

## A review on General Description of *Vachellia farnesiana* (L.) Wight & Arn.

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**ABSTRACT:** This review summarizes the extensive published literature on *Vachellia farnesiana* (Synonyms *Acacia farnesiana* (L.) Willd.) known as an invasive species by firstly providing an overview of its description, general biology and utility. We then critically reviewing ecological literature examining the biotic and abiotic interactions that drive the population and community dynamics of this species followed by information on its invasive status and management. We highlight critical research questions that remain unresolved about an invasive species.

**Keywords:** *Vachellia farnesiana*, description, biology, utility

### *Vachellia farnesiana* (L.) Wight & Arn.'ın Genel Tanımlanması Üzerine Bir Değerlendirme

**ÖZET:** Bu derleme, istilacı özelliğe sahip *Vachellia farnesiana*'nın (Synonyms *Acacia farnesiana* (L.) Willd.) biyolojisi, tanımlanması ve kullanımı ile ilgili mevcut literatür bilgilerinin toplanması, bitki ile ilgili sorunların çözümüne yönelik önerilerde bulunulması amacıyla planlanmıştır. Bu çalışmanın türünün yönetimi, istilacı özelliği, popülasyon ve vejetasyon dinamiklerinin biyotik ve abiyotik ilişkileri irdelenmiştir.

**Anahtar Kelimeler:** *Vachellia farnesiana*, tanımlanması, biyolojisi, kullanımı

### INTRODUCTION

This review summarizes the extensive published literature on *Vachellia farnesiana* by firstly providing an overview of its description, general biology and utility. We then critically reviewing ecological literature examining the biotic and abiotic interactions that drive the population and community dynamics of this species followed by information on its invasive status and management. We highlight critical research questions that remain unresolved in the Australian context of an invasive species.

The species genus *Acacia* (Fabaceae: Mimosoideae) has been known to contain a number of groups, based on molecular and morphological studies, that have required division into at least five genera (*Acacia*, *Senegalia*, Genus 'x', *Acaciala* and *Racoperma*) (Maslin et al. 2003). The currently recognized genus *Vachellia* (formerly know as the *Acacia* subgenus *Acacia*) comprises of 163 species, 133 in Africa and the Americas, 36 in Asia and 11 species in Australia (Kodala and Wilson 2006; Clarke et al. 2009). Nine of the endemic Australian species are restricted to the tropics whilst two are thought to be introduced. *Vachellia nilotica* is naturalized in northern Australia whilst *Vachellia farnesiana* is widespread in subtropical and tropical regions of Australia and is thought to have arrived prior to European colonization (Kodala and Wilson 2006). *Vachellia farnesiana* is widespread outside Australia being founding central America, Africa and Asia (Fig. 1).

These species of *Vachellia* consists mostly of

shrubs and small trees and their ranges extend from cool to tropical regions. *Vachellia* is often a dominant trees or shrubs in tropical and subtropical woodlands, savannas, and also occur in the temperate regions of the world. For example, it used for timber, firewood, charcoal, tannin, gums, scents, fodder, twigs, bee forage and human nourishment (Cervantes et al. 1998; Schelin et al. 2004). *Vachellia farnesiana* also has the ability to fix nitrogen and increase soil fertility. The spread of these species can have both beneficial and detrimental economic impacts on human enterprises such as agriculture, livestock production, forestry and tourist activities, and as well as ecosystem and biodiversity (Arevalo et al. 2010).

### GENERAL DESCRIPTION

#### Common names

As might be expected there are a plethora of common names given to *Vachellia farnesiana* around the world including sweet acacia, aramo (Panama); espino blanco, espino ruco (El Salvador), huisache (Mexico), opoponax, ant acacia (United States); klu (Hawaii); Ellington curse, vaivai vakavotona, ban baburi (Fiji), Amber ağacı (Turkey). In Australia it is known as Mimosa Bush, Cassie, Farnese Wattle, or Thorny Acacia.

#### Taxonomic description

In New South Wales *Vachellia farnesiana* is described as a spreading shrub mostly 1.5–4 m high; bark smooth or finely fissured, grey-brown;

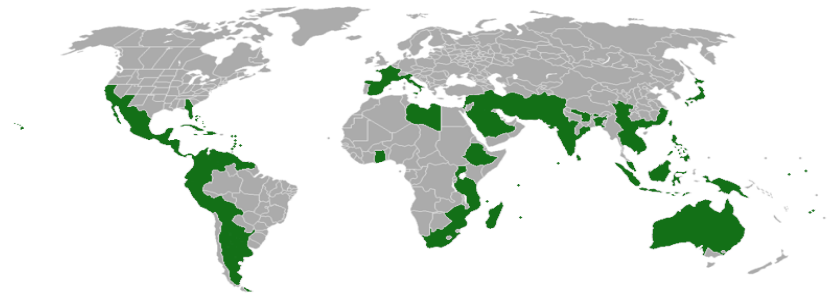


Figure 1. *Vachellia farnesiana* range map in the World (From Wikipedia).

branchlets  $\pm$  zigzagged, often hairy towards apex, glabrous with age, with prominent lenticels.

Leaves with petiole 0.2–2 cm long, hairy especially above, with a circular to elongated gland; rachis 0.3–5.5 cm long, hairy especially above, occasionally with a sugary gland at apex, interjugal glands absent; pinnae 1–7 pairs, 1–4 cm long, hairy especially above; pinnules 5–23 pairs, mostly narrow-oblong, 3–10 mm long, 0.5–2 mm wide, with minute hairs on margin near base (sometimes towards apex) or glabrous, midvein and lateral veins more visible and slightly raised beneath; stipules spinescent, usually 5–25 mm long.

Heads globose, 33–95-flowered, bright yellow or orange-yellow, 1–3 or more in axil of leaves; peduncles mostly 3–30 mm long, hairy.

Pods cigar-like, straight to strongly curved,  $\pm$  terete, turgid, 1.5–8.5 cm long, 8–17 mm wide, dark brown to blackish, glabrous; seeds transverse or oblique, separated by pith.’ (New South Wales Flora online 2010).

#### **Distribution and habitats**

*Vachellia farnesiana* has a pantropical distribution, but was probably introduced in the Old World (Isely, 1969). In the New World it occurs from the southern United States in southern Arizona, Texas and South Florida through the Bahamas and the West Indies, Mexico and Central America to Argentina in South America (Clarke et al. 1989). *Vachellia farnesiana* var. *farnesiana* is found in relatively dry, disturbed habitats throughout much of the tropical and subtropical region of the New World where it is common as an early successional species (Bush and Van Auken 1995).

#### **BIOLOGY**

##### **Morphology**

*Vachellia farnesiana* is a medium-sized shrub up to 7 m high, much branched and very spiny and grows to about 3m high and 2m diameters and is thought to live for 10-50 years. The older bark is dark brown and smooth (Tame, 1992). Plants have a deep

taproot and symbiotic nitrogen fixing bacteria live in a mutuality association on its roots. *Vachellia farnesiana* is evergreen and the leaves are alternate, bipinnately compound with two to six pairs of pinnae, each with 10 to 25 pairs of narrow leaflets 3 to 5 mm in length. The small twigs are dark brown with light-colored dots and paired spines 3 to 20 mm in length at the nodes (Tame, 1992).

##### **Reproduction and dispersal**

Flowering occurs during spring and the flowers are an orange color, very fragrant with a smell of violets. They are grouped in 50 or more global heads and are produced over a period of 2 to 4 months. The fruit is a green pod, turning black or dark brown at maturity, thick, indehiscent, cylindrical, 4-8 cm long and 0.8-1.5 cm in diameter. Each pod contains 12 to 14 seeds (Tame, 1992; Paiva, 1999; PIER, 2003). Biotic stress factors can markedly depress the reproductive capacity due to severely reducing the proportion of fertile filled seeds (Pigott et al. 1992; Garcia and Mejia 2000) although pollen limitation may also be a factor in seed set as species of *Vachellia* are known to be self incompatible.

Seeds of *Vachellia farnesiana* have a hard seed coat that as do many leguminous seeds acts as a barrier for the uptake of water and diffusion of oxygen into the embryo (Cervantes et al. 1996). Hence this species has a physical dormancy mechanism that can be broken using fire, high temperature, light, abrasion and ingestion by animals under natural condition (Rolston, 1978; Bewley and Black 1994; Cervantes et al. 1996; Soliman et al. 2010; Erkovan et al. 2013). Remarkably, *Vachellia farnesiana* can remain viable at room temperature for as long as 151 year (Leino and Edqvist 2010) suggesting it may have a large dormant seed bank in the field. Seed germination and plant growth traits allow this species to have a broad geographic range (Garcia and Mejia 2000).

*Vachellia farnesiana* fruits float in water and so are readily dispersed by streams and floodwaters over large areas. Seeds of *V. farnesiana* can also be

readily dispersed by animals that consume its fruits. In Mexico, its fruit and leaves are readily consumed by sheep during the dry season (Garcia-Winder et al. 2009) and hence may aid in dispersal (Tran and Cavanagh 1984).

Smith (1985) reported that when the aerial portions are killed by fire, this species soon regenerates from basal shoots although *V. farnesiana* is usually propagated from seed, on the other hand, branch cuttings can also be rooted (Webb et al. 1980). It is not known if this species can spread by root sucking.

#### **Germination**

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### **POPULATION ECOLOGY**

#### **Abiotic factors**

The climatic range of *Vachellia farnesiana* includes warm temperate dry through tropical desert to moist forest life zones. Duke (1983) showed annual mean temperature of 14.7–27.8°C. It is reported to tolerate annual precipitation of 64 – 403 mm (Duke, 1983). *Vachellia farnesiana* does not tolerate severe frost and grows well in areas receiving between 500 and 750 mm of rainfall with a dry season of 4 to 6 months. Its best growth occurs on well-drained soils (Parrotta, 2003) and it withstands drought well. Germination is regulated by the need to rupture a hard seed coat followed by adequate moisture and sub-tropical temperatures, hence is common described from disturbed soil (Parrotta, 1992). Germination of seeds is widely reported from the rainy season and can rapidly gives rise to population expansion in pastures (Parrotta, 1992), although there are not published estimates of population expansion in Australia.

*Vachellia farnesiana* can grow under variety of soil conditions usually on well-drained soils in dry localities as well as on loamy or sandy soils including saline soils, at elevations up to 2000 m (Parrotta, 1992). But its best growth is usually on heavy, cracking calcareous clay soils in grasslands in dry habitats between sea level and 1000 m (PIER, 2003).

It can thrive on soils within the range of from pH 5.0–8.0 although in salty soils there may be decreased germinate rate (Rehman et al. 2000). The most suitable soil pH is neutral or near to neutral for nitrogen fixing bacteria that cannot live in acidic soils (Serin and Tan 2001). Under increased CO<sub>2</sub> growth rates increase substantially (Dugas et al. 2001), but growth is strongly limited by drought and to some extent shade (Barros and Barbosa 1995).

*Vachellia farnesiana* can fix atmospheric nitrogen through symbiotic relation with *Rhizobium* allowing growth in nitrogen poor soils. Nitrogen may increase in the soil when nodules senesce or roots die following defoliation. Nitrogen then leaks from the roots and nodules into the soil (Erkovan, 2005; Erkovan et al. 2008). How much nitrogen is fixed and/or transferred to other species by *Vachellia farnesiana* is not well documented upto now.

#### **Biotic factors**

Biotic regulation of different life stages of *Vachellia farnesiana*'s life cycle is well known internationally but it is not in Australia. Pre and post-dispersal seed predation by Bruchid beetles is well documented (Traveset, 1990, 1991), although vertebrate consumption does not appear to affect seed viability. Parrotta (1992) showed that *Vachellia farnesiana* is dispersed by the smaller seed-eating vertebrates like lizards but seeds may be dispersed by ungulates horses, deer and lizards (Traveset, 1990).

Once established there are a number of biotic factors that regulate growth and survival, in particular grazing and browsing commonly occurs by both native and introduced pasture vertebrates. It is browsed by sheep, rabbit, goats, horse, camel, deer and lizards, (Traveset, 1990; Garcia-Winder et al. 2009), when browsed severely large reductions occurs in canopy coverage (Bontrager et al. 1979).

*Vachellia farnesiana* is thought to be an aggressive competitor in pastures and the other disturb area (Parrotta, 1992) because of its rapid height and canopy growth (Rasmussen et al. 1983). In its natural range cover has been shown to reduce grass production for both livestock and native herbivores (Scifers et al. 1982).

### **UTILIZATION**

Whilst *Vachellia farnesiana* is often regarded as an invasive species in many parts of the world, it has been utilized and there is an extensive literature relating to the chemical composition of constituent plant parts, its ability to fix nitrogen and fodder production as well as other ecosystem values.

*Vachellia* species produce many commercial products as do many other plants that belong to the legume group. For example, they are used for timber, firewood, charcoal, tannin, gums, scents, fodder, twigs, bee forage and human nourishment (Cervantes et al. 1998; Schelin et al. 2004). In addition, it has been shown that it has positive benefits in its native semi-arid habitats where it increases levels of soil carbon and nitrogen as well as improving water infiltration and soil structure (Herrera-Arreola et al. 2007).

Seeds of *Vachellia farnesiana* are rich in amino acids such as, lysine, methionine, arginine, glycine, histidine, isoleucine, leucine, phenylalanine, tyrosine, threonine, valine, alanine, aspartic acid, glutamic acid, hydroxyproline, proline, serine (Morton, 1981). The leaves contain lipids, carotenoids, alkaloids, and reducing and non-reducing sugars (Morton, 1981). El Sissi et al. (1973) isolated and identified seven polyphenols from pods (i.e. gallic acid, ellagic acid, m-digallic acid, methyl gallate, kaempferol, atomadendrin, and narigenin).

*Vachellia farnesiana* has been reported to contain anisaldehyde, benzoic acid, benzyl alcohol, butyric acid, coumarin, cresol, cuminaldehyde, decyl aldehyde, eicosane, eugenol, farnesol, geraniol, hydroxyacetophenone, methyleugenol, methyl salicylate, nerolidol, palmitic acid, salicylic acid, and terpineol (Duke, 1981). Also they found narigenin-7-glucoside and naringenin-7-rhamnoglucoside (naringin), as well as naringenin, glucose, and gallic acid in the seed and leaves. Seigler et al. (1979) found that the major cyanogenic glycosides of *Vachellia farnesiana* are linamarin and lotaustralin, and that the amount of cyanide produced by plants within a population varies from below the level of detection to approximately 5  $\mu\text{mol}$  per g of dried plant material. Recently, Clarke et al. (1989) reported that of the numerous Central American specimens of *V. farnesiana* tested for cyanide, 89% gave a positive test. Although most tests were weak, a few were strongly positive. Of the more than 150 specimens examined from South America, only 45% tested positive, with over half being weakly positive.

Whole pods of *A. farnesiana* provide an alternative feed for sheep. In the Americas its foliage and fruits in the dry season are used as sheep feed (Garcia-Winter et al. 2009). Because climatic conditions in arid and semi arid regions limit the growth of forage species those that survive during the dry season are particularly valuable to farmers looking for alternative feed for livestock. Crude protein contents, ash and crude fibre of *Vachellia farnesiana* fruits are 121, 12, and 132 g kg/DM, respectively, may be useful alternative feed in the summer dormant periods (Garcia-Winder et al. 2009). Dried seeds of *Acacia* sp. are reported to

contain per 100 g: 377 calories, 7.0 % moisture, 12.6 g protein, 4.6 g fat, 72.4 g carbohydrate, 9.5 g fiber, and 3.4 g ash. Raw leaves of *Acacia* contain per 100 g: 57 calories, 81.4% moisture, 8.0 g protein, 0.6 g fat, 9.0 g carbohydrate, 5.7 g fiber, 1.0 g ash, 93 mg Ca, 84 mg P, 3.7 mg Fe, 12,255 g-carotene equivalent, 0.20 mg thiamine, 0.17 mg riboflavin, 8.5 mg niacin, and 49 mg ascorbic acid (Van Etten et al. 1963). However, the digestibility of its leaves is significantly lower than Lucerne hay, but crude protein utilization and dry matter intake are similar for goats. The addition of other feeds such as grass may increase performance. It can be of considerable value in supplementing the diet of roughage provided by the *Astrebla* and *Dichanthium* native grasses in the dry season (Everist, 1969; Waghorn and McNabb 2003). Tannins that decrease the palatability of the forage provided by *A. farnesiana*, have an important economic in South and East Africa, Rhodesia, India and the Rio Grande do Sul area of South America (Duke, 1983). The bark and the pods are a source of tannin and are used for tanning and dyeing leather.

The flowers provide a fragrant essential oil which is used in the perfume industry as a violet scent substitute (Le Hou'erou, 2002). A gummy substance obtained from the pods is used in Java as cement for broken crockery. Other parts of the plant are used as an ingredient in the Ivory Coast for arrow poison.

*Vachellia farnesiana* is used in wind breaks, defensive hedges, pasture areas, renew in degraded dry forest and semiarid regions, and as a garden shrub in the developing world. In addition it has been used for heating firewood and for charcoal production. Air-dry wood has a calorific value of 4, 6 kcal/g (Parrotta, 1992). The wood is hard, and is used for posts, turnery, cabinet work, agricultural equipments (Parrotta, 1992). *Vachellia farnesiana* has a seasonal importance source of pollen for production honey (Parrotta, 1992). Leaves and roots of *V. farnesiana* are used as an astringent, demulcent and as tooth brushes in India as well as for medicinal purposes (Duke, 1981; Hartwell, 1971). It is not known whether *V. farnesiana* was used by aboriginal people in Australia.

## MANAGEMENT

### Weed status invasive species status

*Vachellia farnesiana* is noted in many semi-arid parts of the world as an invasive shrub species. For example, in the USA c. 1 million hectare have been colonized due to its spread in the digestive tract of livestock and native vertebrates and reduces

grassland productivity (Meyer and Bovey 1982). More recently its spread on an island has been well documented; Arevalo et al. (2010) suggest that *Vachellia farnesiana* is spreading to new areas very quickly due to dispersion of seed by water, rabbits, birds and followed by enhanced germination. *Vachellia farnesiana* is considered as one of the worst weeds in Fiji (Mune and Parham 1967) and was identified as a management issue in the Northern Territory of Australia some 40 years ago (Hall, 1967).

### Control

The generally negative attitude toward the role of woody plants in rangelands has resulted in much research regarding control since the 1960s (Scifres, 1980). Nevertheless, effective control almost invariably utilizes a range of management factors underpinned by knowledge of the biology and ecology of the species.

*Vachellia farnesiana* is generally destroyed manually by digging out roots and seedlings, and fire burning the stems to ground level and maintaining a fierce heat for several hours followed by cultivation and grubbing (clearing) (Swarbrick, 1997). Mechanical top removal result in only short-term suppression of *Vachellia*, and gives the species competitive advantage (Mutz et al. 1978). However, root plowing or root plowing followed by raking temporarily reduced its density (Rasmussen et al. 1983).

Although the aerial portions may be killed by fire, it soon regenerates from basal shoots (Smith, 1985; Meyer and Bovey 1982). Once established, the seedlings grow rapidly and resprout readily following damage or top removal. Almost pure, dense stands of *A. farnesiana* may develop within two to three growing seasons following brush control methods that disturb the soil (Bontrager et al. 1979). Management activities for enhancing growth and natural regeneration in natural and plantation stands may include control of competing vegetation and periodic soil disturbance (Bontrager et al. 1979; Rasmussen et al. 1983).

*Vachellia farnesiana* is susceptible to translocated herbicides, including picloram, metsulfuorn-methyl, glyphosate and triclopyr, and 2,4-D applied to the foliage, freshly cut stumps or by stem injection at standard rates (Bontrager et al. 1979; Meyer and Bovey 1982). Seedlings and young plants can be controlled, however, by 2,4,5-T ester diluted in 180 liters of water or diesel applied as spray to the leaves and stems but spraying must be repeated (Rasmussen et al. 1983). Shrubs so treated take three to six months to die (Rasmussen et al. 1983). Hall (1967) recommends treating cut stumps

with a mixture of 1 kg of 2,4,5-T in 45 liters of diesel oil. It is also probably susceptible to residual herbicides, including tebuthiuron and hexazinone (Swarbrick, 1997). Sensitive to foliar applications of triclopyr at 1 lb/acre and metsulfuron at 0.45 oz/a and to basal bark applications of 2,4-D or triclopyr at 2% in diesel (Motooka et al. 2002).

In conclusion, *V. farnesiana* is an undesired and invasive plant on the grasslands, but it is essential to save due to produce many commercial products such as timber, firewood, charcoal, tannin, gums, scents, fodder, twigs, bee forage and human nourishment. In addition it is has positive benefits in its native semi-arid habitats where it increases levels of soil carbon and nitrogen as well as improving water infiltration and soil structure.

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