

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

C. A. Kull<sup>1\*</sup>, J. Tassin<sup>2</sup>, G. Rambeloarisoa<sup>3</sup> and J.-M. Sarrailh<sup>4</sup>

This is an author-archived preprint version of an article published in the AFRICAN JOURNAL OF ECOLOGY. The final, definitive version is available via Wiley at <http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2028.2007.00892.x/abstract> or via DOI lookup at <http://dx.doi.org/10.1111/j.1365-2028.2007.00892.x>

Citation: Kull CA, J Tassin, G Rambeloarisoa & JM Sarrailh (2008) Invasive Australian acacias on western Indian Ocean islands: a historical and ecological perspective. *African Journal of Ecology* 46 (4): p.684-89.

<sup>1</sup>School of Geography and Environmental Science, Monash University, Melbourne, Australia

<sup>2</sup>CIRAD, UPR 37, Campus de Baillarguet, 34398 Montpellier Cedex 5, France

<sup>3</sup>WWF Madagascar and West Indian Ocean Programme Office, Antananarivo, Madagascar

<sup>4</sup>CIRAD, UMR PVBMT, 7 chemin de l'IRAT, 97410 Saint-Pierre, La Réunion, France

Email addresses: [christian.kull@arts.monash.edu](mailto:christian.kull@arts.monash.edu); [jacques.tassin@cirad.fr](mailto:jacques.tassin@cirad.fr); [GRambeloarisoa@wwf.mg](mailto:GRambeloarisoa@wwf.mg); [jean-michel.sarrailh@cirad.fr](mailto:jean-michel.sarrailh@cirad.fr)

\*Correspondence: Christian Kull - E-mail: [christian.kull@arts.monash.edu](mailto:christian.kull@arts.monash.edu)

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 19<sup>th</sup> 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. crassicalpa* 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. crassicalpa*, 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 phyllodinous 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.

## Acknowledgements

J. Triolo and G. Chaix shared valuable information on the status of acacias on Réunion and Madagascar, respectively.

## References

- BINGGELI, P. (2003) Introduced and invasive plants. In: *Natural History of Madagascar* (Ed. S.M. GOODMAN & J.P. BENSTEAD). University of Chicago Press, Chicago.
- BROCKWELL, J., SEARLE, S., JEAUVONS, A. & WAAYERS, M. (2005) *Nitrogen Fixation in Acacias*. ACIAR, Canberra.
- CHAIX, G. & L. RAMAMONJISOA (2001) Production de semences pour les reboisements malgaches. *Bois For. Trop.* **269**, 49-63.
- CHAUVET, B. (1968) *Inventaire des espèces forestières introduites à Madagascar*. University of Tananarive, Antananarivo.
- CRONK, Q.C.B. & FULLER, J.L. (1995) *Plant invaders: the threat to natural ecosystems*. Chapman & Hall, London.
- COULAUD, J., BROWN, S.C. & SILJAK-YAKOVLEV, S. (1995) First cytogenetic investigation in populations of *Acacia heterophylla*, endemic from La Reunion Island, with reference to *A. melanoxylon*. *Ann.Bot.* **75**, 95-100.
- FOFIFA (1990) *Introduction d'espèces exotiques à Madagascar*. FOFIFA, Antananarivo.
- FRANÇOIS, E. (1925) La culture des acacias à tannins à Madagascar. *Rev. Bot. Appl. Agr. Col.* **5**, 348-358 & 436-442.
- KRIVANEK, M., PYSEK, P. & JAROSIK, V. (2006) Planting history and propagule pressure as predictors of invasion by woody species in a temperate region. *Conserv. Biol.* **20**, 1487-1498.
- KUEFFER, C., VOS, P., LAVERGNE, C. & MAUREMOOTOO, J. (2004) *Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean: I. Synthesis*. Forest Health & Biosecurity Working Papers FBS/4-5E. Forestry Department, Food and Agriculture Organization of the United Nations, Rome.
- KULL, C.A., TASSIN, J., & RANGAN, H. (2007) Multifunctional, Scrubby, and Invasive Forests? Wattles in the Highlands of Madagascar. *Mt. Res. Dev.* **27**, 224-231.
- MASLIN, B.R. (2001) *Wattles: Acacias of Australia*. CSIRO Publishing, Collingwood.

- MIDGLEY, S. J. & J. W. TURNBULL (2003) Domestication and use of Australian acacias: case studies of five important species. *Austr. Syst. Bot.* **16**, 89-102.
- MULDER, C.P.H. & KEALL, S.N. (2001) Burrowing seabirds and reptiles: impact on seeds, seedlings and soils in an island forest in New Zealand. *Oecologia* **127**, 350-360.
- POLHILL, R.M. (1990) *Légumineuses. Flore des Mascareignes*. MSIRI, ORSTOM, Kew Gardens, Paris.
- RICHARDSON, D.M. (1998) Forestry trees as invasive aliens. *Conserv. Biol.* **12**, 18-26.
- ROCHE, P. (1956) *Techniques de conservation des sols appliquées dans la région du Lac Alaotra*. IRSM, Antananarivo.
- TASSIN, J. & BALENT, G. (2004) Le diagnostic d'invasion d'une essence forestière en milieu rural : exemple d'*Acacia mearnsii* à La Réunion. *Rev. For. Fr.* **56**, 132-142.
- TASSIN, J., RIVIÈRE, J.-N., CAZANOVE, M. & BRUZZESE, E. (2006) Ranking of invasive woody plant species for management on Réunion Island. *Weed Res.* **46**, 388-403.
- TROUETTE, E. (1898) *Introduction de végétaux à l'Île de La Réunion*. Typo Lahuppe, Saint-Denis.
- VAHINALA PROJECT (2007) A catalogue of the vascular plants of Madagascar. Missouri Botanical Garden, available at [www.efloras.org](http://www.efloras.org).
- VOS, P. (2004) *Etude des plantes ligneuses envahissantes de l'archipel des Comores (Union des Comores et Mayotte)*. Note thématique sur la santé des forêts et la biosécurité. FAO, Rome.
- WILLIAMSON, M. (1996) *Biological invasions*. Chapman & Hall, London.

**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
<i>A. acuminata</i> Benth.	1955 (Mad)	NSW, SA, WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. ancistrocarpa</i> Maiden & Blakely	1991 (Réu)	NSW, NT	Enviro. services	-	Planted (Réu)
<i>A. aneura</i> F. Muell. ex Benth.	1952 (Mad)	NSW, NT, QLD, SA, WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. aulacocarpa</i> A. Cunn. ex Benth.	1990s (Mad)	QLD, NSW	Enviro. services	Cook Islands	Planted (Mad)
<i>A. auriculiformis</i> A. Cunn. ex Benth.	1959 (Mad) & 1980s (Mad, May, Moh)	NT, QLD, PNG, Indo	Enviro. services	Pacific, s.e. Asia	Planted (Mau, Réu), <b>invasive</b> (Com, Mad)
<i>A. baileyana</i> F. Muell.	1952 (Mad)	NSW	Enviro. services, ornamental	Africa, New Zealand, w. United States	Planted (Mad)
<i>A. bivenosa</i> DC.	1991 (Réu)	NT, QLD, WA	Dune stabilization	-	Planted (Réu)
<i>A. buxifolia</i> A. Cunn.	1956 (Mad)	NSW, QLD, V	Enviro. services	-	Unsuccessful (Mad)
<i>A. cambagei</i> R. T. Baker	1952 (Mad)	NSW, NT, QLS, SA	Enviro. services	-	Unsuccessful (Mad)

<i>A. crassicaarpa</i> A. Cunn. ex Benth.	1990s (Mad)	QLD, PNG	Enviro. services	Cook Islands, s.e. Asia	Planted (Réu), <b>invasive</b> (Mad)
<i>A. cultriformis</i> A. Cunn. ex G. Don	1952 (Mad)	NSW, QLD	Enviro. services	-	Planted (Mad)
<i>A. cyclops</i> A. Cunn. ex G. Don	1951 (Mad)	SA, WA	Enviro. services	Europe, s. Africa, w. United States	Planted (Mad)
<i>A. dealbata</i> Link	~1900 (Mad)	NSW, T, V	Enviro. services, railway fuel, shade	Europe, s. Africa, New Zealand, w. United States, Azores	<b>Invasive</b> (Mad, Réu)
<i>A. decurrens</i> Willd.	1910s (Mad)	NSW	Tanbark	s. Africa, New Zealand, Hawaii	<b>Naturalized</b> (Mad)
<i>A. elata</i> A. Cunn. ex Benth.	1957 (Mad)	NSW	Enviro. services	s. Africa	Unsuccessful (Mad)
<i>A. falcata</i> Willd.	1956 (Mad)	NSW, QLD	Enviro. services	-	Planted (Mad)
<i>A. hemiteles</i> Benth.	1955 (Mad)	SA, WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. holosericea</i> A. Cunn. ex G. Don	1991 (Réu), 1990s (Mad)	NT, QLD, WA	Enviro. services, Dune stabilization	-	Planted (Réu, Mad)
<i>A. howittii</i> F. Muell.	1954 (Mad)	V	Enviro. services	-	Unsuccessful (Mad)
<i>A. leptocarpa</i> A. Cunn. ex Benth.	1990s (Mad)	NT, QLD, WA, PNG	-	-	Planted (Mad)
<i>A. linifolia</i> (Vent.) Willd.	1956 (Mad)	NSW	Enviro. services	-	Unsuccessful (Mad)
<i>A. longifolia</i> (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)
<i>A. mangium</i> 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), <b>invasive</b> (Com, Mad)
<i>A. mearnsii</i> 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), <b>invasive</b> (Mad, Réu)
<i>A. melanoxylon</i> 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), <b>naturalized</b> (Mad, Réu),
<i>A. microbotrya</i> Benth.	1955 (Mad)	WA	Enviro. services	-	Planted (Mad)
<i>A. obtusata</i> Sieber ex DC.	1956 (Mad)	NSW	Enviro. services	-	Unsuccessful (Mad)
<i>A. omalophylla</i> A. Cunn. ex Benth.	1957 (Mad)	NSW, QLD, V	Enviro. services	-	Planted (Mad)
<i>A. paradoxa</i> DC.	1954 (Mad)	NSW, QLD, SA, V, WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. pendula</i> A. Cunn. ex G. Don	1952 (Mad)	NSW, QLD, V	Enviro. services	-	Unsuccessful (Mad)
<i>A. podalyriifolia</i> A. Cunn. ex G. Don	1954 (Mad)	NSW, QLD	Ornamental	s. Africa	Planted (Mad)
<i>A. polystachya</i> A. Cunn. ex Benth.	? (Sey)	QLD	Enviro. services	-	Planted (Sey)
<i>A. pubescens</i> (Vent.) R. Br.	1955 (Mad)	NSW	Enviro. services	-	Planted (Mad)
<i>A. pycnantha</i> Benth.	1951 (Mad)	NSW, SA, V	Enviro. services	s. Africa, w. United States	Planted (Mad)
<i>A. retinoides</i> Schltld.	1954 (Mad)	SA, T, V	Enviro. services	-	Unsuccessful (Mad)
<i>A. saligna</i> (Labill.) H. L. Wendl.	1952 (Mad)	WA	Enviro. services	Africa, w. United States	Planted (Mad)
<i>A. spectabilis</i> A. Cunn. ex Benth.	1950s (Mad)	NSW, QLD	Enviro. services	-	Unsuccessful (Mad)
<i>A. steedmani</i> Maiden	1955 (Mad)	WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. stenophylla</i> A. Cunn. ex Benth.	1954 (Mad)	NSW, NT, QLD, SA, V, WA	Enviro. services	-	Unsuccessful (Mad)
<i>A. suaveolens</i> (Sm.) Willd.	1956 (Mad)	NSW, QLD, SA, T, V	Enviro. services	-	Planted (Mad)

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

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

