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SHORT COMMUNICATION

The deliberate introduction to Australia of the shrub genus *Pentzia* (Asteraceae) and its subsequent persistence and spread

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***Abstract*:** *Pentzia* is a predominantly southern African genus of low shrubs, many of which are important fodder plants for sheep in semi-arid and arid areas. Attempts since 1869 to introduce *Pentzia incana* to south-eastern Australia for sheep fodder are described. One of these, near Koonamore in north-eastern South Australia, was temporarily successful there and may have led to the only extant stands in Australia – two well-established populations at Mount Serle in the northern Flinders Ranges. These events are related to the biology of the species and to similar events concerning the deliberate introduction of the species to Arizona. These data are discussed in terms of current ideas about plant introduction, dispersal, invasion and the concept of sleeper weeds.

Pentzia globosa is currently known from a single stand in Australia, at Bundaleer Forest in the Mid North of South Australia. The history of this occurrence is briefly discussed.

For both species, it is concluded that regular monitoring is needed in case of rapid spread and that further data are needed on the extent to which they exhibit weedy behaviour in southern Africa.

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Introduction

The genus *Pentzia* (Asteraceae) comprises ± 27 species of highly aromatic low shrubs mostly native to southern Africa but with three species in North Africa and one in Yemen. Many are important fodder plants in arid areas, especially for sheep (Magee & Tilney 2012).

The species of *Pentzia* introduced to Australia are *Pentzia globosa* Less. and *Pentzia incana* (Thunb.) Kuntze (in both cases introduced to New South Wales and South Australia; Thompson 2007); the latter species at least is an important forage plant for sheep in winter rainfall areas of southern Africa (Milton *et al*. 1999). In the late 1920s and early 1930s in an arid part of South Australia, *Pentzia incana* was part of an unusual and neglected project to introduce exotic perennial plants to areas where overgrazing by stock had eliminated the native vegetation, so that such areas could be revegetated and soil drifting prevented (Ratcliffe 1936).

The aim of the present paper is to relate what is known of this project, to describe the subsequent spread of *Pentzia*

incana in Australia and to examine what contribution the story makes to current ideas about plant introduction, dispersal and invasion. Remarkably, at much the same time as the Australian project and for the same reasons, the US Soil Conservation Service introduced *Pentzia incana* to sites in Arizona from which it subsequently spread (Keil 2006). These events are also described. Finally, the history of *Pentzia globosa* in Australia is briefly related.

The Species

Both *Pentzia incana* and *Pentzia globosa* are low, compact shrubs to 60cm high with small leaves to 15mm long and yellow corollas. In *Pentzia incana* (Fig. 1), the younger stems and leaves are white- to grey-tomentose, so the leaves are greyish, while in *Pentzia globosa* the leaves are ± glabrous and so are green. The pappus is a corona c.1mm long in *Pentzia incana* and 0.3mm long in *Pentzia globosa*. The fruits of *Pentzia incana* secrete mucilage when wetted (Thompson 2007, Magee & Tilney 2012); this is true of the whole genus (Oberprieler *et al*. 2007). *Pentzia incana* is known both as Karoo Bush (Ratcliffe 1936) and African Sheep Bush (Thompson 2007). In South Africa, *Pentzia incana* has been described as a palatable generalist (Pienaar *et al*. 2004). Overgrazing by stock leads to it, and other karoo shrubs, replacing native grassland over wide areas (Darkoh 2001).

The approximate mean annual rainfall ranges in South Africa are 160–260mm for *Pentzia globosa* and 170–260mm for *Pentzia incana* (Palmer & Hoffman 1997). *Pentzia incana* flowers opportunistically in response to rainfall and can root where branches touch the soil, leading to clonal spread (Esler 1999).

In the 1920s and 1930s, it was common to treat *Pentzia incana* as one of a drought-adapted growth form called ‘tomentose microphylls’, being shrubs having shoots covered with a dense tomentum and with small leaves. The group includes other composites like *Artemisia* spp. (the sagebrushes) of North America, North Africa etc. but also the chenopods *Atriplex, Einadia, Maireana* and *Rhagodia* (Wood 1924, Trumble 1932).

Pentzia globosa has been listed as a weed in South Africa, while *Pentzia incana* has been listed as a weed both there and in Australia and USA (Randall 2002).

Fig. 1. *Pentzia incana* near Mount Serle homestead, northern Flinders Ranges, 20 April 2012.

The Early Records of *Pentzia incana* in Australia

In about 1869, the Adelaide Botanic Garden received seeds of *Pentzia incana* (as '*Pentia virgata'*) from Dr. Hooker of the Royal Botanic Gardens, Kew (Schomburgk 1872, Kloot 1986). The species was thought to be 'a most valuable sheep fodder' and the plants grew vigorously in Adelaide for at least two years without being watered. In 1871, plants propagated from cuttings were offered to landholders (Schomburgk 1872). A few plants were being grown in the Murray Mallee near Lyrup in 1897 (Anonymous 1897) and near Port Lincoln in 1900 where it was considered 'much too slow of growth to be profitable' (Anonymous 1900).

There are two further records in the period before the trial introduction in 1930; an 1885 record without details from the Queensland nursery trade (Ingram 2008) and a single collection from Nyngan in central west New South Wales in November 1913 (J.H. Maiden s.n. NSW; see Thompson 2007).

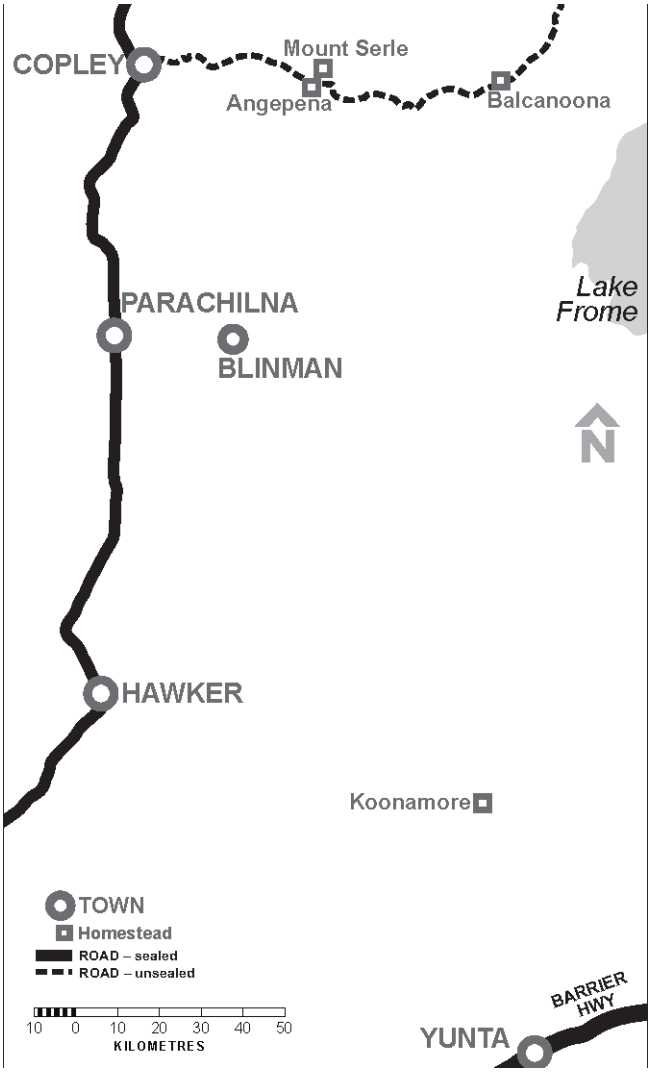

Fig. 2. Part of north-eastern South Australia showing the location of the main place names mentioned in the text.

Later in this paper, the possible spread of *Pentzia incana* from its 1930 introduction site will be discussed. Given the foregoing, the possibility must be kept in mind that some populations may have resulted from planting by landholders rather than unassisted seed dispersal from the 1930 introduction site.

The Introduction Trial of *Pentzia incana* in South Australia

In 1912 T.G.B. Osborn was appointed first professor of botany at the University of Adelaide. By the 1920s, he became concerned about widespread overgrazing and soil erosion in the arid-zone (Robertson 1988) and in 1925 established the Koonamore Vegetation Reserve, now called the TGB Osborn Vegetation Reserve (OVR), to study recovery of overgrazed arid-zone vegetation (Sinclair 2005).

In 1927, Osborn co-opted T.B. Paltridge and J.G. Wood to establish experimental plots at OVR (Specht 2002); one experiment was a seed sowing trial to test whether certain exotic species could be established in that part of the arid zone (Ratcliffe 1936, Table 1). By that time, Wood was fully aware that *Pentzia incana* was important and dominant in similar climates in the Upper Karoo, South Africa (Wood 1924); it was included in the trial (Ratcliffe 1936).

Of the five species listed as included in the trial (Table 1), *Pentzia incana* is the only one known to have flowered, set seed and produced a second crop of seedlings (Ratcliffe 1936). The only other details known are that the *Pentzia incana* seeds were sown into boxes on 16 July 1930, transplanted on 22 October 1930 (University of Adelaide Archives 1930) and that all plants died during drought in early 1934 (Ratcliffe 1936).

After that, nothing is known of *Pentzia incana* at OVR until, in August 1971, M.D.Crisp found a single plant just outside the 'plant introduction quadrat' at OVR (CBG; Crisp 307). This or a nearby plant was re-collected in October 1973 (AD; Crisp 656; Crisp pers. comm.). While *Pentzia incana* has not been the subject of a general, systematic search, the area in and around the OVR plant introduction plot has been inspected annually since 1980 without it being found (R. Sinclair pers. comm.).

Aside from the records from OVR, since the 1930s there are only two areas in Australia where *Pentzia incana* has been recorded as naturalized, both in the northern Flinders Ranges (Fig. 2). Firstly, in November 1964, *Pentzia incana* was collected near Angepena homestead (AD; Lothian 3242). I searched the location without success on 20 April 2012. Secondly, *Pentzia incana* was collected a few km away from this site near Mount Serle homestead in April 1977 (AD; Williams 9258) from where it was re-collected in November 1989 (NSW; Nordenstam 996). Then, in December 2011, a large stand was found about one km from the site of the 1977 record (AD; Brewer 646). Brewer recorded about 300 plants there, but, in April 2012, with more time for searching, I estimated at least 1000 plants over an area of 40m x 150m.

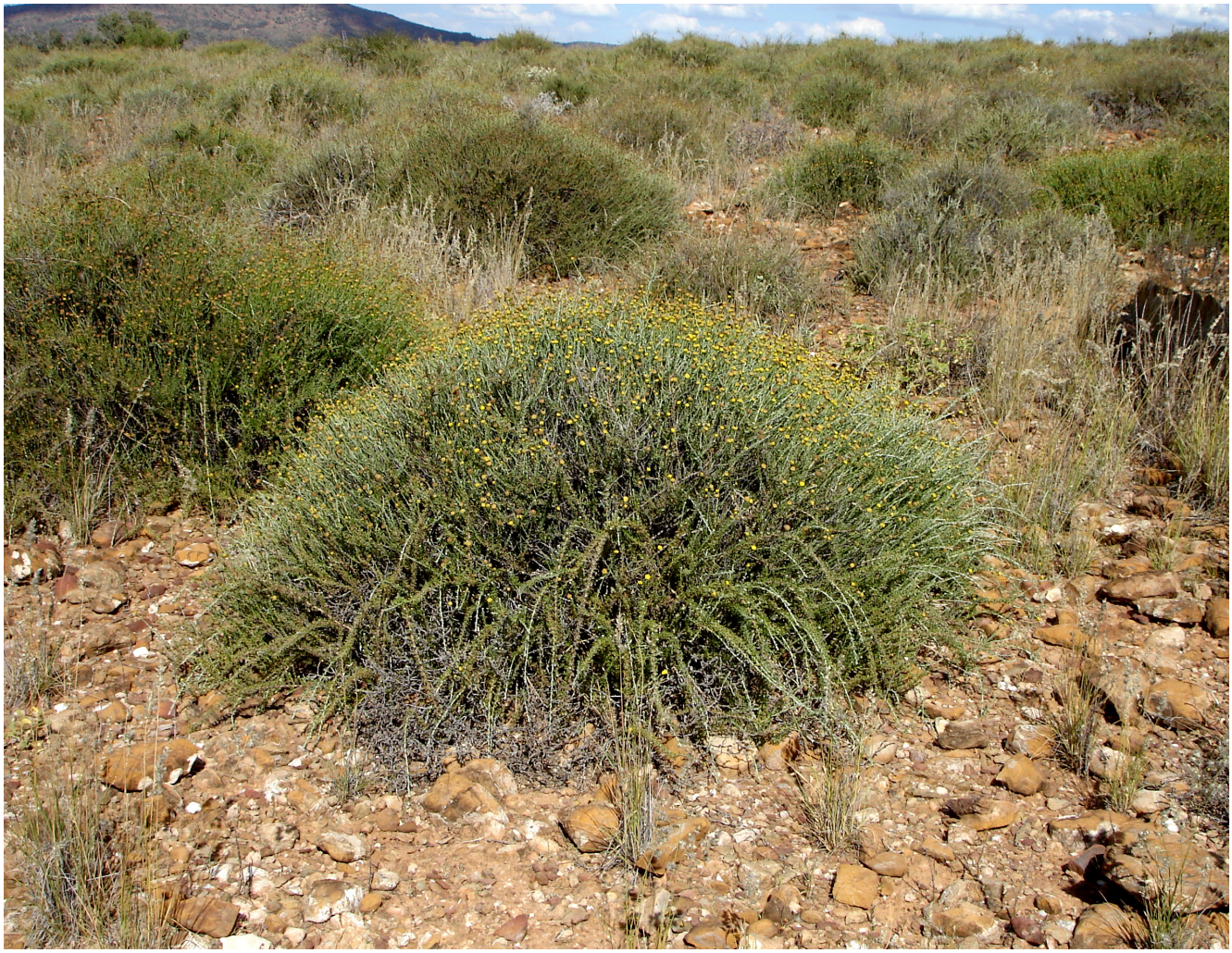

Fig. 3. Low shrubland dominated by *Pentzia incana* up to 40 cm high on stony soils near Mount Serle homestead, 20 April 2012.

Table 1. The results of sowing seeds of exotic perennial plants at OVR; most or all trials held in 1930.

Family/species	Common name	Origin	Result of seed sowing	Reference
Asteraceae				
Parthenium argentatum L.	Guayule	N. America	Seed germinated. Seedling fate unknown	Archives*
Pentzia incana (Thunb.) Kuntze (as *Pentzia virgata*)	African sheep bush	S. Africa	Seed germinated. Seedlings matured. One crop of seed produced	Ratcliffe 1936
Leguminosae				
Parkinsonia sp. (probably *Parkinsonia aculeata* L.)	Jerusalem thorn	N.and S. America	Failed to germinate	Ratcliffe 1936
Trigonella foenum-graecum L.	Fenugreek	Mediterranean	Seed planted. Fate unknown	Archives*
Zygophyllaceae				
Larrea sp. (as *Covillea* sp.)	Possibly creosote bush	N. America	Failed to germinate	Ratcliffe 1936

*University of Adelaide Archives; see References

Pentzia incana is the dominant shrub in this area (Figs. 3 and 4), which is surrounded by grassland dominated by *Enneapogon* sp. Also, I found a further stand, of about 500 plants, 1.7 km away along 200 m of track (AD; Parsons 704).

These records in the Angepena/Mount Serle area are about 180 km from the records at OVR.

Pentzia incana in the Australian Capital Territory

In the late 1920s and the 1930s, the CSIR Division of Plant Industry in Canberra included a Plant Introduction Section which imported and assessed exotic plants of possible economic use. Seeds of *Pentzia incana* (as *Pentzia virgata*) were received in May 1929 from E.J. Dunn of Kew, Victoria (CPI no. 1355, McTaggart & Hartley 1931) and in February 1931 from W.V. Blewett of Imperial Chemicals Industries, Melbourne (CPI no. 2033, McTaggart & Hartley 1932). The notes for the latter state that 'it is a very valuable stock feed on the dry Karoo of South Africa.' Nothing further is known of *Pentzia incana* in the ACT except that there are CANB collections of it by A. Melvaine from 'CSIR plots, Black Mountain, Canberra' from November 1938 and August 1939. These are obviously the basis for the fact that Australia's Virtual Herbarium, the Atlas of Living Australia and New South Wales Flora Online record *Pentzia incana* as being naturalized in the ACT (all accessed on 5 March 2012). Clearly, these records should be deleted.

Pentzia incana in Central Australia

In Alice Springs from 1956 to 1962, the Division of Plant Industry, CSIRO conducted trials to find exotic plant species which could be used to make native pastures more productive. In the initial trials, seeds were sown in irrigated plots. Nine shrub species from the Karoo region of South Africa, including *Pentzia incana*, established satisfactorily at this stage (Winkworth & Hodder 1962). No further details are available on the fate of these species except that the South African composite *Osteospermum muricatum* E. Mey. ex DC. was collected four times as a naturalized weed in Central Australia between 1974 and the early 1980s, but has not been collected or seen since (Albrecht & Pitts 2004).

Pentzia incana in North America

Pentzia incana was introduced to Arizona by the US Soil Conservation Service in the 1930s (Howery 2009) for erosion control and range improvement (Pierson & McAuliffe 1995). It is not known how many plantings were made, but at least one was as recent as 1946 (Munda & Pater 2003).

Fig. 4. Low shrubland of *Pentzia incana* extending for 150 m from a track up to the horizon on a hillslope near Mount Serle homestead, 20 April 2012. Note the absence of *Pentzia incana* on the right side of the fenceline at right. The grazing history at the site is not known.

In 1993, *Pentzia incana* was recorded for the first time from New Mexico (Spellenberg *et al*. 1993) at a distance of 312 km from the nearest stand in Arizona. By 2012, 11 stands were known in Arizona and two in New Mexico (http://intermountainbiota.org/portal/taxa/index.php?taxon=2331, accessed 4 Feb 2012).

The North American literature treats *Pentzia incana* as an invasive weed (Howery 2009), with evidence of it 'tending to seed itself' and successfully establishing seedlings (Spellenberg *et al*. 1993). There is no reference to it being used as a garden plant.

The introduction of *Pentzia globosa* to Australia

Pentzia globosa is known for Australia from only four collections. In 1894, it was collected from Gosford on the New South Wales central coast by an unknown collector. Then, in 1897 it was collected from Bundaleer Forest near Jamestown in the Mid-North of South Australia. A big population was found from the same general location in 1988 (AD; Bates 14272; Thompson 2007). Finally, 1000 plants were recorded from Bundaleer Forest in December 2011 (AD; Brewer 625). The 1988 stand occurred 100 m away from the 2011 one (Bates pers. comm.); both were from plantations of Sugar Gum (*Eucalyptus cladocalyx* F. Muell.).

Bundaleer Forest, where *Pentzia globosa* was recorded as early as 1897, was the first government forest plantation in Australia; planting commenced there in 1876 (Robinson 1971). Dr. R. Schomburgk, the Director of the Adelaide Botanic Gardens, was involved in choosing the tree species (Robinson 1971). It is not known if any shrubs were planted, but Schomburgk had begun propagating *Pentzia incana* at Adelaide in about 1870 (Schomburgk 1872), making it conceivable that *Pentzia globosa* was a deliberate introduction at Bundaleer.

The mean annual rainfall at Jamestown near Bundaleer Forest is 367 mm; a lot higher than the 160–260 mm range for *Pentzia globosa* in South Africa (Palmer & Hoffman 1997).

There is a single record, without details, of *Pentzia globosa* from the Australian nursery trade; from South Australia in 2005 (Ingram 2008).

In summary, at present *Pentzia globosa* is known in Australia from a single population in an area where it has been present, at least intermittently, for a minimum of 115 years. Information is needed on the extent to which it exhibits weedy behaviour in southern Africa; also it should be regularly monitored at Bundaleer Forest in case it begins to spread.

Concluding discussion

Because of the stress imposed by low rainfall, it has been assumed that few introduced plant species are capable of invading arid and semi-arid areas. However, in the case of the arid southwestern United States, Pierson and McAuliffe (1995) have suggested that this may be dangerously inaccurate. There, 15 species deliberately introduced to Arizona by the Soil Conservation Service before 1942 have become widely established. These include the South African shrubby composites *Pentzia incana* and *Euryops multifidus* DC., the latter having become a very serious weed forming virtually uninterrupted monocultures, suppressing native species and causing marked increases in soil erosion (Pierson & McAuliffe 1995).

The northern South Australia/Central Australia area has a similar climate to Arizona. Both areas are arid, with biseasonal rainfall showing significant peaks in winter and summer and both carry plant species whose main growth periods are either in winter or summer (Slatyer 1962, Pierson and McAuliffe 1995). However, it is hard to find Central Australian data to compare with the Arizonan data above. Certainly, the deliberately introduced *Cenchrus ciliaris* L. (Buffel Grass) has become a very serious weed of native vegetation in both areas (Marshall *et al*. 2012). The (temporary?) naturalization of the South African shrubby composite *Osteospermum muricatum* around Alice Springs is dealt with earlier. The finding that, of 72 species nominated as Australian Weeds of National Significance, only 3 are restricted to inland arid and semiarid environments, and other data in the paper (O'Donnell *et al*, 2012), suggest that the weed situation in and around Central Australia is not yet as serious as in Arizona.

It is against this background that we need to assess the potential of *Pentzia incana* to become a problem in southern Australia. It is now more than 80 years since *Pentzia incana* was deliberately introduced at OVR, but it has yet to become widely successful. It is clearly not the weed type that spreads rapidly soon after introduction (e.g. *Mimosa pigra* L. in Thailand, Groves 2006). It could be an example of the lag phase phenomenon whereby alien species are present in low numbers for a long time before an explosion in abundance occurs (Lenda *et al*. 2012). Where the lag period is more than 50 years, as in the present case, such species are called sleeper weeds (Groves 2006).

Unfortunately, we lack the data to accurately assess the extent to which *Pentzia incana* is capable of weedy behaviour. To summarize what little we know, firstly for fruit dispersal, the genus *Pentzia* lacks a parachute-type pappus; it has no special adaptations for wind dispersal. However, because the achenes are only 1–1.5 mm long (Thompson 2007), it is clear that they might be moved substantial distances by wind. Also, the fruits secrete mucilage when wetted (Magee & Tilney 2012); this suggests the possibility of long distance dispersal by adhesion to vertebrates, including intercontinental dispersal by birds, as it does in other species (Franzke *et al*. 2011). Such dispersal may be reflected in the 312 km disjunction involved in the establishment of *Pentzia incana* in New Mexico from the source area in Arizona (see earlier) and in the 180 km disjunction of the Mount Serle *Pentzia incana* stand from the parent OVR stand (if planting by landholders was not involved).

Turning to behaviour other than dispersal, the *Pentzia incana* plants at Mount Serle were flowering and fruiting abundantly (pers. obs.) and the North American data document successful seedling establishment (Spellenberg *et al*. 1993).

Regarding other traits important for weediness (Pheloung *et al*. 1999), we do not know if *Pentzia incana* can self-fertilize, or form a persistent seed bank. However, it is capable of vegetative propagation (Esler 1999). It is also capable of becoming co-dominant over large areas in South Africa (Milton *et al*. 1999) and dominant over smaller ones as at Mount Serle (pers. obs.).

Perhaps the most striking feature of the behaviour of *Pentzia incana* in Australia is the way it re-appeared at OVR after an apparent absence of 37 years. Persistence is also shown by the fact that it has now been present, perhaps intermittently, in the Angepena-Mount Serle area for a minimum of 48 years.

Regarding the weediness trait 'number of introductions outside the natural range of the species' (Pheloung *et al*. 1999), we have the 13 populations in and near Arizona, (an unknown number of them from deliberate plantings), and, at present in Australia, the two sub-populations at Mount Serle. The mean annual rainfall (mar) in the Mount Serle area is about 250 mm. Droughts there may limit *Pentzia incana* expansion given that, in South Africa, 78% of *Pentzia incana* plants died when only 70 mm of rain fell in a year in an area of 269 mm mar (Milton *et al*. 1999). Nevertheless, the presence of sizeable patches dominated by *Pentzia incana* at Mount Serle suggests that regular monitoring is desirable there in case rapid spread occurs. In terms of the definition of sleeper weeds (Groves 2006), *Pentzia incana* has already fulfilled the 50 year lag period criterion; it remains to be seen whether it fulfils the other criterion by becoming seriously invasive.

Finally, there is the question of the possible usefulness of *Pentzia incana*. When I asked for information about *Pentzia incana* in 'Across the Outback', a newsletter for pastoralists in northern South Australia, the only response was on behalf of a New South Wales grazier formerly from South Africa pointing out its value as sheep fodder there and hoping to trial it here. Thus, there is still interest in this topic so many years after the preliminary trials in South Australia in 1869 to 1900 and in 1930, as well as in the Australian Capital Territory (1929–1939) and Central Australia (1956–1962). However, we clearly need more data on the extent of its weediness in South Africa and its adaptability to Australian conditions so that we can assess its usefulness here.

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