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The distribution and invasive potential of Fountain Grass *Pennisetum setaceum* in Namibia

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Abstract

Pennisetum setaceum *is an exotic alien grass species from North Africa with invasive potential in Namibia. The distribution and invasive potential of this species was investigated. The current distribution of this species was compared with the reported distribution in the mid 1980s. It has increased its range in Namibia dramatically since then and is now found in a number of locations throughout Namibia, albeit mostly on road verges and other disturbed areas predominantly in the Highland Savanna and Mountain Savanna biomes. It's popularity as an ornamental grass, particularly amongst farmers, is responsible for its introduction and spread. Observations on a dense stand of* P. setaceum *west of Windhoek indicate this species preference for road verges and schist cuttings in association with relatively mesophytic grasses such as* Heteropogon contortus, Cenchrus ciliaris *and* Panicum maximum*. Its ability to form a major component of the vegetation of each of these habitats suggests that it has a broader tolerance range than the associated indigenous grasses. A range of control measures is suggested to prevent the species spreading further whilst it is still feasible.*

Keywords: *Pennisetum setaceum*; Fountain Grass; distribution; alien invasive; Namibia

Introduction

Pennisetum setaceum (Forssk.) Chiov., commonly referred to as Fountain Grass, is native to the Middle East and North Africa (Henderson 1995; Gibbs Russell *et al*. 1990), extending as far south as Tanzania, through Sudan, Ethiopia, Kenya and Somalia (Chippendall 1955; Chippendall & Crook 1976; Clayton & Renvoize 1982; Grounds 1998; van Oudtshoorn 1992; van Oudtshoorn 1999). This unpalatable perennial grass has become naturalised in southern African countries, including Zambia, Zimbabwe, South Africa, Swaziland (Chippendall & Crook 1976) and Namibia (Gibbs Russell *et al*. 1990) as well as the Democratic Republic of Congo (Chippendall & Crook 1976). It has also become naturalised in Australia, Hawaii,

North America (Milton *et al*. 1998), Lebanon, Syria, Arabia (Clayton & Renvoize 1982) and Fiji (Williams *et al*. 1995).

Although it has been recorded extensively on road verges in Zimbabwe (Chippendall & Crook 1976) and South Africa (Henderson 1995), particularly in the Western Cape (Milton *et al*. 1998), it has previously only been recorded from two localities in Namibia, namely, the Otavi-Tsumeb-Grootfontien triangle (Gibbs Russell *et al*. 1990; Müller 1985; van Oudtshoorn 1999) and the entrance routes to Windhoek (Müller 1985). Recent observations in Namibia by the authors indicate that this species is more widespread than previously thought, occurring on road verges in widely varying climates from the hyper-arid Namib Desert (<100mm) to the relatively high rainfall area between Otavi and Tsumeb (>600mm). *P. setaceum* is a perennial grass that grows in dense tufts with a cylindrical, plumelike light coloured inflorescence (Figure 1). The leaves are dull green, linear with very scabrid margins.

Figure 1: A tuft of *Penisetum setaceum* in its habitat along a road cutting near Windhoek.

In this report, we record the current distribution, and investigate the invasive potential, of this species by studying the dynamics and habitat preferences of a well established population on and near road verges in the Highland Savanna vegetation (Giess 1971) east of Windhoek, Namibia.

Methods

Distribution

The authors recorded the distribution of the species along road verges, and in some parks, during extensive travels through Namibia. The distribution was mapped on a ¼ degree square map of Namibia and compared with the recorded distribution of the 1980s (Figures 2 and 3). Populations were categorised as follows: 1. single individuals; 2. single populations; 3. more than one population occurring 100 m or more apart.

Invasive potential

A questionnaire was sent to the two major nurseries in Windhoek, to determine when the nurseries started selling the plant (to try and establish an approximate starting time for the invasions) and approximately how many are sold per year.

All *P. setaceum* individuals along the major roads within a radius of 15 km from Windhoek were counted during the spring of 1998, excepting for the population adjacent to the suburb Hochland Park. A sample from this population was used to determine the parameters measured. The distance of each population from Windhoek, and from each other was recorded.

The nearest neighbour, and the distance to nearest neighbour, was recorded for each individual. Habitats in which the plant was recorded were categorized as road verges, schist cuttings (along the road verges) and erosion gullies (adjacent to the road verges). These habitats differ particularly in their soil moisture availability, with road verges probably being the most mesic, due to water runoff from roads. Height, tuft diameter and reproductive status were recorded for each individual. Plants were divided into three tuft diameter classes (seedlings, 0 – 30 cm, and > 30 cm) and reproductive status (inflorescence; no inflorescence). A χ^2 goodness of fit test was used to compare observed frequencies of plants containing inflorescences, and the occurrence of the three most common nearest neighbours with the expected frequencies in the different habitats. A simple analysis of variance was performed to determine whether nearest neighbour distances were significantly different in different habitats. This determined whether population structure differed and whether populations experienced differences in competition in the different habitats.

Results

Distribution in Namibia

The occurrence of *P. setaceum* "in the wild" in Namibia, has not been previously documented except for van Oudtshoorn (1999) who indicates it's distribution in the Tsumeb-Grootfontein-Otavi triangle on a distribution map of grasses of Southern Africa. Figure 3 indicates the current distribution of the species, and the status of the populations.

P. setaceum was identified in the following areas as single individuals; single populations; more than one population occurring 100 m or more apart.

More than one population, occurring at least 100 m apart

Windhoek: Numerous populations (nine) occurring west of Windhoek adjacent to the Daan Viljoen road up to the Augeigas River. Approximately 4000 individual were counted. A single plant was observed in the Daan Viljoen Game Reserve. A small population was also observed on the Gamsberg road approximately 2 km southwest of Windhoek.
Otjiwarongo: A few small populations observed in the Otjiwarongo area on the Okakarara road.
Otavi-Grootfontein: Numerous populations occurring on the road verge.
Grootfontein-Rundu: Numerous populations just north of Grootfontein.
Namutoni: Two populations east of Namutoni Gate, just outside Etosha National Park

Single populations

Waterberg Plateau Park: In the vicinity of the Okatjikona Environmental Education Centre in an erosion gully.

Single individuals

Arandis: Individual plants outside town in the vicinity of the railway bridge.
Rossing mine: Individual plants inside mine enclosure.
Keetmanshoop: Individual plants at a service station to the South of the town.
Omaruru: Individual plants on the periphery of the town towards Karibib.
Tsumeb: Individual plants adjacent to the Tsumeb-Grootfontein road.

All of the above populations were on road verges, except for one population near Windhoek, and the population at the Waterberg Plateau Park, which were in erosion gullies.

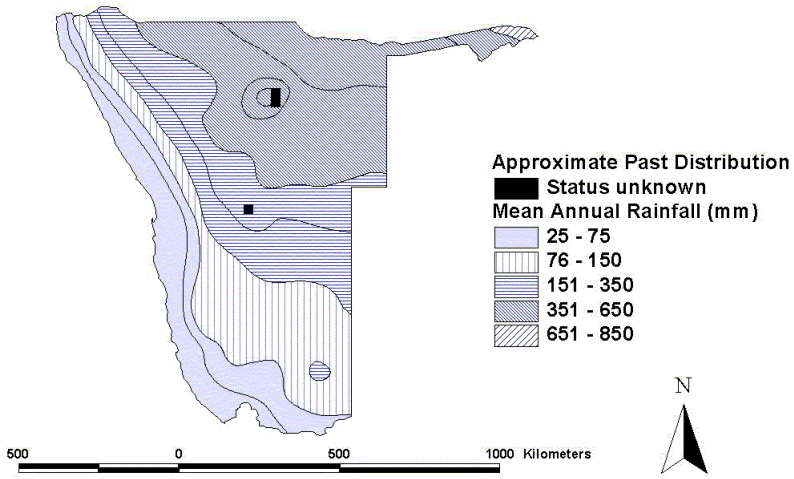

Figure 2: Approximate past distribution of *P. setaceum* in Namibia

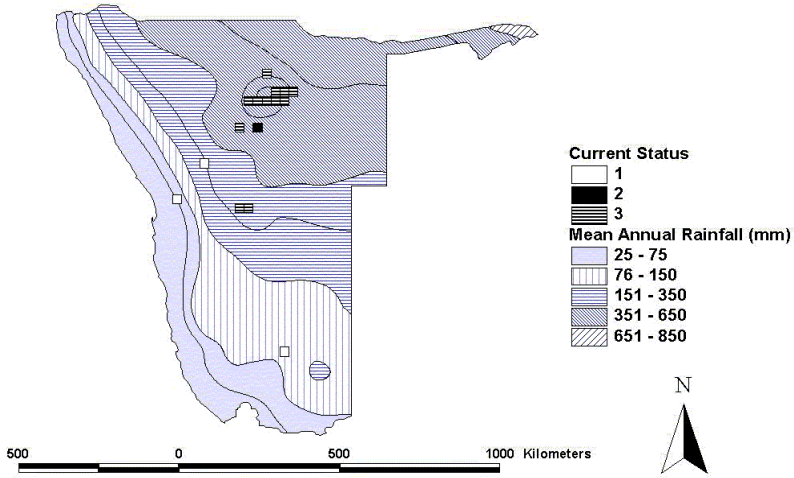

Figure 3: Current distribution and status of *P. setaceum* in Namibia. Status 1: single individuals; Status 2: single populations; Status 3: more than one population.

The distribution of *P. setaceum* falls within six biomes as identified by Giess (1971), but most frequently occurred in the Highland Savanna, and Mountain Savanna biomes. This may largely be due to the sale of plants from nurseries in larger centres, such as Grootfontein and Windhoek, as most plants occurred within a relatively small radius around these centres. However, the relatively higher rainfall of these two biomes, in particular the Mountain Savanna biome, may also partially account for the high numbers. The grass was present in two national parks (Daan Viljoen Game Reserve and the Waterberg Plateau Park).

Invasive potential

Both major nurseries in Windhoek responded to the questionnaire. A total of approximately 800 plants in Windhoek are sold per year. The two nurseries have been selling the plants for 10 to 13 years.

A total of approximately 1000 plants were counted in 9 populations along a stretch of 12 kilometres along a major road to the west of Windhoek (but many more are found within the town's boundaries). No plants were found on the major routes to the east, north and south of Windhoek. The mean distance between populations was 1.5 km, ranging between 0.1 km and 7.5 km.

The populations consisted mainly of well-established plants, with very few seedlings being observed (1 %; Table 1). Tables 1, 2 and 3 refer to the *P. setaceum* population in the Windhoek area, only.

Table 1: Size structure of *Pennisetum setaceum* populations

Tuft diameter	Frequency (%)
Seedling	1
< 30 cm	50
> 30 cm	49

Table 2 shows that *P. setaceum* dominates in schist cuttings where it has established, whereas on road verges its nearest neighbour is usually *Heteropogon contortus*. In erosion gullies, the most common nearest neighbour is *Panicum maximum*. Overall, *H. contortus*, followed by *P. setaceum*, was most frequently the nearest neighbour. The observed frequency of the three nearest neighbours differed significantly between habitats ($\chi^2 = 233.8$, d.f. = 4, $P < 0.001$).

Table 2: Mean nearest neighbour distances and standard deviations (in metres) in the three different habitats and overall

Habitat	n.n. distance (m) sd value in parenthesis	Most frequently occurring nearest neighbours in descending order (% frequency in parentheses)		
Road verges	0.19 (0.20)	*Heteropogon contortus* (59.0)	*Pennisetum setaceum* (16.2)	*Cenchrus ciliaris* (8.3)
Schist cuttings	0.62 (0.53)	*Pennisetum setaceum* (45.9)	*Heteropogon contortus* (15.1)	*Fingerhuthia africana* (7.5)
Erosion gullies	0.37 (0.28)	*Panicum maximum* (27.8)	*Pennisetum setaceum* (16.7)	*Heteropogon contortus* (16.7)
Overall	0.33 (0.39)	*Heteropogon contortus* (44.3)	*Pennisetum setaceum* (25.2)	*Cenchrus ciliaris* (6.8)

A simple analysis of variance test revealed that the nearest neighbour distances amongst the three habitats were highly significantly different ($P < 0.001$). Mean nearest neighbour distances are shown in Table 2.

Table 3: Number of seed-bearing plants in three different habitats

Habitat	Road verge	Schist cuttings	Erosion gullies	Total
No seeds	178	47	1	226
Seeds	173	112	17	302
Total	351	159	18	528

The observed frequencies of seed bearing plants differed significantly between habitats ($\chi^2 = 30.6$, d.f. = 2, $P < 0.01$), with cuttings and gullies having relatively more seed-bearing plants than road verges, which had less seed-bearing plants than expected.

Discussion

According to Bromilow (1995), Chippendall & Crook (1976), Clayton & Renvoize, (1982), Henderson (1995), Milton *et al*. (1998) and van Oudtshoorn (1992), the favoured habitat for *P. setaceum* is rocky slopes in dry disturbed areas along roads and at excavations. This is consistent with our findings. According to Bromilow (1995), *P. setaceum* and *P. villosum* (Feathertop) are common perennial weeds of roadsides and waste places and once established they become difficult to control. We

found that the plant favoured road verges, where extra moisture is available, but also occurred in relatively xeric conditions (schist cuttings and erosion gullies).

Our results show that *P. setaceum* competes and coexists with relatively mesic grasses such as *Heteropogon contortus*, *Cenchrus ciliaris* and *Panicum maximum*, in different habitats. Road verges are considered valuable road reserves in Namibia, being afforded some protection from overgrazing, as well as receiving extra moisture in the form of run-off from the roads. They are also an important source of seed production. Valuable fodder species such as *H. contortus*, *C. ciliaris*, *Stipagrostis uniplumis*, and *Anthephora pubescens* are often common along road verges. Results show that *P. setaceum* coexists with these species, particularly *H. contortus* (Table 2), which is often the dominant grass next to the road, where it intercepts most runoff. In other habitats such as erosion gullies, *P. setaceum* was found in close proximity with *Panicum maximum*, a very valuable grass species for grazing (Müller 1983), in shaded areas with high soil moisture. In Hawaii, *H. contortus* has been steadily replaced by *P. setaceum*, with a consequent loss of biodiversity (Daehler & Carino 1998). If palatable indigenous grasses in Namibia are replaced by an exotic, unpalatable species this could have an adverse effect on livestock farming. *P.setaceum* is apparently not utilised by domestic stock (Chippendall & Crook 1976; van Oudtshoorn 1992; van Oudtshoorn 1999), due to it's hard, coarse and scabrid leaves. However, at least one farmer has planted it as fodder for horses on his farm in the Witvlei area (W. Adank, *pers. comm.*).

The lack of seedlings found in the study (Table 1) suggests that successful recruitment does not occur every year. During the original survey in 1998, the region had experienced drought for the previous five years, and it is possible that there was not sufficient soil moisture to support germination and recruitment. Although most plants occurred on road verges, most of the seed production seems to occur in schist cuttings and erosion gullies; habitats similar to *P. setaceum*'s preferred habitat of rocky slopes in its natural range. The grass is dominant in some schist cuttings. This is probably due to a lack of competition with other grasses, in particular with *H. contortus*, which prefers the moister conditions of the road verge. It is, however, found very close to (often right next to) plants in the crowded road verges, suggesting that, although it prefers open disturbed areas (Chippendall & Crook 1976), it is able to compete successfully with species in close proximity, when moisture conditions are suitable. Observations suggest that *H. contortus* may be able to displace *P. setaceum* in the absence of disturbance. Large individuals, sometimes with a basal tuft of > 1 m. are, however, unlikely to be displaced. It is possible that species such as *H. contortus* are steadily replacing it on road verges, and that the *P. setaceum* plants on the road verges had established in more disturbed conditions (perhaps during times of road repair), and cohorts of recruits will establish when similar disturbances occur. Further monitoring is required to determine this.

Nursery survey results suggest that the populations have only established within the last 13 years. This is supported by the absence of the plant in a reconnaissance survey

of alien organisms, covering central Namibia in 1984 (Macdonald & Nott 1987). Much of this rapid growth would be due to seed dispersal from the ever-increasing garden populations in Windhoek. It is possible, however, that the plant was misidentified in previous studies, and that unpublished records of its existence prior to 1986 occur.

Our results show that populations are, at present, largely confined to road verges. However, its presence in erosion gullies up to 100 m from the road verges in this study, and its presence in erosion gullies in the Waterberg Plateau National Park, well away from major roads suggest that it may become invasive away from road verges as well. The popularity of this species with farmers is likely to facilitate the dispersal of populations away from major road verges in disturbed rangelands near farm dwellings. Seed are eaten by birds (Chippendall & Crook 1976), and are probably used in nest construction of species such as white-browed sparrow weavers, which are common in the savannas of Namibia. Birds (and possibly ants) may therefore also be important dispersal agents of seeds away from road verges. The reported phenotypic plasticity of this species, which has allowed it to become naturalised in a wide variety of habitats (Williams *et al*. 1995; Milton *et al*. 1998), and its apparent unpalatibility (Chippendall & Crook 1976), support the concern that it may become invasive away from road verges.

The fact that they become difficult to control (Bromilow 1995) would suggest that the status of this grass be checked periodically so as to avoid future problems. Van Oudtshoorn (1999) states that it may well later become a problematic invasive, and Milton *et al*. (1998) have demonstrated that it is already problematic in the western Cape, South Africa.

All of the above suggest that *P. setaceum* is an invasive grass in Namibia, and that its potential for future invasion is high. At present, no legislation restricts the sale of these plants from nurseries and, since it is a popular plant, nursery owners would have to be convinced of its invasive potential before they would consider stopping its sale. Müller (1985) stated that a ban should be placed on the sale of *P. setaceum* and other plant species with a high invasive potential in Namibia. It is essential that monitoring studies be initiated, to confirm its invasive potential. The authors are currently updating its distribution in Namibia. Where this grass invades, it should be eradicated immediately, by, for example hand pulling, whilst this is still feasible. Nurseries should seriously consider the implications of its continued sale. Farmers, and the general public, should be warned of its invasive ability.

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References

BROMILOW, C. 1995. *Problem Plants of South Africa.* Briza Publications, Arcadia, RSA.

CHIPPENDALL, L.K.A. 1955. A guide to the identification of grasses in Southern Africa. In: Meredith, D. (ed.) *The Grasses and Pastures of South Africa*. Central News Agency, Cape Town.

CHIPPENDALL, L.K.A & CROOK, A.O. 1976. *240 grasses of southern Africa.* M.O. Collins, Salisbury.

CLAYTON, W.D. & RENVOIZE, 1982. Graminae (Part III). In: Pohill, R.M. (ed.) *Flora of Tropical East Africa.* Crown Agents, London.

DAEHLER, C.C. & CARINO, D.A. 1998. Recent replacements of native pili grass (*Heteropogon contortus*) by invasive African grasses in the Hawaiian Islands. *Pacific Science* 52(3): 220 - 227

GIBBS RUSSELL, G.E.; WATSON, L.; KOEKEMOER, M.; SMOOK, L.; BARKER, N.P.; ANDERSON, H.M. & DALLWITZ, M.J. 1990. Grasses of Southern Africa. *Mem. Bot. Surv. S. Afr.* 58: 250.

GIESS, W. 1971. A preliminary vegetation map of South West Africa. *Dinteria* 4: 1 – 114.

GROUNDS, R. 1998. *The planters guide to ornamental grasses*. David & Charles Publishers, Newton Abbot, Devon, UK.

HENDERSON, L. 1995. *Plant invaders of southern Africa*. Plant Protection Research Institute Handbook No 5. Agricultural Research Council.

MACDONALD, I.A.W. & NOTT, T.B. 1987. Invasive alien organisms in central SWA/Namibia: Results of a reconnaissance survey conducted in November 1984. *Madoqua* 15 (1): 21 -34

MILTON, S.J.; HOFFMAN, J.H.; BOWIE, R.C.K.; D'AMICO, J.D.; GRIFFITHS, M.; JOUBERT, D.F.; LOEWENTHAL, D.; MOINDE, N.N.; SEYMOUR, C.;

TORAL-GRANDE, M.V. & WISEMAN, R. 1998. Invasive Fountain Grass on the Cape Peninsula. *South African Journal of Science* 94: 57-58.

MÜLLER, M.A.N. 1984. *Grasses of South West Africa/Namibia*. Department of Agriculture and Nature Conservation, Windhoek.

MÜLLER, M.A.N. 1985. Invasive alien plants in the commercial grazing areas, urban areas, diamond areas and Hereroland. In: Brown, C.J.; MacDonald, I.A.W. & Brown, S.E. (ed.) Invasive alien organisms in South West Africa/Namibia. *South African National Scientific Programmes Report* No 119: 1-5.

VAN OUDTSHOORN, F. 1992. *Guide to grasses of South Africa.* Briza Publications, Arcadia, RSA.

VAN OUDTSHOORN, F. 1999. *Guide to grasses of southern Africa.* Briza Publications, Arcadia, RSA.

WILLIAMS, D.G.; MACK, R.N. & BLACK, R.A. 1995. Ecophysiology of introduced *Pennisetum setaceum* on Hawaii: the role of phenotypic plasticity. *Ecology* 76: 1569-1580.