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Agricultural introductions as a source of weeds: what have we missed?

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Introduction

Grice (2008) raised the issue of commercial weeds: those plants that have a real or perceived commercial value but which also impose a cost through their invasive potential. In this paper, I argue that, although it is recognized that most naturalized plants in Australia were deliberate introductions, there is widespread ignorance about the perceptions of commercial value that lead to their introduction. Such ignorance is likely to lead to insufficient weighting being given to the threats posed by trials of potential new crop and pasture species and varieties. In this paper, I provide case studies of several taxa for which good records exist of their introduction for potential commercial agricultural production, but for which recent literature appears ignorant of the history of their perceived value and deliberate introductions.

Recent weeds literature has focused on the potential for ornamental plants to become weeds because the gardening industry is has been the source for the introduction of 25 360 or 94% of new plant species into Australia (Randall 2001, Mack and Erneberg 2002, Groves *et al*. 2005). However, as shown by Cook and Dias (2006) many of the so-called garden plants, and especially those in the families Poaceae (grasses) and Fabaceae (legumes), were also introduced by agriculturalists for various purposes. For grasses and legumes, the approximately 2200 species in each family that were introduced under the Commonwealth Plant Introduction (CPI) scheme comprised nearly twice as many species in those families as occur naturally on the whole continent. Of the grass species introduced under CPI, about 10% are naturalized, although sources other than the CPI scheme may have contributed to the extant populations.

In this paper, I provide case studies for five genera containing plants that are either noxious weeds or Weeds of National Significance: *Eragrostis*, *Mimosa*, *Nassella*, *Sporobolus* and *Parkinsonia*. I show how contemporary weeds literature has overlooked evidence that their utility for forage or soil conservation was viewed favourably in the past and that agriculturalists were responsible for at least some of the material that has been naturalized. I do this not to attribute blame but as a basis for arguing that a sound understanding of the origin of weedy species is critical to the development and implementation of policy and plans for their control.

Case studies

Eragrostis

Eragrostis curvula is one of about 54 species of *Eragrostis* introduced to Australia under the Commonwealth Plant Introduction scheme as a potential pasture grass. Due to the low palatability of many of its strains, this species is now a declared noxious weed in Western Australia, South Australia, Victoria, New South Wales and Tasmania. Parsons and Cuthbertson (1992) describe it as having been 'imported for experimental assessment several times since' 1900. In their 2001 revision (Parsons and Cuthbertson 2001), they describe the origin as:

'this grass was probably first introduced to Australia by accident as a contaminant of pasture seed. Different cultivars of this grass have also been used as a soil stabilizer in erosion control situations.'

These descriptions completely fail to capture the extent of the effort to trial and promote this species. In fact, 164 accessions were deliberately introduced, and one line, 'Consol' is a registered herbage plant cultivar (Anon 1982). Between 1910 and 1966 trials were conducted at 24 sites across Australia (Leigh and Davidson 1968). A paper proposing to continue evaluating *E. curvula* for soil conservation purposes in New South Wales was published just after the plant was declared a noxious weed in several shires of that state (Johnston and Aveyard 1977). The registration of cultivar Consol in 1982 mentioned that the unacceptability to livestock of some naturalized forms of the species was causing some concern, but did not state that the species was declared noxious in certain areas five years earlier (Anon 1982). An authoritative review of *E. curvula* published in 1990 by the Food and Agriculture Organization of the United Nations and co-authored by Queensland pasture agronomist P.J. Skerman made no mention of its noxious weed status but rather concluded that the grass 'establishes easily, persists well under grazing…, [is] valuable in erosion control [and has] good palatability' (Skerman and Riveros 1990). A recently published list of the strengths and weaknesses of this species in an interactive CD on forages (Cook

et al. 2005) fails to do justice to the plant's noxious weed status in Australia:

'Strengths: Grows on low-fertility soils; establishes easily; good cold tolerance; valuable in erosion control; drought-hardy; long growing season.

Limitations: Not adapted to heavy clays; nutritive value declines rapidly; can become a weed; intolerant of waterlogging.'

Although the report does comment that *E. curvula* has become a weed, this is just one comment in amongst substantial praise for the species. The appraisal of its value as a forage species gives no advice on reconciling the weedy and forage values.

Mimosa spp.

In Australia, *Mimosa pigra* is a Weed of National Significance, and is highly invasive spiny shrub in tropical wetlands while *M. pudica* and *M. diplotica* (formerly *M. invisa*) are low growing declared noxious weeds in northern Australia.

Mimosa rubricaulis was recorded as an introduced plant growing in Darwin Botanic Gardens in the late 1800s (Holtze 1891). Miller and Lonsdale (1987) argued convincingly that this plant was actually *M. pigra,* but then went on to argue that it 'may have been introduced purposely to Darwin for botanical interest, as a novelty … or … as a contaminant in other seed.' They did not consider the possibility that Holtze viewed the plant favourably as potential forage. Elsewhere, the origin of *M. invisa* (*M. diploticha* C.Wright ex Sauvalle) has been ascribed to contaminated seed (Parsons and Cuthbertson 2001, Smith 2002), and *M. pudica* to ornamental horticulture (Parsons and Cuthbertson 2001, Paynter *et al*. 2003; Smith 2002). Randall (2001) lists *M. pudica* and *M. pigra* as garden plants, presumably on the basis that both were grown in the Palmerston (Darwin) Botanic Garden.

In contrast to this speculation about the garden and contaminant origin of these species, substantial literature exists about the agricultural potential of *Mimosa* spp. and their introduction for agricultural purposes.

Experience of *M. invisa* as a green manure crop in rotational cropping systems led to 'intensive propaganda' for the widespread use of this species in the tropics – a campaign which was reported to have had considerable success during the 1930s (Anon 1936). Its first appearance in Queensland was reported to be at Tully, Queensland in 1929, when many green manure crops were being trialled. Whyte *et al.* (1953) listed it as a green manure species, and it was recorded as a promising plant introduction at Kununurra, albeit with hesitation about the thorny varieties (Christian *et al.* 1958). *Mimosa pudica* was recorded as being of high fodder value in Queensland in the 1930s (Anon 1936) and is listed as a pasture species (Whyte *et al.* 1953). *M. bracatinga* (sic) is also listed as a useful grazing species (Wheeler and Hill 1990) and *M. pigra* was listed as a tropical forage legume held by the Australian Tropical Forage Genetic Resources Centre (Strickland *et al*. 1987).

The records of introductions of *Mimosa* species for pasture investigations by CSIRO, Queensland Department of Primary Industries, and New South Wales Department of Agriculture include *Mimosa* spp. (26 accessions 1931–81), *Mimosa caesalpiinifolia* Benth. (4 accessions 1946–1966), *Mimosa incana* (sic 1 accession 1948), *Mimosa invisa* (*M. diplotricha* Sauvalle: 12 accessions 1931–61), *M. martindelcampoi* Gonz. Medr. (1 accession 1980), *M. pudica* L. (4 accessions), *M. scabrella* Bent. (2 accessions 1937–1983) and *M. uruguayensis* Hook. & Arn. (1 accession 1983).

The speculation about the origin of *M. invisa* and *M. pudica* in the weeds literature is completely at variance with the statements in the plant introduction and pastoral literature. This raises questions about the speculation by Miller and Lonsdale (1987) about the origin of *M. pigra* in Australia as a botanical curiosity, novelty or contaminant. We know that both *M. rubricaulis* (*M. pigra?*) and *M. pudica* were being grown in the Palmerston Botanic Garden in 1892, and that Mueller recorded the former species being grown in the Melbourne Botanic Gardens in 1881 (Mueller 1881) and Bailey the latter species in Bowen Park and the Brisbane Botanic Gardens in 1885 (Mueller 1881, Bailey 1885, Holtze 1891). Holtze's 1887 list of useful plants in the garden specifically excluded fodder species, so we can assume that any plant absent from that list was either not being grown in the garden at the time, or was considered by Holtze to be a fodder plant (Holtze 1887, 1888). Since Holtze was a strong advocate for introduced pasture species and was a correspondent with both Bailey and Mueller (Holtze 1901), it is highly likely that both species of *Mimosa* were being grown in Darwin probably at least from the early 1880s and their absence from his 1887 list therefore indicates that Holtze considered them both to be fodder species. Such a view of the fodder value of the genus would be consistent with those of many pasture agronomists throughout the 20th century.

Thus *Mimosa* species have been widely touted as pasture and green manure crops in plant introduction and pasture literature and yet unsubstantiated views that accident, contamination, illegal importation and ornamental horticulture contributed to their presence in Australia are widely held in the weeds literature.

Parkinsonia aculeata

Parkinsonia aculeata is a spiny shrub to 8 m tall which invades a wide range of habitats in northern Australia.

Randall (2001) described *Parkinsonia aculeata* as a garden plant, and indeed it is described in a recent gardening book as having 'clusters of yellow flowers in spring', with no mention of its noxious weed status (Cundall 2003). It was being grown in Brisbane in the 1880s (Bailey 1885). Parsons and Cuthbertson (2001) similarly ascribe its origin in Australia to ornamental or amenity planting, overlooking the many descriptions of its use for forage and soil conservation (Ratcliffe 1936, Hall *et al*. 1972, Skerman 1977). Although the four CPI accessions date from 1959–1972, its perceived value for soil conservation dates at least from the 1930s (Ratcliffe 1936).

Sporobolus spp.

The weedy *Sporobolus* grasses consist of a number of species of invasive grasses with low palatability. They are claimed in recent weeds literature to have originated through unknown or accidental means or as contaminants (Smith 2002, Grice 2004). In contrast, *Sporobolus indicus* was recorded as being planted and given positive appraisals as a pasture species in Queensland, NSW and New Zealand in the late 1800s and early 1900s (Bailey 1885, Duthie 1888, Turner 1892, Hilgendorf 1918, Levy 1928). *Sporobolus pyramidalis* was trialled for soil conservation in Victoria (Zallar 1981) and was said to show promise during trials in New South Wales (Leigh and Mulham 1964).

Levy's (1928) article on *Sporobolus indicus* (ratstail grass) in New Zealand demonstrates the difficulty of reaching agreement on the weedy status of many species. Commenting on the positive appraisal of ratstail grass by some graziers, he wrote 'It is not for me or any one else in New Zealand to gainsay the opinions of these men [of high standing in pastoral NZ] for such opinions are based on the practical experience of a long lifetime, and come from a stock of wonderful general and specific knowledge of practically all pasture plants with which ratstail may be compared.' The general application of this logic would allow the introduction and sowing of any species providing someone thought well of it, regardless of the negative sentiments of others. In describing the approach to pasture plant introductions under the CPI scheme, Williams (1965) stated that 'The majority of introductions which appear to have the remotest chance of being useful in any part of northern Australia are maintained either as living collections or in seed stocks.' Clearly this approach allowed great potential for the introduction of plants whose undesirable traits were not apparent, which affected

stakeholders other than graziers, or for which there were a wide diversity of views.

Nassella spp.

A number of exotic stipoid grasses in the genera *Nassella*, *Jarava*, *Acnatherum* and *Piptochaetum* are considered weeds due to their invasiveness and low palatability.

Recent literature on weedy stipoid grasses has largely failed to acknowledge the extent of deliberate introductions and subsequent trials of this group in southern Australia for pasture, fibre and soil conservation purposes. While Prof. Bernado Rosengurtt's 1970 publication on grasses of Uruguay has been cited as authoritative information on the natural distribution of the weedy stipoid grasses in recent weeds literature (McLaren *et al.* 1998), his role in the presence of these grasses in Australia is less well known. Largely through Rosengurtt's efforts, Uruaguay's botanic garden specialized in the collection and supply of pasture grasses and legumes (Howard *et al.* 1963). Some of the earliest recorded deliberate importations of *Nassella* species into Australia were in response to Rossengurtt's publication in 1945 of lists of pasture species for which seed was available for exchange (Rosengurtt 1945a, b). These lists included *N. bavioensis*, *N. charruana*, *N. hyalina*, *N. megapotamica*, *N. neesiana*, *N. rosengurrttii*, and *N. trichotoma*. From these lists, CSIR (now CSIRO) imported all species of *Nassella* except the latter two. Five species of the related genus *Piptochaetum* were also imported. Two years later, Rosengurrtt assisted one of the first Australian plant collecting expeditions to South America, which added *N. rosengurrttii* to the list of introductions (Hartley 1948). It is quite possible that some of the early records of *Nassella* spp. in Australia originated from correspondence and seed exchange with Rosengurrtt by other Australian government agencies. Bailey's expedition to Chile in 1958–59 added further to the collection of stipoid grasses, including eight accessions of *Nassella chilensis* which he said were 'undoubtedly drought resistant and should be tested with care in the very dry areas – possibly the mulga country' (Bailey 1961). He also wrote that *N. hyalina* was reputed to have some forage value. McLaren *et al.* (1998) noted that the stipoid grasses *Jarava plumosa*, *Nassella megapotamia*, and *N. neesiana* were trialled as pasture species, but they appear to have been unaware of the trials of *N. hyalina*, *Achnatherum brachychaetum*, *N. rosengurrttii* and *N. chilensis* (Cuthbertson *et al.* 1955, Cameron 1959, Buckley 1960, Costin and Wimbush 1963, Anon. 1964, Leigh and Mulham 1964, Zallar 1981). Other stipoid species were also trialled at Crooble near Moree in NSW (Anon. 1951). *N. hyalina* was said to be complementary to subterranean clover, although its seed characteristics were seen as a liability (Anon. 1962). Its ability to spread and regenerate was seen as an asset (Cuthbertson *et al.* 1955).

The failure of CSIR to import *N. trichotoma* from Uruguay in 1945 was probably the result of description of that species as a weed as soon as it was identified in Australia (Cross 1937). In contrast, the first record in New Zealand makes no mention of the plant as a weed (Allan 1936), but rather refers to its graceful habit, a feature still noted in gardening literature (Cundall 2003). Even in Cross's 1937 paper, the occurrence of a grass that was also a weed was seen as a novelty because grasses were not commonly seen as being weeds at the time. In all likelihood, had he not made such a vigorous case against *N. trichotoma*, it also would have been imported in 1945 and trialled as a forage based on Rosengurtt's advice.

Discussion

Puth and Post (2005) argue that the initial dispersal has been neglected in the study of invasive species. The CPI scheme, which was just one of the agricultural plant introduction schemes operating during the 20th century in Australia, alone was responsible for the introduction of 145 000 accessions of more than 8200 species over about 80 years (Cook and Dias 2006). During just two decades (1980s and 1990s) in Queensland, over 2000 introduced pasture plants were evaluated at over 100 sites (Bishop 2003). Understanding this initial dispersal is critical to effective management of the plants already introduced to Australia. The potential for sleeper weeds (Groves 2006) to be persisting in plant introduction trials documented, if at all mainly in grey literature must be vast.

By ascribing the origin of so many invasive plants to accident, contamination or ornamental horticulture, weed scientists are downplaying the potential of agricultural trial sites as nascent foci (*sensu* Moody and Mack 1988). Ignorance of this history has led to studies of the genetics of *Nassella neesiana* in Australia (Britt *et al.* 2002) and of *Bromus tectorum* in the USA (Novak and Mack 2001) to be conducted without reference to the records of deliberate introductions of these species by government agencies in the two countries. This is likely to lead to flawed conclusions about the origin and spread of invasive species.

Apart from the Commonwealth Plant Introduction Scheme, and some of the efforts of the Acclimatisation Societies (Cook and Dias 2006), these introductions are poorly documented. Plants were trialled across the country, and many are likely to still be there until climatic and other conditions favour their spread. The historic records and archives of universities, state agencies and industry peak bodies should provide a fruitful method of locating potential sources of future weeds. Stopping importation of potential weeds is clearly important, but for many species, they are probably already here in multiple accessions, and at multiple sites.

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