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THE NATURALISED FLORA OF SOUTH AUSTRALIA 2. ITS DEVELOPMENT THROUGH TIME

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Abstract

The development of the naturalised flora of South Australia has been quantified by examining the number and the familial and generic composition of species in four years of significance in local botanical history and the present, viz. 1855, 1909, 1929, 1965 and 1984. The numbers of naturalised species were 101, 397, 539, 803 and 977 respectively. The last figure includes seven doubtfully recorded species and a further 64 believed to be extinct, not having been collected since 1950. The overall rate of acquisition of naturalised species has been just over six per year. The consistently best-represented families have been Gramineae, Compositae, Leguminosae and Cruciferae, whilst the best represented genera have been *Trifolium* and *Medicago*. Similar rankings were found in Victoria and New South Wales. The reasons for this are discussed.

Introduction

From the herbarium specimens and literary records previously reviewed (Kloot, 1987), a checklist of the naturalised alien flora was prepared (Kloot, 1987). The checklist includes the date of first record of each species as well as the date of the first herbarium specimen. In many cases these two dates are identical.

There are two methods available to estimate the number of alien plants naturalised at different times. The first is to use the checklist and assume that any plant was naturalised by the time of the first collection. The second is to study and analyse the relevant literature such as Mueller (1853), Black (1909, 1922-29, 1943-52), Robertson (1957) and Eichler (1965). The data derived from both approaches are presented and compared in this paper. The terms "naturalised" and "established" are used as defined previously (Kloot, 1987) except where they are cited from other writers who commonly used the word "naturalised" in my sense of "established".

Data

Mueller's (1853) figure of "about 100" naturalised (*sic*) aliens was supported by my study of extant specimens and relevant literature for that period (Kloot, 1983) and it was concluded that by 1855, 101 specimens were established in South Australia.

It is not possible to dissect the figures to the extent possible for current records, but the following analysis was made of the species included by Kloot (1983).

	Species	Genera	Families
Monocotyledons	19	15	2
Dicotyledons	82	70	30
Totals	101	85	32

The best-represented families were:

Gramineae	14 genera	19 species
Compositae	14	16
Caryophyllaceae	8	10
Cruciferae	7	7
Leguminosae	4	7

At the generic level there were 3 species of *Bromus* and 2 each of *Briza*, *Lolium*, *Calendula*, *Sonchus*, *Spergularia*, *Stellaria*, *Medicago*, *Trifolium*, *Vicia*, *Papaver*, *Erodium*, *Centaureum*, *Heliotropium* and *Rumex*. The remaining 70 genera had one species each.

However, according to the checklist data (Kloot, 1986), only 90 species had first collection dates of 1855 or earlier. The reasons for the discrepancy will be discussed below.

Black (1909, p. 3) stated that his book treated 368 species. According to my count only 364 can be included in a tally of established species, the remaining 4 species being explicitly noted as not being "naturalised" (*sic*). The following analysis is based on the 364 species:

	Species	Genera	Families
Monocotyledons	96	64	7
Dicotyledons	268	160	49
Totals	364	224	56

The most numerous families were as follows:

Gramineae	39 genera	62 species
Compositae	37	51
Leguminosae	12	44
Cruciferae	14	22
Iridaceae	14	20
Caryophyllaceae	8	11
Labiatae	7	11
Scrophulariaceae	8	10

At the generic level, *Trifolium* was represented by 14 species, *Medicago* by 9 species, *Euphorbia* and *Bromus* by 6 species each, *Vicia* by 5 species, 6 genera by 4 species, 19 genera by 3 species, 49 genera by 2 species and 145 genera by 1 species each.

According to the checklist data, 397 species were collected in 1909 or earlier. It is noted that by this time the difference in number is in favour of the specimens and this will be discussed below.

Wood (1937) analysed the South Australian flora presumably using the first edition of Black's (1922-29) Flora as a data base, and noted that there were 381 species of naturalised (*sic*) alien plants in South Australia belonging to 160 genera. My own count of Black's Flora revealed considerably more than this, viz. 526 species belonging to 307 genera. Even allowing for splitting of genera in later years the discrepancy is very large and I can only suggest that Wood excluded species that were not 'established' in my sense i.e. he omitted those species that I would classify as 'adventive' or 'casual'. He apparently excluded the 69 'Alien but scarcely naturalised plants' i.e. casuals, that Black (1929) appended to his last volume.

My count of the species in Black's first edition yielded the following analyses:

	Species	Genera	Families
Monocotyledons	120	78	12
Dicotyledons	406	223	57
Totals	526	301	69

The best-represented families were as follows:

Gramineae	50 genera	78 species
Compositae	42	61
Leguminosae	14	56
Cruciferae	21	29
Caryophyllaceae	15	26
Iridaceae	14	21
Scrophulariaceae	9	18
Labiatae	9	15

At the generic level, *Trifolium* was represented by 18 species, *Medicago* by 12 species, *Euphorbia* by 8 species, *Bromus*, *Rumex*, *Chenopodium* and *Silene* by 6 species each, 9 genera by 5 species, 7 genera by 4 species, 24 genera by 3 species, 62 genera by 2 species and 190 genera by 1 species.

There is again a discrepancy, although only slight, between this figure of 526 and that of 539 being the number of species in the checklist that were first collected in 1929 or earlier.

In his revision of Wood's (1937) handbook, Specht (1972) also briefly referred to alien plants. Using the second edition of Black's Flora (Black, 1943-52; Robertson, 1957) and the Supplement (Eichler, 1965), he arrived at a total of 654 alien species. Again my count is somewhat higher, although not to the same extent as it differs from Wood's count of the first edition. My analyses, which also included a few species noted in the separately issued Corrigenda and Addenda (Eichler, 1966) are as follows:

	Species	Genera	Families
Monocotyledons	180	98	12
Dicotyledons	541	299	67
Totals	721	397	79

The most-heavily represented families were:

Gramineae	63 genera	117 species
Compositae	57	91
Leguminosae	20	73
Cruciferae	27	40
Caryophyllaceae	15	33
Iridaceae	16	24
Rosaceae	10	22
Scrophulariaceae	12	21
Labiatae	11	21
Solanaceae	8	20
Liliaceae	7	17

At the generic level, *Trifolium* was represented by 22 species, *Medicago* by 16, *Oxalis* and *Euphorbia* by 11 each, *Bromus* by 9 and *Allium*, *Amaranthus*, *Silene*, *Fumaria* and *Solanum* by 8 species each, 7 genera by 6 species, 14 genera by 5 species, 28 genera by 4 species, 24 genera by 3 species, 66 genera by 2 species and 258 genera by 1 species each.

There is a considerable difference between the figure of 721 species derived here and that of 803 species whose first collection date was 1965 or earlier. Like the figures for 1909 and 1929, the latter number is greater than that derived from the published literature.

Analysis of the checklist reveals that 977 species were recorded in the naturalised alien flora of South Australia up to December 1984. Of them 73 are either extinct or doubtful records. Such doubt may arise because of suspected misidentification or the uncertainty as to whether the extant specimens were actually collected in South Australia or elsewhere, or from situations outside cultivation. The following table summarises the information derived from analysis of the entries in the checklist.

SPECIES						
	Established*	Adventive	Casual	Doubtful	Extinct	Total
Monocotyledons	119	71	44	3	13	250
Dicotyledons	333	212	125	6	51	727
Totals	452	283	169	9	64	977

*As defined (Kloot, 1986a)

GENERA			
	Present	Doubtful or Extinct	Total
Monocotyledons	114	6	120
Dicotyledons	346	19	365
Totals	460	25	485

FAMILIES			
	Present	Extinct	Total
Monocotyledons	13	1	14
Dicotyledons	77	2	79
Totals	90	3	93

The most-heavily represented families are:

Gramineae	68 genera	142 species
Compositae	70	123
Leguminosae	26	83
Cruciferae	30	53
Iridaceae	20	43
Caryophyllaceae	16	34
Solanaceae	11	29
Liliaceae	12	27
Rosaceae	11	26
Labiatae	14	25

The genera containing the most species are as follows:

<i>Trifolium</i>	26 spp.
<i>Medicago</i>	14
<i>Solanum</i>	13
<i>Oxalis</i>	12
<i>Opuntia</i>	12
<i>Euphorbia</i>	12
<i>Amaranthus</i>	10
<i>Cyperus</i>	9
<i>Bromus</i>	9
<i>Fumaria</i>	8
<i>Polygonum</i>	8

Of those remaining, 8 genera contain 7 species each, 11 contain 6 species, 16 contain 5 species, 22 contain 4 species, 31 contain 3 species, 75 contain 2 species and 312 genera are represented by 1 species each.

Discussion

The number of naturalised alien species present at any time were, with one exception, consistently underestimated by contemporary observers. There are a number of reasons for this. Firstly, taxonomic revisions separate species erroneously considered as but one. For example, *Aira caryophyllea* as understood by Black (1909) is now known to be three species, *A. caryophyllea*, *A. cupaniana* and *A. elegantissima* (see Jessop, 1984), all of which had actually been collected before 1909.

Secondly, at the time of writing, authors may not be aware of recently collected specimens or of material which may be unavailable to them for various reasons. This particularly applies to J.M. Black who appears to have made very little use of collections lodged at the National Herbarium, Melbourne (MEL), which are at least as rich in South Australian material up to the death of Mueller in 1896 as are local collections.

Thirdly, it takes time for a plant to arrive, become established, be noticed and then collected so it is likely that plants collected for the first time in a given year were actually present earlier. For most species, it is impossible to estimate such lag periods where the date of introduction is unrecorded. Therefore to establish a consistent basis in this study for determining the year of naturalisation the date has been taken of the first collection of apparently naturalised populations i.e. excluding obviously cultivated specimens.

Fourthly, in the case of garden escapes, or more generally, any intentionally cultivated species, collectors will differ in their interpretation of a spreading infestation. Some will consider spreading from a garden as naturalisation, others would defer such an interpretation until the original connection with the garden was broken. Even where sheet annotations are superficially clear, i.e. the collector indicated that it was spreading from a garden, a later interpretation of that statement is still problematical for flora writers. For such cases in this study, a subjective decision was made, usually in consultation with other experienced botanists.

For these reasons therefore the numbers of specimens first collected in 1909, and 1965 respectively exceed the numbers derived from the cited literature of those years.

Conversely, there are documented cases where readily-recognised plants, the identities of which are beyond doubt, were present in South Australia for many years prior to the date of the earliest extant collections. Thus the first collection located of *Xanthium spinosum* is from 1904, although that species had been the subject of the Thistle and Burr Act of 1862. *Ricinus communis*, although apparently naturalised during the 1840s (Kloot, 1983), was not collected until 1903.

Furthermore, there are cases (Kloot, 1983) where specimens are wrongly considered to be separate species, e.g. *Centaurea solstitialis* from *C. melitensis*, and plants noted as naturalised when in fact they were not, at least at that time.

Errors arising from the two latter reasons, are not included in the figure of 101 species given for 1855. The discrepancy between the figures of 90 and 101 species for that year arise from the lack of collections of plants known to have been present, (Kloot, 1983).

	Increment	Species/year	Total
1847-1852	90	15.0	90
1853-1868	—	—	90
1869-1878	7	0.7	97
1879-1885	73	10.4	170
1886-1902	37	2.2	207
1903-1909	192	27.4	399
1910-1929	141	7.1	540
1930-1945	98	6.1	638
1946-1965	161	8.1	799
1966-1984	105	5.5	904

For period 1847-1984, the overall rate is 6.6 species/year.

For period 1836-1984, the overall rate is 6.1 species/year.

Table 1: The apparent annual acquisition of naturalised alien species in South Australia based on the earliest extant collections.

Since colonization the rate of acquisition has continued more or less constantly to the present (Table 1). In fact, if it is argued that my figure for 1984 must be an underestimate for the reasons canvassed above, then it is possible that the rate of establishment may actually be increasing.

Whether that be the case or not, the constant rate of acquisition of alien species does not augur well for the conservation of native vegetation as individual species or as plant communities.

Although the absolute numbers of their genera and species have increased markedly between 1855 and the present, it is remarkable that the relationship of the families relative to each other has stayed so constant over that period. They all tend to be families consisting of both intentionally and unintentionally introduced species, although the Caryophyllaceae has a preponderance of the latter. The families Iridaceae, Solanaceae, Liliaceae and Rosaceae which only became prominent in later periods, have a greater proportion of intentionally introduced species.

At the species level, nothing can be drawn from the 1855 list, but by 1909 a trend emerged which has continued to the present. The two pasture legume genera *Trifolium* and *Medicago* have consistently headed the species list. In spite of the fact that documentation was not located in most cases, I believe that species of these genera were widely imported and sown

under the general term "clovers". In some cases, a species may have been imported as a contaminant of seed of another, but all would have been welcomed, particularly prior to the development of modern pasture technology.

Of the other well-represented genera, *Solanum*, *Oxalis* and *Opuntia* are documented as having a majority of intentionally introduced species. *Euphorbia* is not as certain, although its characteristic flowers and attractive foliage have caused some species to be grown ornamentally and could well have been sufficient reason for others lacking documentation.

Amaranthus seems to have been the most successful "weedy" genus and this is probably due to seed of that genus contaminating imported garden seeds which, when sown, placed the weeds in a suitable environment.

	South Australia	Victoria (Ross, 1976; Todd 1979, 1981, 1985)	New South Wales (Jacobs & Pickard, 1981)
Dicotyledonous Families			
Compositae	123	101	153
Leguminosae	83	65	110
Cruciferae	53	41	49
Caryophyllaceae	34	30	34
Solanaceae	29	32	38
Rosaceae	26	24	45
Labiatae	25	17	24
Scrophulariaceae	24	25	33
Monocotyledonous Families			
Gramineae	142	136	208
Iridaceae	43	20	26
Liliaceae	27	4	19
Cyperaceae	14	9	21

Table 2: The number of introduced species in the most numerous families in south-eastern Australia.

Recent comparable figures for the south-eastern Australian States (Table 2) show a remarkable similarity between the number and ranking of the major families of the naturalised flora. Because north-eastern New South Wales is an almost sub-tropical environment, the Solanaceae and Cyperaceae, both being families more typically tropical, are more heavily represented in that State. Similarly, sub-tropical grasses not found in South Australia or Victoria markedly enhance the number of Gramineae in New South Wales. Conversely the naturalised species of Iridaceae originating from South Africa appear to have found the mediterranean conditions of South Australia more congenial and are more numerous there.

At the generic level, there is also much similarity between the States' respective floras (Table 3). *Solanum* and *Cyperus* being more sub-tropical in distribution are better represented in New South Wales. The case with *Crotalaria* is even more striking. Introduced species of this genus are not found at all in South Australia and Victoria. The distribution data provided by Jacobs and Pickard (1981) show that it is largely confined to the northern coast of the State where the environment tends to be sub-tropical. The considerably higher numbers of *Bromus* for New South Wales and *Rubus* for that State and Victoria, are probably a reflection of more intensive taxonomic work in those genera in local institutions leading to the recognition of more species. The situation with *Oenothera* is not so certain. Whilst detailed investigations may be responsible for some of the extra species, there may be some biological reason for the large

number of species in New South Wales or there may even be an historical explanation, in that Sydney would probably have been the most common port of call for ships travelling from the west coast of North America. It may be relevant that *Oenothera* is very well-represented in South Africa (Wells & Stirton, 1982).

	South Australia	Victoria (Ross, 1976; Todd 1979, 1981, 1985)	New South Wales (Jacobs & Pickard, 1981)
<i>Trifolium</i>	26	20	22
<i>Medicago</i>	14	10	11
<i>Solanum</i>	13	12	16
<i>Oxalis</i>	12	9	12
<i>Opuntia</i>	12	6	5
<i>Euphorbia</i>	12	7	12
<i>Amaranthus</i>	10	9	10
<i>Cyperus</i>	9	8	13
<i>Bromus</i>	9	9	17
<i>Juncus</i>	7	9	12
<i>Rubus</i>	7	11	13
<i>Oenothera</i>	4	4	12
<i>Crotalaria</i> (introduced)	—	—	11

Table 3: Numbers of introduced species in the most numerous genera in south-eastern Australia.

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