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Uninvited guests: how some weeds of arid Australia arrived as stowaways and became widespread

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Abstract: In the 19th and 20th centuries, numerous plant species were deliberately introduced into Australia for use in crops, pastures, gardens and horticulture, while others arrived by chance. Many subsequently escaped and became weedy. Of the 54 weed species of natural environments of arid and semi-arid Australia that are considered here, 22 were intentionally introduced, 24 were accidentally introduced and eight were probably introduced both accidentally and intentionally. Recent new introductions are few, due to pre-border, border and post-border protections, but many current arid zone weeds continue to spread.

Introduction

Introduced plants were recorded in Australia very soon after European settlement, when Governor King provided Lord Hobart with 'Lists of Plants in the Colony of New South Wales that are not Indigenous' (King 1803). The species included many types of grains, vegetables, fruits and ornamentals. In amongst them were species that escaped and became weedy, and some eventually established far afield in arid and semi-arid (hereafter simply 'arid') Australia (Parsons and Cuthbertson 2001). Since settlement, over 27,000 plant species have been imported into Australia and about 10% have become established in the environment (Groves *et al.* 2005). Of these, over 400 are now part of the arid flora (JK Scott, MH Friedel, AC Grice and BL Webber (unpublished ms)).

In this paper I investigate the complex history of plant invasions in arid Australia, and provide evidence for the means of arrival for 54 invasive alien species that impact on natural environments.

Methods

The number of truly invasive alien species of more than local impact in arid Australia is debatable. The species presented here were identified from several sources: JK Scott *et al.* (unpublished ms), Buckley (1981), NT Weed Management Branch (unpublished) and advice from reviewers. No attempt is made here to define 'impact' or determine whether the term is used consistently amongst the sources.

To identify vectors and actual or potential points of entry into Australia, I undertook extensive web-based searches of grey literature, such as Lucid, as well as searches of published articles and books, including those listed in the References. Distributions of species within Australia and dates of early records were identified from Australasia's Virtual Herbarium (AVH) and Atlas of Living Australia (ALA), the latter including some records not accessible through AVH. Parsons and Cuthbertson (2001) was also an important source of some early records.

History of weed invasions

In total 54 species were investigated, of which 22 were intentionally introduced, 24 were accidentally introduced and eight were probably introduced both accidentally and intentionally (Table 1). While the focus of this paper is the 'uninvited guests', all are included here to enable readers to consider if these are correctly categorised. New information is welcome!

Early unintentional introductions often occurred as contaminants of seeds and grain, and some species were recorded very soon after European settlement. *Sonchus oleraceus* was first reported in WA in 1838, *Argemone ochroleuca* was recorded near Sydney in 1844, and *Conyza bonariensis* was recorded near Port Stephens in the 1840s. *Carthamus lanatus* was an accidental introduction at Sydney Cove, but may have been mistaken for the valuable dye-producing safflower. *Xanthium occidentale* came with cotton seed in the 1860s, non-native *Tribulus terrestris* arrived as a contaminant of seed pre-1896, while *Parthenium hysterophorus* was possibly introduced through contaminated machinery during WW2, or was a 1958 introduction via seed.

Table 1. Invasive species of arid Australia, with date and location of first reported occurrence

Accidental or presumed accidental introduction	
<i>Acetosa vesicaria</i> (1892 Perth WA) ¹	<i>Eragrostis minor</i> (1907 Rockhampton Qld) ¹
<i>Aerva javanica</i> (1937 De Grey River WA) ¹	<i>Eragrostis trichophora</i> ; also known as <i>E. cylindriflora</i> (1971 Alice Springs NT) ¹
<i>Alternanthera pungens</i> (1898 'NSW') ²	<i>Neurada procumbens</i> (2000 150 km SE Alice Springs NT) ¹
<i>Argemone ochroeluca</i> (1844 Sydney NSW) ²	<i>Parthenium hysterophorus</i> (1950 Toogoolawah nr Brisbane Qld) ¹
<i>Calotropis procera</i> (1935 Mungana Qld) ¹	<i>Senna occidentalis</i> (1883 Cooktown Qld) ¹
<i>Carrichtera annua</i> (~1913 nr Port Pirie SA) ³	<i>Sonchus oleraceus</i> (1838 Fremantle WA) ¹
<i>Carthamus lanatus</i> (1803 Colony of NSW) ⁴	<i>Tribulus terrestris</i> (non-native) (1853 Murray River Vic/NSW) ¹
<i>Cenchrus echinatus</i> (1860s Qld gold rushes?) ²	<i>Vachellia farnesiana</i> (pre-1788) ⁵
<i>Citrullus colocynthis</i> (1923 Townsville Qld) ¹	<i>Xanthium occidentale</i> (1860s nr Brisbane Qld) ²
<i>Citrullus lanatus</i> (1836 Kangaroo Is SA) ²	<i>Xanthium spinosum</i> (1830s Nepean River NSW) ²
<i>Conyza bonariensis</i> (1842 Telligerry Swamp NSW) ¹	
<i>Cucumis myriocarpus</i> (1851 Torrens River SA) ¹	
<i>Eragrostis barrelieri</i> (1883 Beltana-Lyndhurst SA) ¹	
<i>Eragrostis cilianensis</i> (1885 Manly NSW) ¹	
Accidental or presumed accidental, and intentional, introduction	
<i>Cenchrus ciliaris</i> (1897 Wyndham WA) ¹	<i>Cynodon dactylon</i> (pre-1788) ⁶
<i>Cenchrus pennisetiformis</i> (1915 Geraldton-Greenough WA) ¹	<i>Dichanthium annulatum</i> (1856 Depot Creek, head of Victoria River NT) ¹
<i>Cenchrus setaceus</i> (1903 Eurelia SA) ¹	<i>Nicotiana glauca</i> (1850 Torrens River SA) ¹
<i>Chloris virgata</i> (1875 nr Alice Springs NT) ¹	<i>Vachellia nilotica</i> (1874 Nickol Bay WA) ¹
Intentional introduction	
<i>Arundo donax</i> (1894 Gosford NSW) ¹	<i>Phoenix dactylifera</i> (1890 Pilbara, WA) ⁹
<i>Asphodelus fistulosus</i> (1857 Melbourne Botanical Gardens Vic) ²	Mesquites
<i>Cenchrus setigera</i> (1920s Munda(bullangana) Station, W of Port Hedland WA) ⁷	<i>Prosopis glandulosa</i> (1935 nr Toowoomba) ¹
Cactaceae examples	<i>P. juliflora</i> (1899 Sydney Botanic Gardens, NSW) ¹
<i>Cylindropuntia fulgida</i> (1984 Radium Hill and Parachilna Hotel SA) ¹	<i>P. pallida</i> (1936 De Grey Station WA) ¹
<i>Cylindropuntia imbricata</i> (1934 Quirindi NSW) ¹	<i>P. velutina</i> (1899 Sydney Botanic Gardens, NSW) ¹
<i>Opuntia aurantiaca</i> (1883 NSW) ²	<i>Ricinus communis</i> (1803 Colony of NSW, as 'Palma Christi') ^{2,4}
<i>Opuntia stricta</i> (pre-1839 Parramatta NSW) ²	<i>Solanum nigrum</i> (1847 Flinders Island) ¹
<i>Emex australis</i> (1830 WA, from Cape Colony) ²	<i>Sorghum almum</i> (1953 Rockhampton Downs NT) ¹
<i>Melinis repens</i> (1870s Brisbane Qld) ⁸	<i>Tamarix aphylla</i> (1930s Whyalla and Broken Hill) ²
<i>Orbea variegata</i> (1967 Whyalla SA) ¹	<i>Ziziphus mauritania</i> (1842 North Adelaide garden, as Chinese jujube) ^{2,10}
<i>Parkinsonia aculeata</i> (1894 Melbourne Botanical Gardens, Vic) ¹	
<i>Passiflora foetida</i> (1875 'In gardens of Queensland') ¹	

¹Australasia's Virtual Herbarium and Atlas of Living Australia, ²Parsons and Cuthbertson (2001), ³Quinn and Andrew (1915), ⁴King (1803), ⁵Natural Resources Commission of NSW (2013), ⁶<https://keyserver.lucidcentral.org/weeds/data/media/Html/>, ⁷Hardie (1981), ⁸Macpherson (1894), ⁹Keighery (2010), ¹⁰McEwen (1842)

Weed species were also transported in packaging and hay: *Carrichtera annua* established from abandoned packing material on a Port Pirie roadside in 1935. *Cenchrus setaceus* may have come in hay, as it was first collected in a farming community east of Port Augusta in 1903. Livestock also carried weeds. *Alternanthera pungens* arrived on horses returning from the Boer War, *Xanthium spinosum* is alleged to have arrived on the tails of horses from Chile in the 19th century and *Cucumis myriocarpus* probably piggy-backed on sheep and cattle arriving with the earliest Fleets, travelling via

Cape Town. Several *Eragrostis* species, *cilianensis*, *minor* and *trichophora/cylindroflora*, were also potential contaminants of livestock, produce or fodder, as were *Nicotiana glauca*, first recorded in 1850 at the Torrens River and *Senna occidentalis*, first recorded in 1883 in Cooktown.

Camel harness was almost certainly the source of a number of species known to occur in the homelands of the cameleers. From the 1860s camels were brought into SA via Port Augusta to service communities, pastoral properties and mines in SA, NT, NSW and Queensland. From the 1880s, camels were imported via Fremantle predominantly, and other coastal ports, to service WA. *Acetosa vesicaria* was first recorded near Perth in 1892, and subsequently on camel routes throughout the interior. *Cenchrus ciliaris* was first found in the Kimberley by the Roebourne mining warden in 1887 and then south of Wyndham in 1897 at the Ord River crossing, on the route to the Hall's Creek mines. It too was subsequently found on many inland camel routes. *Cenchrus pennisetiformis*, supposedly introduced by General Birdwood after WWI, was collected in 1915 in the Geraldton-Greenough area, a location for camel importation. *Aerva javanica* was introduced into north-western WA in the 1880s, and was collected from Anna Plains for use in reclamation of the Ord River region in the 1960s. It was understood to have come from camel harness, and is known to have been used in the Middle East for cushion and saddle padding. *Calotropis procera*, also used for padding, was first reported near Mungana, north Queensland, where camels serviced the railhead around 1900 for the copper mines. Early records from the 1880s of *Eragrostis barrelieri* are strongly associated with camel routes in SA and NT; records for *Chloris virgata* in the NT from the 1870s and near Tibooburra in the 1900s also correlate with camel routes. And of course the date palm (*Phoenix dactylifera*) was planted by cameleers at many camp sites.

Citrullus lanatus, first recorded on Kangaroo Island in 1836, may have come with the sealers and whalers, *Cenchrus echinatus* may have been introduced to Queensland during the 1860s gold rushes, and *Neurada procumbens*, recorded in 2000, may have come on tourist footwear. How *Citrullus colocynthus* arrived is unknown.

Cynodon dactylon, *Vachellia farnesiana* and *Dichanthium annulatum* were established prior to European settlement and also deliberately introduced subsequently for specific purposes, such as fodder and turf. Arguably, these could have been introduced by maritime traders and explorers, who frequented the Indonesian and west Pacific areas for over 3000 years (Bean 2007).

Recent new introductions are few, due to pre-border, border and post-border protections, but many current arid zone weeds continue to spread, via wind and water, people, vehicles, livestock, transport corridors and wildlife. Interestingly the expanding distribution in remote arid Australia of *Cenchrus ciliaris* is likely to be enhanced through seed spread by camels, whose harnesses first brought it to Australia.

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