observations made between 2010 and 2014 by field biologists and the authors (Supplementary material Table S1). To estimate the extent of *I. pseudacorus* infestations, 100 m × 20 m transects, along dams and river banks where *I. pseudacorus* was present, were surveyed at seven localities. The seven localities were in Limpopo Province (Klein Kariba Resort, wetland adjacent to camping site), Gauteng Province (Pretoria, Equestria, where Furrow Road crosses the spruit; Johannesburg area on Witkoppen road on stream joining Jukskei River; Roodepoort, along Christiaan De Wet road; and Paulshof area along stream), and KwaZulu-Natal Province (Pietermaritzburg, Balgowan, junction off Balgowan road and Curry's Post road; Merrivale, Celtiskloof, outside the garden fence).

To determine invasive potential, the post-border Australian Weed Risk assessment scheme (Pheloung et al. 1999) was used. This scheme has been applied in a variety of geographies and is reported to be almost accurate (Gordon et al. 2008, 2010; Hulme 2012).

To estimate seed production, we counted the number of capsules per stem and number of seeds per capsule at ten sites. To confirm identification we examined material from virtual herbaria in the countries of origin and voucher specimens from Germany housed at the Compton herbarium (NBG, abbreviation according to Holmgren et al. 1990).

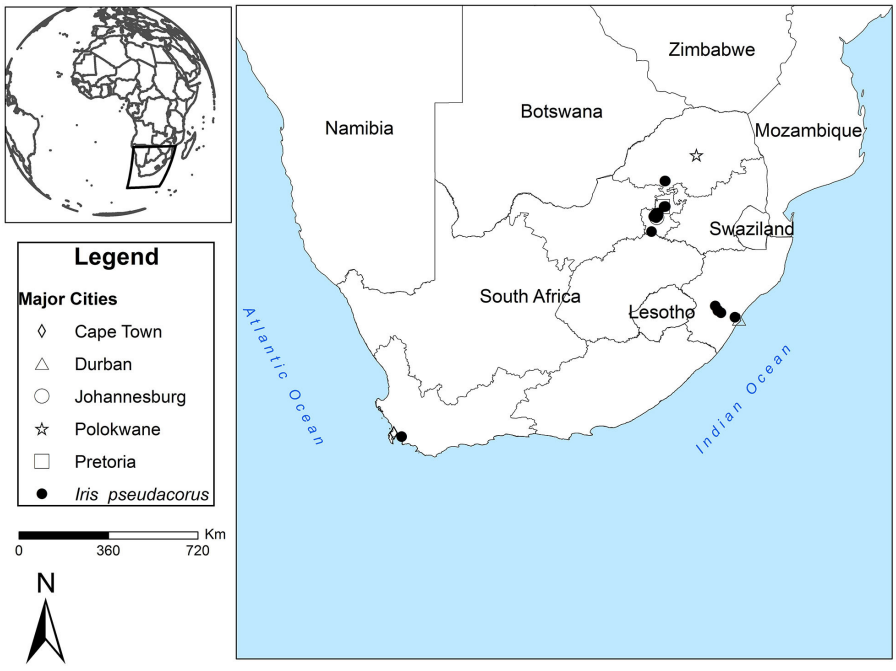

Figure 3. Known distribution of *Iris pseudacorus* in South Africa (for details see Supplementary material Table S1).

Results and discussion

The first record of *I. pseudacorus* outside cultivation in South Africa was made in 2004 along the Vaal River (between Vereeniging and Vanderbijlpark), Gauteng Province (SAPIA 2013). *I. pseudacorus* was recorded in Klein Kariba Resort, Limpopo Province in 2005 and from 2006 to 2014 the species was recorded in the Western Cape and KwaZulu-Natal Provinces and more records discovered in Gauteng Province (Figure 3; Table S1). The population in Johannesburg at Witkoppen Road (Gauteng Province) is suspected to have escaped from Potplace Nursery as the plants were growing alongside a water drainage, just outside the nursery. Potplace Nursery was inspected and plants were found in a pond; the owners were not aware of its potential invasiveness. To verify the source of the infestation the authors searched 20 m up the drainage from the nursery and no other plants were discovered.

We suspect that plants at all of the surveyed sites initially established from rhizomes of discarded plants from nearby gardens and nurseries (Denslow and Katz 2011). This is evident from the population discovered along Witkoppen Road where subsequent spread may have resulted from the breaking up of rhizomes.

For the invasive risk assessment, 44 of the 49 questions in the post-border Australian Weed Risk assessment scheme were answered, leading to a score of 23 which would have resulted in the species being rejected in a pre-border evaluation (Supplementary Table S2). According to the assessment environmental sector is at risk from invasion by this species.

To date 24 naturalised populations have been reported (14 from Gauteng Province; seven from KwaZulu-Natal Province; two from Limpopo Province; and one from the Western Cape Province, Table S1). Most populations were discovered in 2011 (15) following a countrywide survey, but more populations are still being found (Figure 4).

One stem produces an average of 11–20 (to maximum of 27) seed capsules and each capsule produces, on average, about 60 viable seeds (Jaca pers. obs.). Further studies need to be conducted on seed germination as the viability of seeds does not assure successful germination. Low temperatures may be required to break seed dormancy, as is the case for other invasive species in South Africa such as *Cotoneaster pannosus* Franch., *C. franchetii* Bois, *Pyracantha angustifolia* (Franch.) C.K. Schneid, *P. coccinea* M.Roem. and *P. crenulata* (Roxb. ex D.Don) M.Roem. that are restricted to areas where freezing winter

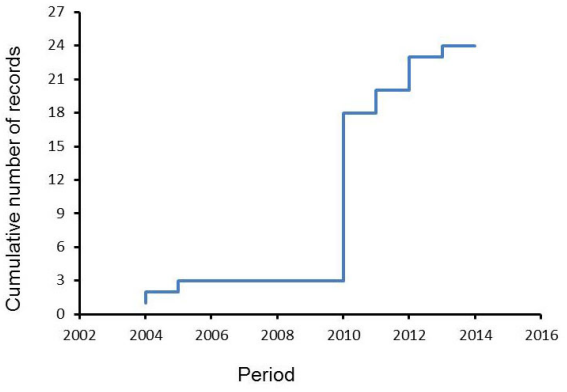

Figure 4. Cumulative number of localities recorded from 2004 to 2014.

temperatures are a requirement to trigger seed germination (Henderson 2007). In some areas surveyed this species has started to spread up to 250 m from where it was planted. Plants were recorded in all of the seven transects surveyed in the Limpopo, Gauteng and KwaZulu-Natal Provinces. This could indicate that *I. pseudacorus* has the potential to spread in South Africa. Though still contained in manageable populations, if the species is left unattended, the invasion may result in severe adverse impacts for native wetland species.

In Connecticut (eastern North America) and Hawaii, *I. pseudacorus* was able to exclude the native *Peltandra virginica* (L.) Schott, a species whose fruits are an important food of wood ducks (*Aix sponsa* L.) during the nesting season (Cox 1999). Crawford (2000), also reported that along the lower Potomac River near Washington D.C., *I. pseudacorus* has contributed to the conversion of riparian marshes, favoured by indigenous *Salix* species, into mesic forest dominated by exotic *Fraxinus* species. Thomas (1980) further elaborated that *I. pseudacorus* speeds up the destruction of swamps on Theodore Roosevelt Island, reducing suitable habitat and available forage of the wood duck.

I. pseudacorus was recorded mainly along river banks, stream banks, edge of dams and wetlands. These habitats are similar to those in the native region where herbarium samples were collected. We observed that in urban and suburban settings this species is clogging drainage pipes, flood control ditches and reducing stream width. This is concurrent with studies in Montana where it is reported to cause reduction in stream width by up to 25 cm creating new banks and contributing to sediment retention (Tyron 2006).

Conclusion

Iris pseudacorus was first recorded as naturalized at one locality in 2004 and by 2014 at an additional 23 sites. The distribution map and habitat records indicate that the species has managed to establish itself in natural areas. *I. pseudacorus* can potentially become a major problem in South Africa by modifying stream ecosystems, outcompeting native plants and forming dense stands if not controlled. Like many invasive semi-aquatic plants, *I. pseudacorus* is disturbance-adapted; natural disturbances and human induced factors are associated with its spread. It is crucial to understand the distribution, ecology and spread of this species for management. *I. pseudacorus* is spreading in South Africa, but still occurs in low densities. It has consequently been identified as a species of concern that requires urgent attention (NEM:BA 2014). Some horticulturist are unaware of the potential invasiveness of this species hence the plant still continues to be sold in local nurseries. Therefore there is a need for awareness directed to horticulturists who are still growing and selling this plant. We plan to expand our search for the species throughout South Africa and neighboring countries and to assess the feasibility of eradication or control.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records of naturalised populations of *Iris pseudacorus* in South Africa from 2004–2014.

Table S2. Evaluation of invasive risk of *Iris pseudacorus* using the Australian Weed Risk Assessment scheme (Pheloung et al.1999).

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Supplementary material

Table number	Table abbreviation	Table title
Table S1	Tab S1	Records of naturalised populations of *Iris pseudacorus* in South Africa from 2004–2014.
Table S2	Tab S2	Evaluation of invasive risk of *Iris pseudacorus* using the Australian Weed Risk Assessment scheme (Pheloung et al.1999).
References	References	References for Table S2

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Table S1. Records of naturalised populations of *Iris pseudacorus* in South Africa from 2004–2014.

Record no.	Location	Record date	Province	Herbarium records in South Africa	Coordinates of the locality site		Accuracy	Habitat type	Estimate of population size (ha)
					Latitude, S	Longitude, E			
1	Vaal river, between Vereeniging and Vanderbijlpark	Oct-04	Gauteng		-26.66667°	27.83333°	5m	Stream	0.01
2	Klein Kariba Resort, wetland adjacent to camping site	Oct-05	Limpopo		-24.83333°	28.33333°	1m	Wetland	0.0646
3	Pretoria, Equestria, where Furrow road crosses the spruit	Oct-10	Gauteng	NBG0270296-0	-25.75727°	28.33166°	1m	Stream	0.1631
4	Johannesburg Botanical Garden	Sep-11	Gauteng	PRE0862348-0	-26.02944°	27.97500°	4m	Wetland	0.001
5	Johannesburg, Witkoppen road, stream water drainage next to Potplace nursery	Sep-11	Gauteng		-26.02944°	27.97500°	5m	Stream	0.0138
6	Johannesburg, Sandton at Mushroom Park	Sep-11	Gauteng	PRE0862347-0	-26.10500°	28.06361°	5m	Pond	0.003
7	Johannesburg, Witkoppen road on stream joining Jakskei river	Sep-11	Gauteng		-26.03028°	27.97305°	5m	Stream	0.0009
8	Johannesburg Botanical Garden in the first small pond	Sep-11	Gauteng	PRE0862350-0	-26.16167°	28.00005°	1m	Wetland	0.002
9	Johannesburg Botanical Garden	Sep-11	Gauteng		-26.15333°	28.99972°	1m	Wetland	0.001
10	Pretoria, Equestria, along the spruit	Sep-11	Gauteng		-25.75963°	28.32927°	1m	Stream	0.0766
11	Pietermartzburg, Balgowan, juction of Balgowan road and Curry's Post road	Oct-11	KwaZulu–Natal	NH0135635-0	-29.37500°	30.12500°	5m	Waterway	0.001
12	Klein Kariba Resort, wetland adjacent to the dam	Oct-11	Limpopo	PRE0862351-0	-24.84587°	28.32942°	3m	Wetland	0.005
13	Pietermaritzburg Curry's Post, Heavenly haven	Oct-11	KwaZulu–Natal	NH0135633-0	-29.37500°	30.12500°	5m	Waterway	0.002
14	Howick, Merrivale (industrial area), along roadside next to the bridge (growing with *Typha capensis*)	Oct-11	KwaZulu–Natal		-29.51197°	30.23197°	5m	Roadside, stream	0.0003
15	Merrivale, Celtiskloof, outside the garden fence (starting to escape from the garden)	Oct-11	KwaZulu–Natal		-29.52153°	30.23755°	5m	Wetland	0.002
16	Johannesburg, Kyalami, along R55 road, stream water drainage	Nov-11	Gauteng		-25.99056°	28.07638°	1m	Roadside, stream	0.0132
17	Durban, Kloof surburb, along tributary to Molweni river	Nov-11	KwaZulu–Natal		-29.77056°	30.85111°	5m	River	0.003
18	Johannesburg, Roodepoort, along Christiaan De Wet road	Nov-11	Gauteng		-26.11972°	27.91361°	1m	Wetland	0.0179
19	Pretoria, Moreleta Spruit, N4 to Brookside	Nov-12	Gauteng		-25.76278°	28.28806°	5m	Stream	0.001
20	Johannesburg, Witkoppen Park	Nov-12	Gauteng	PRE0862346-0	-26.01050°	28.00705°	5m	Wetland	0.0114
21	Howick, Merrivale, between Johanson Bros and C.J. Maize meal industrial	Oct-13	KwaZulu–Natal		-29.52975°	30.23158°	5m	Wetland	0.0009
22	KwaZulu–Natal Botanical Gardens, near the wooden bridge next to bananas along the river	Oct-13	KwaZulu–Natal		-29.60531°	30.34536°	5m	River bank	0.0015
23	Johannesburg, Paulshof area along stream	Nov-13	Gauteng		-26.03150°	28.05105°	5m	Stream	0.0256
24	Stellenbosch University Botanical Gardens	May-14	Western Cape		-33.93643°	18.86538°	1m	Stream	0.0032

Table S2. Evaluation of invasive risk of Iris pseudacorus using the Australian Weed Risk Assessment scheme (Pheloung et al.1999).

Question	Answer	Reference	Score	Range of possible scores
Is the species highly domesticated?	Yes	Ross1962, Wells and Brown 2000, Stone 2009, Tu et al. 2003, Morgan 2010	-3	0 or -3
Is species naturalised where grown?	Yes	Steele 1902, Cody 1961	1	-1 or 1
Does the species have weedy races?	Yes	Eckert et al 1973	1	-1 or 1
Species suited to South African climates	Yes	Bioclimatic model	2	0, 1 or 2
Quality of climate match data (0—low; 1—intermediate; 2—high)	High	Global Biodiversity Information Fcacility 2014	2	0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	Native range occupies four Koppen-Geiger zones	1	0, 1 or 2
Native or naturalised in regions with extended dry periods	No	Tu et al. 2003	0	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	Tu et al. 2003, Cody 1961, Sutherland 1990, Denslow and Katz 2011	1	0 or 1
Naturalised beyond native range	Yes	Sutherland 1990, Stone 2009	2	1 or 2
Garden/amenity/disturbance weed	Yes	Sutherland 1990, Tu et al. 2003	2	0,1 or 2
Weed of agriculture/horticulture/forestry	Yes	Grier and Grier 1929	4	1, 2, 3 or 4
Environmental weed	Yes	Global compendium of weeds	4	1, 2, 3 or 4
Congeneric weed	No	No evidence	0	0,1 or 2
Produces spines, thorns or burrs	No	Tu et al. 2003	0	0 or 1
Allelopathic	No	No evidence	0	0 or 1
Parasitic	No	No evidence	0	0 or 1
Unpalatable to grazing animals	Yes	Tu et al. 2003	1	-1 or 1
Toxic to animals	Yes	Bernhard-Smith 1923, Bruce 1920, Ramey 2001	1	0 or 1
Host for recognised pests and pathogens	Unknown	No evidence	0	0 or 1
Causes allergies or is otherwise toxic to humans	Yes	Tu et al. 2003	1	0 or 1
Creates a fire hazard in natural ecosystems	No	Tu et al. 2003	0	0 or 1
Is a shade tolerant plant at some stage of its life cycle	No	Sutherland 1990	0	0 or 1
Grows on infertile soils	Unknown	No evidence	0	0 or 1
Climbing or smothering growth habit	No	Sutherland 1990, Tu et al. 2003, Jacobs et al. 2010	0	0 or 1
Forms dense thickets	No	Herbacious plant	0	0 or 1
Aquatic	No	Sutherland 1990, Tu et al. 2003, Jacobs et al. 2010	0	0 or 5
Grass	No	Sutherland 1990, Tu et al. 2003	0	0 or 1
Nitrogen fixing woody plant	No	Sutherland 1990, Tu et al. 2003	0	0 or 1
Geophyte	Yes	Sutherland 1990, Tu et al. 2003, Cody 1961, Morgan 2010	1	0 or 1
Evidence of substantial reproductive failure in native habitat	No	Sutherland 1990, Tu et al. 2003	0	0 or 1
Produces viable seed	Yes	Sutherland 1990, Tu et al. 2003	1	-1 or 1
Hybridises naturally	No	Sawyer 1925	-1	-1 or 1
Self-fertilisation	Unknown	No evidence	-1	-1 or 1
Requires specialist pollinators	No	No evidence	0	0 or -1
Reproduction by vegetative propagation	Yes	Sutherland 1990, Tu et al. 2003	1	-1 or 1
Minimum generative time (years)	1 year	Sutherland 1990, Tu et al. 2003	1	-1, 0, or 1
Propagules likely to be dispersed unintentionally	Unknown	No evidence	-1	-1 or 1
Propagules dispersed intentionally by people	Yes	Stone 2009, Tu et al. 2003, Morgan 2010	1	-1 or 1
Propagules likely to disperse as contaminanst of produce	Yes	Maki and Galatowitsch 2004	1	-1 or 1
Propagules adapted to wind dispersal	No	Tu et al. 2003	-1	-1 or 1
Propagules buoyant	Yes	Coops and van der Velde 1995, Tu et al. 2003	1	-1 or 1
Propagules bird dispersed	No	Tu et al. 2003	-1	-1 or 1
Propagules dispersed by other animals (externally)	No	Tu et al. 2003	-1	-1 or 1
Propagules dispersed by other animals (internally)	No	Tu et al. 2003	-1	-1 or 1
Prolific seed production	No	Sutherland 1990, Tu et al. 2003	-1	-1 or 1
Evidence that a persistent propagule bank is formed (> 1 yr)	Yes	Sutherland 1990, Stone 2009	1	-1 or 1
Well controlled by herbicides	No	Tu et al. 2003, King County 2009	1	1 or -1
Tolerates or benefits from mutilation, cultivation or fire	Yes	Sutherland 1990, Clark et al. 1998	1	-1 or 1
Effective natural enemies present in South Africa	Non known	No evidence	1	1 or -1
Total score	Reject		**23**	

References for Table S2

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