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Domestication of wattles with edible seeds for the wheatbelt of Western Australia

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SUMMARY

This paper reviews species with potential for edible wattle seed production for the wheatbelt region of Western Australia. It identifies that market demand for seed products is a major constraint to any large-scale plantings aimed specifically at wattle seed production. Comprehensive analyses of seeds for anti-nutritional or toxic components and taste appraisals of newly targeted species are also an imperative. To date there has been insufficient research to guarantee uniformity and consistency of seed yield using wattles new to domestication. These issues must be addressed if economic gain from growing edible wattles is to be achieved. In the meantime the most significant benefit from cultivating them will be to incorporate them into plantings aimed at ameliorating land degradation. Attributes and relevant details are presented for 22 endemic species considered the most promising for the production of seed for human food in the wheatbelt of Western Australia. Four of these species, namely, ***A. anthochaera, A. microbotrya, A. murrayana, A. saligna*** and ***A. victoriae***, were considered the best prospects and are discussed in detail.

INTRODUCTION

A great deal of what we know today about edible wattle seed has been built upon the traditional knowledge of ***Acacia*** species by Australian Aborigines. This knowledge draws on over 40,000 years of traditional utilisation of our native flora. Information presented in the recent book ***Edible Wattle Seeds of Southern Australia*** (Maslin ***et al***. 1998) was very much reliant on this knowledge. Our aim in this review is to use that information to outline the domestication potential of the most promising edible-seeded wattles for cultivation in the Western Australian wheat-sheep agricultural region (i.e. the 300-500 mm rainfall zone in the south west of the state).

A major impetus for compiling ***Edible Wattle Seeds of Southern Australia*** came from research on the use of wattles in the Sahelian region in West Africa. In the 1970s, Australian wattles from the seasonally dry tropics, such as kalkardi (***Acacia elachantha***) and Cole's wattle (***A. colei***), were introduced into the Sahel for fuelwood, windbreaks and amenity plantings (Cossaltar 1986; House and Harwood 1992). Subsequently, during years of drought-induced famine, seeds from these species were trialed as a source of human food in the Maradi region of Niger (Thomson 1992; Harwood 1994; Rinaudo ***et al.*** these proceedings). When staple grain crops failed, CSIRO researchers, aware of the traditional Australian Aboriginal use of ***Acacia***, recommended that seeds from the introduced Australian species be tried as an alternative food. People in the Sahel processed the seeds using local cereal-grinding technology normally used for processing their staple grain crop, millet. The ground wattle seed flour was then incorporated into local recipes. Based on the success of this development the future domestication of edible-seeded wattles in the Sahel appears promising. The species being used having many attributes that facilitate their domestication. With appropriate silvicultural management they are easy to establish, fast-growing, show excellent survival and are heavy seeders within two years of planting (Harwood ***et al.*** 1999). They also exhibit unusual levels of phenotypic uniformity, a trait probably linked to their polyploid origins (Thomson 1992). With the promise shown by edible wattles in Sahel, the advent of a local bushfood industry in Australia and the regional need to grow plants to reverse land degradation, we felt it timely to compile ***Edible Wattle Seeds of Southern Australia*** to help guide further R&D on these species.

There are major constraints on the cultivation of edible wattles in southern Australia. Our aim here is not to review the economic viability of edible wattle seed production, although the market demand for seed products is a major constraint; ascertaining size and viability of this market is essential prior to any large-scale plantings aimed specifically at wattle seed production. Comprehensive analyses of seeds for anti-nutritional or toxic components and taste appraisals of newly targeted species are also imperatives. Variable and unpredictable attributes must also be anticipated in the domestication of wild plants. To date there has been insufficient research to guarantee uniformity and consistency of seed yields of wattles new to domestication. These issues must be addressed if growing edible wattles is to be economically viable. In the meantime the most significant benefit will be to incorporate edible wattles into plantings aimed at ameliorating land degradation.

NUTRITIONAL VALUE AND WATTLE SEED PRODUCTS

The nutritional value of wattle seed is comparable to other legume seeds except that they contain higher levels of dietary fibre. In a study of 26 tropical and arid zone species, Brand and Maggiore (1992) showed that the seeds averaged 23% crude protein, 26% available carbohydrate and 32% fibre. Potentially toxic compounds were absent or present at non-harmful levels. Positive results for nutrition content, non-toxic components and palatability were also obtained from dietary trials and nutritional studies of ***A. colei*** in West Africa (Harwood ***et al.*** 1999). However, insofar as temperate species are concerned very little is known about the nutritional status of wattle seeds or possible toxicity problems, and there is a need for research in these areas before major investment is made in developing large-scale seed production.

In Australia, the main potential products from the seeds of edible wattles include: flavouring agents (especially in dairy products such as cream and ice cream), beverages (where ground roasted seeds are used as a coffee substitute), as a stable carbohydrate (biscuits, breads and pasta) and as a low-glycaemic index food for diabetics.

Desirable attributes for domestication of edible-seeded wattles

There are almost 1000 species of ***Acacia*** in Australia, representing great diversity in morphological, ecological, biological and utilisation characteristics (e.g. Maslin 2001a; McDonald ***et al***. 2001). To identify which species might be suitable for producing commercial quantities of seed under cultivation for human consumption, the following attributes were considered:

Nutrition and toxicology–Of primary importance was the need to select species with nutritious, palatable seeds with no anti-nutritional or toxic components. High priority was thus given to species traditionally consumed by Australian Aborigines. We reasoned that species recorded as edible by Aborigines have been under an ongoing selection process over the past 40,000 years and could be presumed relatively safe to eat. We relied heavily on information in the public domain but unfortunately such information was not available for all the species that warranted consideration. Some potentially promising species were not described until recently so there were no historical records to draw on. Other species warranted inclusion because they were close relatives of species recorded as having been consumed. In these cases we had to make the assumption that their seed was nutritious and edible. This strategy was adopted in anticipation that a thorough assessment of the nutritional and toxicological characteristics of seeds would be undertaken on any species targeted for incorporation into human diets. This applies to all the species treated here.

Growth habit–Species must have appropriate growth attributes and present pods in a way suitable for easy harvesting. For example, compact, multi-stemmed shrubs with vigorous coppicing ability and with pods on the branch tips (i.e. borne on terminal racemes) were ranked highly. The ability to produce coppice regrowth could be important in circumstances where large-scale plantings required the development of broad-acre mechanical harvesting techniques. Species with a single, well-defined trunk would tend be suited more to harvesting by mechanical shaking techniques. Species with moderate to long life spans of around 10-20 years and fast growth rates were also ranked highly. Short-lived perennials would have high recurrent re-establishment costs and slow-growing plants would be economically unproductive.

Pod characteristics–A fundamentally important selection criterion was the ability of plants to produce heavy seed crops with pods that ripen simultaneously on a reliable, annual basis. Species with pods that ripen over a long period of time would be difficult to harvest. The ability of wattles to be reliable seeders appears to be correlated with their taxonomic group. For example, species with one-nerved phyllodes (such as ***A. victoriae*** and A. ***microbotrya***) tend to be more reliable seeders that those with multinerved phyllodes. Species such as Jam (***A. acuminata***) and Western Myall (***A. papyrocarpa***) fall into the latter category. Although the latter two are heavy seeders and their seeds palatable, their fruiting behaviour tends to be erratic and possibly related to the timing, frequency and intensity of rainfall. Such species were not rated highly for commercial plantings.

Seed characteristics–Acacias vary considerably in the size of their seed and how the seeds are shed from the pods. Species with large or moderately large seeds were generally ranked more highly than smaller-seeded species or those with thick seed coats. The length of time that the seeds are retained in the pods after they have ripened is an important consideration. The longer the seeds are retained the better, because this will extend the period over which the seeds can be harvested. The relative ease with which the seeds can be extracted from the pods after harvesting is important; seed loss before and during harvest due to the dehiscent nature of the pod must be considered.

Silviculture–Ease of establishment in cultivation was an important consideration. In most cases this was difficult to assess because field trials have not yet been carried out. Wattles have hard seed coats, i.e. the seed is easy to handle and store and is well-suited to direct seeding techniques, but usually requires some form of pre-treatment to ensure rapid, uniform germination. Pre-treatment techniques such as tumbler scouring can be used on a large scale to enhance germination of most species.

Ecology–Species known to occur in a range of different soil types and are adapted to a wide climatic range were ranked more highly than those with narrower ecological tolerances. Such species have a greater chance of success when cultivated over a wide range of growing conditions. Despite the natural ecology of species, however, the adaptability of some species will not become known until the plant is cultivated over a range of growing conditions.

Weed potential–There are well-known examples of wattle species becoming serious environmental weeds. For example, Australia's official floral emblem ***A. pycnantha*** has been grown widely as an ornamental and is now considered a weed in many parts of southern Australia. While this species can produce large quantities of seed and there are reports of it having been consumed by Aborigines, it is not recommended for cultivation in Western Australia. More research is required to determine if all cultivated edible wattle species will become weeds.

Taste–An important attribute that was not critically assessed in ***Edible Wattle Seeds of Southern Australia*** is that of taste. There appear to be significant differences in flavour between various species and it would be useful to undertake a more systematic evaluation of these. For example, Mulga (***A. aneura*** sens. lat.) is recorded as having a 'peanut butter' flavour by Latz (1995) and could find a niche market as a novelty table spread. Similarly, some species such as ***A. retinodes*** are considered to have a more pleasing taste than others. Wider public acceptance of this 'new' food could be encouraged if palatability differences are explored and exploited.

Polyploidy–The most successful tropical dry zone species used for edible seed production are polyploids. Plants of the hexaploid ***A. colei*** (Moran ***et al***. 1992) from individual provenances are very uniform in their growth rate, habit and seed crop when cultivated on uniform sites. These characteristics, very desirable for commercial seed production, are linked to their genetic uniformity and an apomictic or asexual mode of reproduction that is typical of polyploid plants (Grant 1981). Research to screen the ploidy level of species targeted for domestication in southern Australia could therefore be rewarding. An understanding of the breeding system is essential for selection and breeding programs.

Taxa in the ***A. aneura*** group are known to comprise polyploids and could be grown for seed production, but growth rates are slow and heavy pod production in natural populations is dependent on both winter and summer rainfall. ***Acacia cowleana*** is part of the ***A. colei-A. elachantha*** species complex (McDonald and Maslin 1997) and is a known polyploid (***2n*** = 78 ***fide*** Moran ***et al.*** 1992). It occurs mainly in the northern arid zone but some of its southern populations (e.g. from the Alice Springs region) could warrant trialing for seed production in southern Australia.

Hybrids–The two most promising species identified in ***Edible Wattle Seeds–A. victoriae*** and ***A. murrayana***– are taxonomically related**.** The potential to manipulate hybrid crosses between these two species warrants investigation. It is possible that hybrid plants might have wider edaphic tolerances, faster growth rates and higher seed production than either parent species. Producing such hybrids, however, would likely be a long, costly task.

SPECIES SUITABLE FOR THE WHEATBELT OF SOUTH-WEST WESTERN AUSTRALIA

Edible Wattle Seeds of Southern Australia identified 47 species judged to have potential for cultivation in southern semi-arid regions of Australia as sources of seed for human consumption. All of the 18 'best prospect' species belong to a single taxonomic group characterised by one-nerved phyllodes and racemose inflorescences. Racemes support numerous flower heads and as such have the potential to produce many more pods than do simple inflorescences. Racemes of the 'best prospect species' are also terminal or arranged en masse in axils on new shoots at the tips of branchlets. When in flower these species represent some of the most showy, spectacular flowering wattles. This attribute also makes them amenable for harvesting since the pods are held on the outside of the crown.

Table 1 lists the attributes of species that have potential to be grown for edible seed in the low-rainfall agricultural zone (300-500 mm rainfall) of south-west Western Australia. For many species some attributes such as seed yield remain unknown, and others such as frost resistance are categorised only in very broad terms. The most appropriate site for cultivation in the landscape (recharge or discharge zone) is shown for each species. Only three of the species listed (***A. inceana***, ***A. saligna*** and ***A. victoriae***) are recommended for planting in groundwater discharge areas. This is because very few ***Acacia*** species with promising attributes for seed production grow naturally in these zones. A subjective ranking of these species based on their overall attributes is also given. Detailed profiles of five species considered to have the greatest potential for domestication in the Western Australia low-rainfall agricultural zone are presented below.

Acacia victoriae and ***A. murrayana*** are considered the two most promising species. Their seeds were commonly used as food by Australian Aborigines, have good nutritional characteristics and one (***A. victoriae***) is currently the most important edible wattle species in the Australian bushfood industry. Natural populations occur across a wide range of climates, have moderate to fast growth and are moderate to heavy seeders. Both species are easily propagated from seed, and plantations can be established by direct seeding. It may be possible to regenerate over-mature, declining stands of these species by coppicing and / or shallow ripping to induce suckering. Although the two species are taxonomically related and morphologically quite similar, they prefer different soil types and under cultivation have the potential to complement one another. ***Acacia victoriae*** normally grows on heavy clay or clay-loam which may be somewhat saline, while ***A. murrayana*** normally prefers sandy soil or sandy loam. The seeds of ***A. victoriae*** have demonstrable potential as specialty food in Western diets and they command high prices relative to other grain and seed crops. This species is generally regarded as the industry standard.

TABLE 1
Natural attributes of native Western Australian edible wattles with potential for domestication in the agricultural zone.

Species	State	Wheatbelt distribution	Frost frequency	Soil type	Growth habit	Coppicing	Flowers	Seed matures	Planting zone	Rank
A. acuminata (Jul.)	WA	Northern; central; southern	Low	Sandy loam, sandy clay, loam; acid to alkaline	Shrub or tree 3-5(-12) m tall	Weak to moderate	July-Oct	Sep-Dec	Recharge	**2-3**
A. aneura (Jul.)	WA, NT, SA, NSW, Qld	Northern	High	Loam, sand, clayey sand; acid to neutral (alkaline)	Tree or low shrub 2-15 m tall	Nil to weak	Irregular; Mar-May	Oct-Dec	Recharge	**2-3**
A. anthochaera (Phy.)	WA	Northern	Low	Sand, loam; neutral to alkaline	Multi-stemmed shrub or small tree 2-5(-8) x 4-6 m	Unknown	Aug-Oct (Dec)	late Nov-Jan	Recharge	**1**
A. blakelyi (Phy.)	WA	Northern	Low	Sand or loam; acid to neutral	Shrub or tree 2-4 x 2-4 m	Unknown	July-Sep	Nov-Jan (-Oct)	Recharge	**2**
A. brumalis (Phy.)	WA	Northern; central	Low	Sand, clay, loam; some moderately saline	Shrub or small tree 1.5-3 m tall	Unknown	late May-Sep	late Nov-early Jan	Recharge	**2**
A. burkittii (Jul.)	WA, SA, NSW	Northern; central	Low	Loam, sandy loam, (clay); alkaline (neutral)	Shrub or tree 1-4(-10) m	Weak to moderate	July-Sep	Nov-Dec (-Oct)	Recharge	**2-3**
A. hakeoides (Phy.)	WA, SA, Qld, Vic, NSW	Southern	High	Sandy loam (clay); alkaline (neutral)	Multi-stemmed shrub or small tree 1-4 x 3-6 m	Good	(June-) July-Sep (-Oct)	late Oct-early Dec	Recharge	**2**
A. hemiteles (Phy.)	WA	Northern; central	Low	Sand, loam, clay; neutral, acidic, alkaline	Multi-stemmed shrub 0.5-2 x 1-4 m	Unknown	June-Oct main flush Aug-Sep	late Nov-early Feb	Recharge	**2**
A. inceana (Plu.)	WA	North; central	Low	Sand, clay; alkaline; moderately saline	Shrub or small tree 1-3 m tall	Unknown	Sep-Oct	Dec	Recharge-discharge	**3**
A. jennerae (Phy.)	SA, NSW, NT, WA	Northern; central	Low	Sand, loam; acid to neutral moderately saline;	Multi-stemmed shrub 2.5-4 (-6) x 3-6 m	Good	Jan-Aug, main flush April-July	N: Oct-Nov S: Nov-Jan	Recharge	**1-2**
A. jibberdingensis (Jul.)	WA	Northern; central	Low	Sand, sandy loam; neutral	Shrub or small tree 2-4(-7) x 4-5 m	Unknown	June-Oct	Dec-Jan	Recharge	**3**
A. leptopetala (Phy.)	WA	Central	Nil	Sand, clay, loam, sandy loam; neutral to acid	Shrub 2-3 x 2-3.5 m	Unknown	Irregular	?throughout year	Recharge	**3**
A. meisneri (Phy.)	WA	Central	Low	Sandy loam; neutral	Shrub 2-4 x 3-5 m	Unknown	Irregular	Mostly Dec-Jan	Recharge	**2**

TABLE 1 (continued)

Species	State	Wheatbelt distribution	Frost frequency	Soil type	Growth habit	Coppicing	Flowers	Seed matures	Planting zone	Rank
A. microbotrya (Phy.)	WA	Northern; central; southern	Low	Loam (sand, clay loam); acid to neutral	Shrub or small tree 2-5(-7) x 3-9 m	Variable; also root suckers	April-early July	Oct-Dec (-Jan)	Recharge	**1**
A. murrayana (Phy.)	NSW, Qld,	Northern	Low-high	Sand (clay loam); acid to alkaline	Multi-stemmed shrub or tree 2-5(-8) x 3-8 m	Good; also root suckers	Aug-Nov	Nov-Jan	Recharge	**1**
A. prainii (Phy.)	WA, SA, NT	Northern; central	Low	Sand (clay loam); neutral to alkaline	Shrub or small tree 1.5-3 (-5) x 3-5 m	Unknown	mid July-Oct (-Nov)	Nov-Jan	Recharge	**3**
A. ramulosa (Jul.)	NSW, Qld, NT, SA, WA	Northern	High	Sand (clay loam); alkaline (acid)	Multi-stemmed shrub or small tree 2-6 x 3-8 m	Good	(Mar-June) July-Sep	Sep-Nov (-Jan)	Recharge	**2**
A. redolens (Plu.)	WA	Southern	Low	Clay-loam (sandy loam, clay); neutral (alkaline); saline	Shrub 0.5-2(-5) x 3-5 m	Unknown	Aug-Oct	Dec	Discharge	**2**
A. saligna (Phy.)	WA	Northern; central; southern	Low	Sand (clay loam); acid to alkaline; often moderately saline	Shrub or tree 2-5 x 6-10 m	Strongly; also root suckers	Aug-Oct	Nov-Jan	Recharge-discharge	**1-2**
A. scirpifolia (Phy.)	WA	Northern	Low	Sandy loam (clay loam); neutral	Shrub or small tree 2-4 x 3-6 m	Unknown	Aug-Oct	Nov-Jan	Recharge	**3**
A. subrigida (Phy.)	WA	Northern	Low	Sand; acid	Shrub to 3 m tall	Unknown	Sep-Oct	Jan	Recharge	**3**
A. victoriae (Phy.)	All main-land States	Northern	Nil to high	Sand, clay; alkaline (acid); saline	Multi-stemmed shrub or tree 2-5(-9) x 5-10 m	Good	Late Aug -Oct	Nov-Jan	Discharge	**1**

Abbreviations: Column 1 (species): Jul = section Juliflorae; Phy = section Phyllodineae; Plu = section Plurinerves. States: NSW = New South Wales; NT = Northern Territory; Qld = Queensland; SA = South Australia; Vic = Victoria; WA = Western Australia.

Soil type: shows soil texture, pH status and if known to be saline.

Frost frequency: *high* = heavy frosts in most years over a substantial part of natural range; *low* = low incidence of frost in some parts of natural range; *nil* = nil or very low incidence of frost throughout the range.

Rank: refers to domestication potential for edible wattle seed production in the target zone; 1 = has all attributes of a good edible wattle species; 2 = lacks some of the key attributes; 3 = poorly known in cultivation, may lack a number of key attributes.

1. Acacia victoriae F.Muell. ex Benth.

Taxonomy–Acacia victoriae and with nine close relatives comprise the informal '***A. victoriae*** group' (Maslin 1992). The group is closely related to the '***Acacia murrayana*** group'. ***Acacia victoriae*** is a highly variable species. For example, specimens from Queensland and from the Kimberley region of Western Australia have very long phyllodes (to 10 cm). The taxonomic status of ***A. victoriae*** subsp. ***arida*** requires further investigation. Specimens ascribed to this subspecies have densely tomentose branchlets and phyllodes and occur on sandy soil in southern N.T., northern S.A., western N.S.W. and south-west Qld (Maslin 2001a).

Growth attributes–Acacia victoriae ranges from a dense to straggly shrub or small tree, commonly 2-5 m tall but sometimes reaching 9 m tall. It readily regenerates from root suckers and sometimes forms thickets. ***Acacia victoriae*** is usually spiny, with small, pungent stipules that occur in pairs in the axils of the phyllodes. The stipules are usually evident on new growth and especially on young plants, but they are absent in some populations. The foliage provides useful fodder for stock in semi-arid regions (Everist 1969; Askew and Mitchell 1978) and in stocked areas plants with browse lines are common. In natural stands growth is rapid but the species is relatively short-lived (Grice ***et al.*** 1994); 10-15 years appears to be the maximum life-span. Wood from trees in natural stands has a basic density of 800 kg m^{-3} (Ilic ***et al.*** 2001). Maiden (1889) noted that ***A. victoriae*** is an indicator species of underground water and that it has an extremely deep root system, estimated to be in excess of 20 m (although this depth would be remarkable and needs verification).

Occurrence–This has one of the widest distributions of any Australian ***Acacia*** species, occurring in arid and semi-arid areas of all mainland States (map 218 in Maslin 2001a).

Climate–Natural populations of ***A. victoriae*** occur mainly in the climate zone with a hot dry summer and cold winter but extend into the tropical zone with a hot dry summer and warm winter. The mean maximum temperature of the hottest months is 35-39°C and mean minimum temperature of the coldest months is 5-10°C; the mean annual rainfall ranges from 125-300 mm (Doran ***et al.*** 1997). Rainfall seasonality varies from uniform to summer maximum but throughout much of the range rainfall is sporadic and unreliable. Inland sites experience some frosts (about 1-11 per year).

Soils–These range from sandy loam and clay loam to clay, with a pH range of 5.5-9.5. It commonly occurs on soils considered adverse for plant growth including highly alkaline, cracking clay, saline and poorly drained soils.

Phenology and seeds–Acacia victoriae flowers from August to October. Flowering does not appear dependent on the incidence of rainfall (Askew and Mitchell 1978), and this could be linked to its root architecture (see below). Flowering occurs at an early age (less than 2 years). Seeds mature mainly between November and January. ***Acacia victoriae*** has easily harvested papery pods that are held on the tips of the branches. The seeds separate from the pods with minimal mechanical processing. The use of seeds by Australian Aborigines is documented in O'Connell ***et al.*** (1983) and Latz (1995). The nutritional attributes of the seed are excellent: they contain 17% crude protein, 41% carbohydrate and 29% fibre (Brand and Cherikoff 1985).

Silviculture–Acacia victoriae is suitable for cultivation throughout the wheatbelt region of Western Australia on sites where its roots can access groundwater. Field observations from natural stands suggest that the persistence of ***A. victoriae*** in arid regions is due to localised distribution on run-on sites and the ability of its root system to tap groundwater, possibly at considerable depths. The successful cultivation of this species will rely on this critical aspect of site selection. In glasshouse trials ***A. victoriae*** has been ranked as moderately salt tolerant (Aswathappa ***et al.*** 1986). It also has the potential to be cultivated successfully on a range of other adverse soil types as some natural stands occur on highly alkaline, cracking clay and poorly drained soils. Establishment during the rainy season is essential and some irrigation during the early years of growth would facilitate its successful cultivation. Protection from grazing stock is necessary during establishment.

Acacia victoriae is a relatively short-lived species (10-15 years) but coppices well (Chippendale and Jephcott 1963). It has moderate fire tolerance but can be killed by severe drought (Askew and Mitchell 1978). Its moderate life-span and coppicing ability make it amenable for mechanical harvesting of established plantations. Harvesting of coppice regrowth could extend over a number of seasons, likely to be in more than five, but trials are required to ascertain how quickly it flowers and seeds from coppice regrowth.

The wide geographical range of ***A. victoriae*** and its ability to tolerate a range of soil types suggest that selection of suitable provenances may be critical for its successful cultivation.

Genetics–Acacia victoriae is a diploid species (**2n** = 26) (Hamant ***et al.*** 1975**).** Research to elucidate its patterns of genetic variation and its breeding system is warranted, particularly as it is currently the main species targeted for domestication.

Limitations–Restricted to cultivation on sites with run-on water or where its roots can tap groundwater.

Further reading–Cunningham ***et al***. 1981; Whibley and Symon 1992; Doran ***et al***. 1997: 350.

2. Acacia murrayana F.Muell. ex Benth.

Taxonomy–Acacia murrayana, ***A. gelasina***, ***A. pachyacra***, ***A. praelongata*** and ***A. subrigida*** comprise the '***A. murrayana*** group', a group which has affinities to the '***A. victoriae*** group' and the '***A. juncifolia*** group' (Maslin 1995: 200, and 2001: 373). Future taxonomic studies of ***A. murrayana*** may recognise infraspecific taxa to accommodate the considerable variation in phyllode shape, width and colour (Maslin 2001a).

Growth attributes–Acacia murrayana is usually a shrub 3-4 m tall with an often-spreading, bushy crown, but occasionally it occurs as a small tree to 5 (-8) m tall. Due to its root-suckering ability this species commonly forms clonal thickets or groves and is sometimes referred to as Colony Wattle. It is documented as having fast to moderate growth rate with a moderate life-span (10-50 years), although longevity of individual bushes is likely to be closer to 10 than 50 years (Thomson ***et al***. 1994). Wood from natural stands has a basic density of 600 kg m^{-3} (Ilic ***et al.*** 2001). ***Acacia murrayana*** coppices well as it is reported to resprout from the base, stem and roots following wildfire (Hodgkinson 1982; Latz 1995).

Occurrence–Acacia murrayana is widespread in the arid zone, extending from the northern wheatbelt in W.A. through central Australia to Qld (map 212 in Maslin 2001a).

Climate–Climate parameters of the areas of natural occurrence indicate that ***A. murrayana*** prefers hot, persistently dry conditions. The climates of its natural range are characterised by hot dry summers and cold to warm winters. The mean maximum temperature of the hottest months is 34-38°C, the mean minimum temperature of the coldest months is 4-6°C and the mean annual rainfall range is 120-500 mm (Doran ***et al.*** 1997: 190-191). Rainfall seasonality varies from uniform to summer maximum but rainfall is sporadic and unreliable throughout its range. The region receives about 1-8 frosts per year.

Soils–These range from deep red sand and sandy loam to clay loam; pH range is 5.5-6.5.

Phenology and seeds–It flowers profusely from August to November, depending on locality. Plants are precocious, e.g. heavy flowering commenced at age 17 months in a trial in southern Queensland (Ryan and Bell 1989). Pods mature over a short time during November to January. For example, in the northern wheatbelt of Western Australia during 1999, peak flowering occurred on ***A. murrayana*** around 12 October and mature pods were present six weeks later, on 24 November (B.R.Maslin unpubl.). Seeds are moderately large (18 000-27 000 per kg) and are separated easily from the papery pods. It is a heavy, uniform seeder, particularly in favourable seasons and especially in moist ecological niches. While foliage is unpalatable, pods are sought after by stock (Mitchell and Wilcox 1994).

Silviculture–Based on its natural distribution, ***A. murrayana*** is likely to be best-suited for cultivation on recharge areas in the northern wheatbelt region of Western Australia. It should perform best on well-drained soils with a relatively high proportion of sand. The ability of its roots to tap groundwater on recharge sites may also be critical for its successful cultivation. Based on glasshouse trials, ***A. murrayana*** is relatively salt-sensitive and is not recommended for cultivation on saline soil (Aswathappa ***et al***. 1986); it is also unlikely to tolerate waterlogging.

Rainfall data might suggest that watering or irrigation is not essential except during establishment. However, the species often regenerates, grows and fruits heavily on well-watered sites along road verges, and supplementary watering / irrigation is likely to enhance growth, longevity and seed production. Its moderate longevity and coppicing ability mean that repeated harvesting over five or more years is likely to be feasible. Plants can be pruned to one main stem, which would facilitate mechanical harvesting including shaking and catching methods or modified combine harvesters.

The wide geographical range of ***A. murrayana*** with associated substantial climatic variation suggests that provenance selection may be critical for its successful cultivation. Its performance in higher rainfall areas, i.e. greater than 300 mm mean annual rainfall, remains to be ascertained. Assessment should be based on a representative range of provenances.

Genetics–There is no published information on the genetic structure, breeding system or ploidy in this species. Such information will be required as part of any domestication program.

Limitations–Although there are no reports of adventive outbreaks from cultivated stands the weed potential of ***A. murrayana*** is relatively high. This is due to its root suckering ability (especially in disturbed sites such as road verges) and its potential for heavy seeding. Site disturbance by fire, overstocking and road works can lead to large populations of ***A. murrayana*** (Mitchell and Wilcox 1994). When cultivated on adverse sites, the survival, drought tolerance and longevity of ***A. murrayana*** are relatively poor (Maslin ***et al.*** 1998).

Further reading–Thomson 1994; Wilcox and Mitchell 1994; Doran ***et al.*** 1997: 190-191; Maslin 2001a.

3. Acacia anthochaera Maslin

Taxonomy–Acacia anthochaera is a poorly known species belonging to the '***A. prainii*** group' (Maslin 2001a). Until recently it was regarded as a variant of ***A. hemiteles*** with long phyllodes. Putative hybrids between ***A. anthochaera*** and ***A. hemiteles*** are known from their zone of overlap. ***A. anthochaera*** is also related to ***A. murrayana.***

Growth attributes–Acacia anthochaera is usually a dense, rounded, multi-stemmed shrub 2-4 m high. It may develop into a tree to 8 m tall, although arborescent plants are not commonly encountered in the wild. It is not known to produce root suckers. Its growth attributes, including coppicing ability, require investigation.

Occurrence–It is endemic in W.A. where its main area of occurrence is in the northern wheatbelt region from near Yuna south to Cowcowing; also found near Galena and Karroun Hill. In some places it extends slightly east of the wheatbelt into more arid areas.

Soils–Grows on flat, low-lying areas in red-brown sand or loam which varies from slightly to moderately saline; it sometimes grows on the margins of salt lakes.

Climate–Natural populations of ***A. anthochaera*** experience hot dry summers and cold winters. The mean maximum temperature of the hottest months is 34-36°C, the mean minimum temperature of the coldest months is 5-6°C and the mean annual rainfall range is 290-325 mm. Rainfall is strongly seasonal with a winter maximum.

Phenology and seeds–Flowers profusely from August to October, with the main flush in September. Flowering is profuse from a young age. It is an abundant seeder in good seasons; pods mature from late November to January. The reliability of annual fruit set is largely unknown but evidence to date suggests that it is fairly regular. Occasional poor fruit set may be related to the timing and / or intensity of preceding rainfall events. Pods are held terminally on the plants, making them readily accessible for collection. The seeds are medium-sized to large (about 20 000 per kg but needs confirmation: see Maslin 1998) and although retained in the pods following dehiscence, are easily separated by shaking techniques or hand stripping. Given its close taxonomic relationship to ***A. murrayana***, a species traditionally consumed by Australian Aborigines, its seeds are likely to have similar nutritional characteristics.

Silviculture–Acacia anthochaera is a hardy, drought-tolerant species that warrants trial on recharge areas of the northern wheatbelt. Compared to the other species profiled in this paper, it has a relatively restricted natural distribution encompassing only limited environmental variation. Accordingly there is likely to be limited variation in provenance.

Genetics–Nothing known.

Limitations–Many silvicultural and genetic attributes are unknown. There is likely to be less scope for selection and improvement than in other more widespread ***Acacia*** species.

Further reading–Maslin 1995; Maslin ***et al.*** 1998; Maslin 1998.

4. Acacia microbotrya Benth. sens. lat.

Taxonomy–Acacia microbotrya belongs to a large species complex comprising 43 close relatives Australia-wide, the informal '***Acacia microbotrya*** group' (see Maslin 1995 for discussion). This species appears to be most closely related to ***A. amblyophylla*** (confined to the Shark Bay region, W.A.) and ***A. jennerae*** (widespread in arid and semi-arid areas from W.A. through N.T. and S.A. to western N.S.W. and south-western Qld, map 108 in Maslin 2001a). Variation patterns within ***A. microbotrya*** are under investigation and current indications suggest that there are three distinct entities in the species. Plants from north of about the latitude of Moora are treated by Maslin (2001a) as ***A. microbotrya*** var. ***borealis***, those from south of Moora as ***A. microbotrya*** var. ***microbotrya,*** and a third entity, restricted to near Dandaragan, may represent the plant previously described as ***A. subfalcata*** Meisn. Resolution of the variation patterns and the taxonomic status of the entities in this species is essential to facilitate its domestication.

Growth attributes–Acacia microbotrya is a reasonably fast-growing species and, according to Gardner (1957), probably lives for 20-30 years under most conditions. Plants referable to var***. borealis*** are usually spreading shrubs or small trees 2-4 m tall, whereas var. ***microbotrya*** tends to be more robust and grows to small trees 3-6(-7) m tall; the Dandaragan variant develops into substantial trees 7-10(-15) m tall. Root suckering occurs in all three variants and is most evident in disturbed sites such as road verges where clonal thickets sometimes develop. Wood density is not known.

Occurrence–Acacia microbotrya is confined to the Western Australian wheatbelt, extending from the Murchison River to near Katanning with scattered occurrences around Ongerup and Lake King.

Climate–The natural range is characterised by hot dry summers and cold winters. Mean annual rainfall range is 350-550 mm.

Soils–Occurs on a range of soil types including sand and sandy loam but most commonly on clay-loam. The pH range is 5.5-6.0.

Phenology and seeds–The species flowers earlier than many other acacias in south-western W.A., mainly from April to July. Pods mature during October–December. Seeds are large to very large (about 14 000 seeds per kg) and it is normally a heavy seeder, although suckering plants in dense clonal populations usually remain in a vegetative phase.

Silviculture–Acacia microbotrya is hardy, drought- and frost-tolerant with a moderate to fast grow rate and warrants trials throughout recharge areas of the wheatbelt. Plants from different parts of the natural range may vary in their suckering ability. Currently ***A. microbotrya*** is used in direct seeding programs for regeneration and shelterbelt plantings in the northern wheatbelt region of W.A. It is useful as a low windbreak and has potential as a short- to moderate-lived Sandalwood host. While some plants of ***A. microbotrya*** produce reasonable quantities of potentially edible gum it is unlikely to have commercial value; according to Anderson (1978), ***A. senegal*** (Gum Arabic) is the only ***Acacia*** gum that has been toxicologically tested to establish its safety as a food additive.

Genetics–A study is in progress to characterise patterns of genetic variation (Margaret Byrne, CALM, ***pers. comm.***).

Limitations–Effective utilisation of ***A. microbotrya*** is dependent on the resolution of its taxonomic variation.

Further reading–Maslin 2001a, 2001b.

5. Acacia saligna (Labill.) H.L.Wendl.

Taxonomy–Acacia saligna is a variable species and a study by the second author and others will be undertaken in 2002 aimed at elucidating the patterns of variation. It has no known close relatives but is superficially similar to ***A. pycnantha*** (see Maslin 2001a for discussion).

Growth attributes–Acacia saligna has a variable growth form but it normally is a shrub or small tree 2–6 m tall, either single- or multi-stemmed; the mature trunk attains breast height diameter of 20–40 cm. Its crown is bushy and spreading or sometimes pendulous. Some populations form thickets due to its root suckering habit. Life span is about 10-20 years (Whibley and Symon 1992), but it coppices well and biomass production can be optimised by regular annual harvesting (Doran ***et al.*** 1997: 210-213). The wood of ***A. saligna*** has an air-dry density of about 600 kg m^{-3} (Marcar ***et al.*** 1995) and has been successfully processed into particle board in Tunisia (El-Lakany 1987).

Occurrence–Endemic in W.A. where it extends from the Murchison River to east of Esperance, with outlying populations on Meka, Murgoo and Jingemarra Stations (Maslin 2001a). Also naturalised throug south-eastern Australia from south-east Qld to S.A. and Tas.

Climate–Climate parameters indicate that natural populations of ***A. saligna*** tolerate a wide range of climatic conditions, characterised by hot to warm, distinctly dry summers and cold to temperate winters. The mean annual rainfall is 280-1210 mm; the mean maximum temperature of the hottest month 26-36°C; and the mean minimum temperature of the coldest month 4-9°C (Doran ***et al.*** 1997). Rainfall seasonality ranges from winter to uniform; naturalised populations proliferate in summer maximum rainfall zones.

Soil–Acacia saligna grows naturally on a considerable range of soil types ranging from deep sand to clay-loam. The pH range is 5.5-7.5. Based on glasshouse salinity trials, ***A. saligna*** was slightly salt tolerant (Marcar ***et al.*** 1995), but based on field trials, House ***et al.*** (1998) reported ***A. saligna*** to be moderately to highly salt tolerant.

Phenology and seeds–Acacia saligna is a moderate to heavy seeder in most years. In Cyprus its seed yield varied from 54-67 kg ha^{-1} for average plantations (Anon. 1955) up to 170 kg ha^{-1} (Michaelides 1979).

Silviculture–Acacia saligna is suitable for cultivation in all wheatbelt regions of W.A. where it warrants trial in both recharge and discharge areas. Under cultivation it grows rapidly and demonstrates tolerance of calcareous, alkaline and moderately saline soils. In some parts of W.A. it is already planted on areas with a high water table to mitigate salinity. Plantations have been established in Western Australia by mechanised, direct seeding in areas with annual rainfall as low as 350-500 mm (Scheltema 1992). Plantations have also been established from rooted cuttings. Although short-lived (typically 10-15 years) it may be possible to rejuvenate declining stands of ***A. saligna*** by coppicing and / or shallow ploughing to induce root-suckering. Michaelides (1979) recommended a short rotation of 5-10 years duration, with regeneration by coppicing. However, considerable provenance variation should be expected when assessing ***A. saligna*** for any of its domestication attributes. For example, natural stands from the Swan Coastal plain region, particularly between Yanchep and Mandurah, comprise the largest plants known and probably represent the most valuable resource for trials aimed at biomass production. Variation throughout its range in attributes such as seed production, root-suckering and coppicing ability warrant investigation. In northern Africa ***A. saligna*** is highly valued as fodder for sheep and goats (El-Lakany 1987; Crompton 1991) and its potential in this role in W.A. is being assessed (Gaye Krebs, Curtin University of Technology, ***pers. comm.***). The foliage and seeds are protein-rich and particularly palatable to sheep and goats (Michaelides 1979).

Protection of newly established plantations from grazing animals is essential. Gall rust may be a serious problem in some parts of W.A., with more than 90% of ***A. saligna*** trees bearing conspicuous woody galls (Berg 1978), and more research is needed to ascertain to the severity of this infection and possible control measures.

Genetics–Preliminary planting trials in Western Australia indicate that there is considerable provenance variation within this species; a study is in progress to characterise patterns of genetic variation (Margaret Byrne, CALM, ***pers. comm.***).

Limitations–Weediness: the species is currently a major environmental weed in south-eastern Australia, the Mediterranean, South Africa, California, Spain and Portugal.

Further reading–Fox 1995; Maslin 1974; Whibley and Symon 1992; Doran ***et al.*** 1997, pp. 210–213.

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