Invasive Australian acacias on western Indian Ocean islands: a historical and ecological perspective

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Trees and shrubs of the genus *Acacia* from Australia have been widely introduced in tropical and subtropical regions (Midgley & Turnbull, 2003; Brockwell *et al*., 2005). Having evolved in hard ecological conditions, many can colonize poor soils and have thus been heavily utilized in non-conventional forestry; a number are now considered problematic invasives (Cronk & Fuller, 1995; Richardson, 1998).

Australian acacias were introduced to western Indian Ocean islands beginning in the 19th century; some species have become highly invasive (Kueffer *et al*., 2004; Tassin *et al*., 2006). This paper reviews the history of these introductions and their ecological consequences in this geographic area (Madagascar; Seychelles; Comoro Islands; Mascarene Islands). We consider invasive an introduced species that extends beyond its previous range (Williamson, 1996).

At least 43 Australian acacia species have been introduced to western Indian Ocean islands, the majority (39) to Madagascar, especially during the 1950s (27 species). Five species can currently be seen as invasive in this region, seven others have been registered as naturalized (sometimes invasive) in other countries (Table 1).

Bipinnate wattles

The two most invasive species to date are bipinnate cool-climate wattles from south-eastern Australia. The first, *A. dealbata* Link (silver wattle) was introduced in 1841 to Réunion (Trouette, 1898), and probably contemporaneously to Mauritius (Polhill, 1990). It was widely planted in Réunion to control erosion and is locally naturalized. It

was introduced around 1900 to Madagascar for afforestation, railway fuel, and roadside shade (François, 1925). Mid-century it was widely sown, sometimes unsuccessfully from airplanes; by the late 1960s it covered more than 30,000 ha (Roche, 1956; Chauvet, 1968). It is now widespread in cooler zones of the central highlands (over 1200m) where we estimate varying densities of presence on circa 300,000 ha. Most growth is spontaneous from seeds and re-sprouting roots. Given seed persistence, multiple dispersal mechanisms (water, wind, ants), and the plant's behaviour in comparable environments (e.g. southern Africa), it has a high potential of becoming ecologically problematic and has been noted as invasive (Binggeli, 2003). However, most policymakers do not currently consider it as a threat due to its utility (e.g., woodfuel, construction, fertilizer) and because it reforests open, degraded zones (Kull *et al*., 2007).

The second, *A. mearnsii* De Wild. (black wattle), was introduced to Réunion in the late 1870s (Trouette, 1898), and widely planted in Madagascar in the 1920s (François, 1925). Seeking to emulate successful tannin production in Africa, the French established plantations around Moramanga and east of Fianarantsoa (Kull *et al.* 2007). The tree has naturalized around now-abandoned plantations and is known to pioneer forest clearings. It has been found in Ranomafana National Park, where it may become problematic (Vahinala Project, 2007). On Réunion, the species was promoted during the early 1950s to restore fertility in *Pelargonium* fallows but became invasive following the 1960s collapse of the market for this cash crop. Bird diversity remains very poor in naturally regenerated *A. mearnsii* stands (Tassin & Balent, 2004).

Phyllodinous acacias

The phyllodinous cool-climate *A. melanoxylon* R. Br. (blackwood) is less widespread than the bipinnate wattles, yet also invasive in places. In Madagascar, it was one of hundreds of exotic trees introduced in the 1950s (Chauvet, 1968; FOFIFA, 1990). It has naturalized around a defunct arboretum at 2000m in the Ankaratra mountains (C. Kull, *pers. obs*.). In Réunion, it is invasive and threatens some native populations of its close relative *Acacia Heterophylla* (Lam.) Willd. The origins of *A. heterophylla* in Réunion, as a polyploid of *A. melanoxylon*, are not clear (Coulaud *et al.*, 1995). Introduction through petrels, which, as burrowing seabirds, can disperse seeds (Mulder & Keall, 2001), is a possibility.

Phyllodinous acacias from tropical Australia and adjacent islands are more recent introductions but present high potential for future spread. Their ability to grow on poor soils makes them highly competitive. These species – *A. aulacocarpa* A. Cunn. ex Benth.*, A. auriculiformis* A. Cunn. ex Benth.*, A. crassicarpa* A. Cunn. ex Benth.*, A. holosericea* A. Cunn. ex G. Don*, A. leptocarpa* A. Cunn. ex Benth.*, A. mangium* Willd.*,* and *A. trachycarpa* E. Pritz.– were widely tested and disseminated beginning in the 1980s for reforestation and agroforestry (Chaix & Ramamonjisoa, 2001; Midgley & Turnbull, 2003). *A. auriculiformis* and *A. mangium,* are noted as invasive in the Comoros, where they invade *padza* badlands (Kueffer *et al.,* 2004). These species, together with *A. crassicarpa*, grow well in low to mid elevation humid and subhumid zones on Madagascar, and have demonstrated invasive behaviour (G. Chaix, *pers. comm.*). On Réunion, foresters destroyed invasive patches of several of these trees in 2006 at the vicinity of old forestry trials.

Some other Australian species are not yet invasive but may become problematic, such as *Acacia polystachya* A. Cunn. ex Benth. in Seychelles (Kueffer *et al*., 2004). No Australian *Acacia* species is recorded to be invasive in Mauritius and Rodrigues (Kueffer *et al*., 2004).

Recommendations

Both bipinnate and phyllodinous groups of *Acacia* contain invasive species. Early detection and rapid control are needed to prevent new invasions. Most attention should be given to species with a history of heavy planting in numerous localities (particularly *A. dealbata*, *A. mearnsii*, but also the tropical phylodinous acacias) as invasion is more likely with longer presence and high propagule pressure (Krivanek *et al*., 2006), and to additional species known to be invasive elsewhere (Table 1; e.g. *A. longifolia* (Andrews) Willd., *A. pycnantha* Benth., *A. saligna* (Labill.) H. L. Wendl.). A main concern is that the ecological impacts of several acacia invasions, particularly on Madagascar, are currently under-evaluated, as opposed to documentation of their utility to farmers and for soil rehabilitation (e.g. Kull *et al.* 2007).There is a need (i) for further research on the ecological impacts of these introduced species (see Binggeli, 2003), (ii) to develop and implement legislation to control the introduction of other species, (iii) and to develop early detection procedures near critical biodiversity conservation sites.

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Table 1: List and characterization of the Australian *Acacia* species introduced in the Western Indian Ocean islands. Mad: Madagascar; Anj: Anjouan; May: Mayotte; Moh: Mohéli; Réu: Réunion; Mau: Mauritius; Rod: Rodrigues; Sey: Seychelles.
NSW: New South Wales; NT: Northern Territory; QLD: Queensland; T: Tasmania; V: Victoria; WA: Western Australia; PNG: Papua New Guinea; Indo: Indonesia. "Enviro. services" includes more than one of the following: reforestation (and associated goals like woodfuel), watershed protection, dune stabilization, or soil conservation. Sources: authors; Polhill, 1990; Chaix & Ramamonjisoa, 2001; Maslin, 2001; Kueffer *et al*., 2004; Tassin *et al*., 2006.

Species	Earliest known date	State of origin	Purpose	Recorded naturalization or invasion elsewhere	Status on W. Indian Ocean islands
A. acuminata Benth.	1955 (Mad)	NSW, SA, WA	Enviro. services	-	Unusccessful (Mad)
A. ancistrocarpa Maiden & Blakely	1991 (Réu)	NSW, NT	Enviro. services	-	Planted (Réu)
A. aneura F. Muell. ex Benth.	1952 (Mad)	NSW, NT, QLD, SA, WA	Enviro. services	-	Unusccessful (Mad)
A. aulacocarpa A. Cunn. ex Benth.	1990s (Mad)	QLD, NSW	Enviro. services	Cook Islands	Planted (Mad)
A. auriculiformis A. Cunn. ex Benth.	1959 (Mad) & 1980s (Mad, May, Moh)	NT, QLD, PNG, Indo	Enviro. services	Pacific, s.e. Asia	Planted (Mau, Réu), **invasive** (Com, Mad)
A. baileyana F. Muell.	1952 (Mad)	NSW	Enviro. services, ornamental	Africa, New Zealand, w. United States	Planted (Mad)
A. bivenosa DC.	1991 (Réu)	NT, QLD, WA	Dune stabilization	-	Planted (Réu)
A. buxifolia A. Cunn.	1956 (Mad)	NSW, QLD, V	Enviro. services	-	Unusccessful (Mad)
A. cambagei R. T. Baker	1952 (Mad)	NSW, NT, QLS, SA	Enviro. services	-	Unusccessful (Mad)

A. crassicarpa A. Cunn. ex Benth.	1990s (Mad)	QLD, PNG	Enviro. services	Cook Islands, s.e. Asia	Planted (Réu), **invasive** (Mad)
A. cultriformis A. Cunn. ex G. Don	1952 (Mad)	NSW, QLD	Enviro. services	-	Planted (Mad)
A. cyclops A. Cunn. ex G. Don	1951 (Mad)	SA, WA	Enviro. services	Europe, s. Africa, w. United States	Planted (Mad)
A. dealbata Link	~1900 (Mad)	NSW, T, V	Enviro. services, railway fuel, shade	Europe, s. Africa, New Zealand, w. United States, Azores	**Invasive** (Mad, Réu)
A. decurrens Willd.	1910s (Mad)	NSW	Tanbark	s. Africa, New Zealand, Hawaii	**Naturalized** (Mad)
A. elata A. Cunn. ex Benth.	1957 (Mad)	NSW	Enviro. services	s. Africa	Unusccessful (Mad)
A. falcata Willd.	1956 (Mad)	NSW, QLD	Enviro. services	-	Planted (Mad)
A. hemiteles Benth.	1955 (Mad)	SA, WA	Enviro. services	-	Unsuccessful (Mad)
A. holosericea A. Cunn. ex G. Don	1991 (Réu), 1990s (Mad)	NT, QLD, WA	Enviro. services, Dune stabilization	-	Planted (Réu, Mad)
A. howittii F. Muell.	1954 (Mad)	V	Enviro. services	-	Unusccessful (Mad)
A. leptocarpa A. Cunn. ex Benth.	1990s (Mad)	NT, QLD, WA, PNG		-	Planted (Mad)
A. linifolia (Vent.) Willd.	1956 (Mad)	NSW	Enviro. services	-	Unusccessful (Mad)
A. longifolia (Andrews) Willd.	1950 (Mad)	NSA, QLD, SA, T, V	Enviro. services, ornamental	s. Europe, s. Africa, New Zealand, s. United States	Planted (Mad, Mau, Rod)
A. mangium Willd.	before 1870 (May, Moh), 1980s (Anj, Mad), 1994 (Réu)	QLD, PNG, Indo	Enviro. services, forestry	widespread in Pacific, s.e. Asia	Planted (Réu, Sey), **invasive** (Com, Mad)
A. mearnsii De Wild.	1907 (Mad), 1870s (Réu)	NSW, SA, T, V	Enviro. services, tanbark, railway fuel	s. & e. Africa, New Zealand, West Indies, Macronesia, Hawaii	Planted (Sey), **invasive** (Mad, Réu)
A. melanoxylon R. Br.	1951 (Mad)	NSW, QLD, SA, T, V	Forestry, Enviro. services, ornamental	Africa, New Zealand, w. United States, s. South America, Azores, Hawaii	Planted (Mau, Rod), **naturalized** (Mad, Réu),
A. microbotrya Benth.	1955 (Mad)	WA	Enviro. services	-	Planted (Mad)
A. obtusata Sieber ex DC.	1956 (Mad)	NSW	Enviro. services	-	Unusccessful (Mad)
A. omalophylla A. Cunn. ex Benth.	1957 (Mad)	NSW, QLD, V	Enviro. services	-	Planted (Mad)
A. paradoxa DC.	1954 (Mad)	NSW, QLD, SA, V, WA	Enviro. services	-	Unusccessful (Mad)
A. pendula A. Cunn. ex G. Don	1952 (Mad)	NSW, QLD, V	Enviro. services	-	Unusccessful (Mad)
A. podalyriifolia A. Cunn. ex G. Don	1954 (Mad)	NSW, QLD	Ornamental	s. Africa	Planted (Mad)
A. polystachya A. Cunn. ex Benth.	? (Sey)	QLD	Enviro. services	-	Planted (Sey)
A. pubescens (Vent.) R. Br.	1955 (Mad)	NSW	Enviro. services	-	Planted (Mad)
A. pycnantha Benth.	1951 (Mad)	NSW, SA, V	Enviro. services	s. Africa, w. United States	Planted (Mad)
A. retinoides Schltdl.	1954 (Mad)	SA, T, V	Enviro. services	-	Unusccessful (Mad)
A. saligna (Labill.) H. L. Wendl.	1952 (Mad)	WA	Enviro. services	Africa, w. United States	Planted (Mad)
A. spectabilis A. Cunn. ex Benth.	1950s (Mad)	NSW, QLD	Enviro. services	-	Unusccessful (Mad)
A. steedmani Maiden	1955 (Mad)	WA	Enviro. services	-	Unusccessful (Mad)
A. stenophylla A. Cunn. ex Benth.	1954 (Mad)	NSW, NT, QLD, SA, V, WA	Enviro. services	-	Unusccessful (Mad)
A. suaveolens (Sm.) Willd.	1956 (Mad)	NSW, QLD, SA, T, V	Enviro. services	-	Planted (Mad)

A. terminalis (Salisb.) J. F. Macbr.	1956 (Mad)	NSW, T, V	Enviro. services		Unusccessful (Mad)
A. trachycarpa E. Pritz.	1990 (Réu)	WA	Enviro. services	-	Planted (Réu)
A. verticillata (L'Her.) Willd.	1954 (Mad)	NSW, SA, T, V	Enviro. services	-	Unusccessful (Mad)

Figure 1: Map of western Indian Ocean locations (drawn by K. Valle).