

Bee pollination in the threatened Australian shrub *Senna acclinis* (Caesalpinioideae)

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Williams, G. (c/o Entomology Department, The Australian Museum, 6 College Street, Sydney, NSW, Australia 2000) 1998. Bee pollination in the threatened Australian shrub Senna acclinis (Caesalpinioideae). Cunninghamia 5(3): 767–772. Senna acclinis is a gap-phase shrub primarily restricted to subtropical rainforest remnants in coastal New South Wales and Queensland. The species has declined due to clearing of habitat. Aspects of the reproductive ecology of Senna acclinis were studied in a small population in littoral rainforest on the NSW north coast. Senna acclinis was found to be pollinated by a taxonomically diverse assemblage of generalist native bees. Three of these, Amphylaeus nubilosellus, Hylaeus turgicollaris and Lasioglossum polygona, were observed to buzz pollinate flowers.

Although apparently self-compatible, the anthers do not readily release pollen unless vibrated. Conservation of remaining *Senna acclinis* populations may be dependent on the availability of a pool of pollinators capable of releasing pollen from the poricidal anthers, the elimination of exotic *Senna* species from rainforest remnants, and the presence of appropriate microhabitats such as canopy gaps and sunlit margins.

Introduction

The genus *Senna* (family Fabaceae, subfamily Caesalpinioideae) worldwide comprises approximately 350 species of shrubs and herbs (Harden 1991). Fifteen species are recorded from New South Wales but six of these are exotic species, introduced from the Americas and Africa (Harden 1991), that have become naturalised to varying degrees.

Senna acclinis (F. Muell.) Randell is a native shrub restricted to the central and northern coastal forests of New South Wales, and Queensland. In New South Wales it is chiefly recorded from subtropical rainforest remnants but is now rare owing to clearing of habitats (Harden 1991). *Senna acclinis* is listed as endangered on Schedule 1 of the New South Wales *Threatened Species Conservation Act 1995*, and has a 3RC- ROTAP (Rare or Threatened Australian Plants) status (Briggs & Leigh 1995). Although the reproductive ecology of a number of foreign Caesalpinioideae has been studied (e.g. Silander 1978, Dulberger 1981, Dulberger & Bawa 1994) that of *Senna acclinis* has not been described previously. The aims of this paper are to provide information on the reproductive ecology of *Senna acclinis* and to supplement information currently available for the formulation of management strategies.

Methods and Results

A small clump (approximately 5 × 3 m) containing 14 mature *Senna acclinis* plants was studied during 1996–97 in littoral rainforest at Hallidays Point (32°04'30"S,

152°32'45"E) on the north coast of New South Wales. These plants constituted the majority of known mature plants at this locality. *Senna acclinis* growing and flowering at the study site were restricted to small disturbed openings in the canopy. Seedlings grow below mature plants but neither seedlings nor mature plants were located in undisturbed shaded rainforest understorey elsewhere at the site, suggesting that *Senna acclinis* is a gap-phase species. Visitors to flowers were observed on three occasions in 1996 during daylight. Insects were the only flower visitors observed, but only species that came into contact with the stigma or stamens were considered potential pollinators. Voucher insect specimens were collected for later identification and examination of pollen loads (Table 1). Small native bees, in particular, are very difficult to identify in the field and the need to collect some individuals for identification and reference was unavoidable. Pollen isolated from flower visitors was compared with *Senna acclinis* pollen to determine foraging constancy.

Table 1 Pollen loads on insects visiting *Senna acclinis* flowers (n/a = no apparent pollen; number of foreign pollen species in brackets; 'home' pollen = *Senna* pollen).

Taxa no.	voucher pollen	% 'home'	sites of pollen lodgement
<i>Amphylaeus nubilosellus</i>	1	100	vertex, hind femora, abdominal
	2	71 (1)	ventrites, scattered grains on body
	3	> 90(1-2)	surface generally
	4-8	n/a	
<i>Hylaeus turgicollaris</i>	1	100	foretibia, thorax
	2-3	n/a	
<i>Lasioglossum polygoni</i>	1	100	ventrites 1-2, hind femora
	2	> 99 (1-2)	and tibiae, thorax generally, base
	3	100	of wings, fore, mid and hind leg
	4	~ 60 (1)	
<i>Lasioglossum victoriellum</i>	1	> 95(1)	frons, ventrites 1-2, hind legs
<i>Lasioglossum</i> sp.	1	> 95(1-2)	ventrites 1-6, hind legs
	2	100	
<i>Exoneura</i> sp.	1	100	hind legs, ventrite 1, ventral
	2	100	surface generally
<i>Myrmecia nigrocincta</i>	1	100	mesotibia, mid trochanter mesepisternum
<i>Phanagenia ?fasciata</i>	1	n/a	

Senna acclinis flowers are bisexual but at least partly protogynous; yellow in colour; approximately 30 mm wide at full anthesis (in female-phase flowers the corolla is only partly open and the stigma abuts the anthers; in male-phase flowers the corolla is fully

open); lightly but sweetly fragrant; style long, falcate, narrowly tapered to apex, pale green; stigma lighter creamy green, turning brownish in colour and recurving away from anthers when no longer receptive; stamens usually 10; immature anthers approximately same colour as corolla, ochre in colour when pollen is mature and able to be displaced; anthers dehiscent longitudinally along central suture but pollen does not readily dehisce unless stamens are vibrated (= 'buzz' or vibratile dehiscence); pollen not strongly sculptured. Flowers do not possess obvious nectar rewards or nectariferous glands; most buzz pollinated angiosperms offer pollen as the only reward (Buchmann 1983). There is no depth effect in the corolla, consequently floral morphology does not limit visitor access but the poricidal anthers restrict access to pollen.

To exclude visitors and determine the potential of flowers to self-fertilise, 55 unopened flower buds on four plants were covered with fine nylon fabric bags (29 October 1996). Bags were removed on 20 December 1996 when all flowers in bagged inflorescences had abscised. No fruit had developed from bagged flowers. An additional 16 flowers were similarly bagged in mid-December 1997, and anthers on nine of these were vibrated by hand using a tuning fork (A). Vibration resulted in displacement of pollen, as a distinct cloud, from mature anthers. Although pollen clouds appeared to envelope individual stigmas no fruit developed and all bagged flowers abscised. However, it was difficult to time field visits to coincide with maturation of anthers and so the absence of developing pods from vibrated flowers may be due to flaws in the methodology. In addition, a single *Senna acclinis* plant (18 months old; < 25 cm in height), held in an open nursery shadehouse at Lorien Wildlife Refuge, Lansdowne near Taree, flowered on 25 December 1997 (despite extensive field traverses of the region no other populations of *Senna acclinis* are known within a 25 km radius of this location). The flowers were left unbagged and were accessible to native bees from adjacent riparian subtropical rainforest and wet sclerophyll forest (see Williams & Adam 1997 for species list). Of the three flowers produced, two set fruit (pod 1 = 17 seeds, pod 2 = 21 seeds; of which 7 germinated), indicating that the species is self-compatible, but that unvibrated anthers retain pollen and this acts as a barrier to self-fertilisation.

Visitors to flowers of all 14 mature plants in the clump at Hallidays Point were observed between 1230–1400 hours (E.S.T.) on 26 October 1996 and between 0958–1410 hours on 29 October 1996. Casual observations were also undertaken on 20 December 1996 (no observations were undertaken on the nursery specimen held at Lorien Wildlife Refuge). Species visiting flowers are listed in Table 1.

Six bee species, *Hylaeus turgicollaris* Michener, *Amphylaeus nubilosellus* (Cockerell) (Colletidae-Hylaeinae), *Lasioglossum polygona* (Cockerell), *Lasioglossum victoriellum* (Cockerell), *Lasioglossum (Parasphecodes)* sp. (Halictidae), and *Exoneura* sp. (Anthophoridae), visited *Senna acclinis* plants in the clump. All species carried *Senna acclinis* pollen (Table 1) but only one of the three *Hylaeus turgicollaris* specimens collected carried pollen (4 grains) (Table 1). *Hylaeus turgicollaris* was previously only recorded from the type locality, Jamberoo, approximately 300 km to the south (Cardale 1993). *Lasioglossum polygona*, *Lasioglossum victoriellum*, *Lasioglossum (Parasphecodes)* sp. and *Exoneura* sp. carried large quantities of pollen principally massed on the sternum

(ventral metasoma) and hind femora and tibiae. Exotic honey bees *Apis mellifera* Linn. were common at the site and although recruiting to adjoining mass-flowering *Guioa semiglauc*a (F. Muell.) Radlk. (Sapindaceae) trees in the rainforest canopy were not observed visiting *Senna acclinis* flowers. This may be because *Senna acclinis* does not appear to offer nectar rewards and pollen does not readily dehisce from anthers.

Other insects observed visiting flowers were the large myrmecine ant *Myrmecia nigrocincta* Smith and a pompilid wasp *Phanagenia ?fasciata* Fab. No pollen was isolated from the wasp. *Myrmecia nigrocincta* commonly forages for nectar from numerous flowering trees and shrubs in subtropical rainforest (Williams 1993, 1995). The ability of ants to function as pollinators has been widely debated (reviewed in Williams & Adam 1994) and is dependent upon the nature of the plant breeding system, plant morphology or chemical defenses that deter ant visits, limitations imposed by ant foraging patterns, and the presence and function of ant metapleural gland secretions, which may be toxic to pollen. The ability of *Myrmecia nigrocincta* to function as a pollinator has not been studied but Peakall et al. (1987) have recorded *Myrmecia urens* Lowne pollinating the orchid *Leporella fimbriata* (Lindl.) George. In this example, however, *Myrmecia urens* transported orchid pollinia rather than pollen grains. *Myrmecia nigrocincta* foraged progressively on adjoining plants at Hallidays Point without returning to their nest site between visits to individual plants. Although *Senna acclinis* is apparently self-compatible the inability of *Myrmecia nigrocincta* to appropriately release pollen would restrict its capacity to effect pollination.

In addition to general observations, visitation rates (frequency) by potential pollinators were investigated on two closely adjoining plants (1.5–2 m in height), in the same clump, between 1000–1410 hours on 29 October 1996. Plants were partly shaded when observations commenced and remained largely in partial sunlight throughout this time. The only insect visiting flowers on the two plants during this period was the native bee *Amphylaeus nubilosellus*. Eight voucher specimens were collected, three of which carried *Senna acclinis* pollen (Table 1). Collectively, there were 37 *Amphylaeus nubilosellus* visits during the 4 hours of observation with the plants averaging 1 bee visit every 7 minutes. Individual flowers were often revisited, however, the time between bee visits to flowers ranged from < 1–48 minutes. Time spent foraging at individual flowers ranged from < 1 minute to > 12 minutes. Flowers in full sunlight generally received frequent visits and many shaded flowers were not visited during the period of observation.

Three bees *Amphylaeus nubilosellus*, *Hylaeus turgicollaris* and *Lasioglossum polygona* frequently (but not always) removed pollen from dehiscent anthers by landing on stamens and then vibrating anthers by 'buzzing' their flight muscles. The duration of individual buzzing events was generally less than 2 seconds but the sound was audible over a distance of at least 1 m and was often the only indication that bees were present at flowers. In addition to bees being potentially dusted with pollen, buzz removal of pollen resulted in pollen deposition on the inner surfaces of petals directly below the anthers, and this pollen may become available for transport by other flower visitors. All three bees collected the pollen from the petal surfaces, so that in effect the petals functioned as secondary pollen presenters. After collecting pollen *Amphylaeus*

nubilosellus and *Hylaeus turgicollaris* frequently rested on sunlit leaves and groomed their bodies. Hylaeinae carry pollen in their crop but small amounts of pollen were isolated from the body surfaces of both species (Table 1). That bees would groom following visits to previously 'buzzed' flowers, indicated that single bee visits resulted in partial removal of pollen only. Harder & Barclay (1994) suggest that restricted removal of pollen from flowers with poricidal anthers encourages pollen transport by greater numbers of pollinators and, in turn, acts to promote successful pollen dispersal.

Discussion

Buzz collection of pollen has been recorded in numerous bee taxa (Roubik 1989), including several Australian species (Houston & Thorp 1984, Gross 1993). Gross (1993) observed that anthophorid and halictid bees in tropical Queensland buzz collected pollen from the pioneer shrub *Melastoma affine* D. Don. (Melastomataceae), which has poricidal anthers and thus requires buzz pollination. As with the three species recorded buzz collecting pollen from *Senna acclinis*, the bees observed by Gross, capable of buzz collecting pollen from *Melastoma affine*, did not always buzz anthers.

Although *Senna acclinis* appears to be self-compatible it is dependent on a pool of pollinators capable of removing the generally indehiscent pollen. The bees recorded visiting *Senna acclinis* are generalists (though they may exhibit temporal or spatial foraging constancy to individual flowering species) and have been recorded from other plant taxa (Cardale 1993, Williams 1993, 1995, Williams & Adam 1997). The ability of *Senna acclinis* to recruit pollinators from a pool of bees that are generalist foragers, rather than being dependent upon a single pollinator, may reduce the vulnerability of *Senna acclinis* populations to local extinction. The study site is the subject of a community-based rainforest regeneration project but exotic *Senna pendula* (Willd.) Irwin & Barneby, and less commonly *Senna* × *floribunda* (Cav.) Irwin & Barneby, infest the rainforest margins (P. Muggeridge pers. comm.). Although the exotic species did not flower concomitantly during this study, an overlap in flowering phenology at this site, or elsewhere with other disjunct *Senna acclinis* populations, may impact on the pollination ecology of surviving *Senna acclinis* populations. Bond et al. (1991) record that invading Australian *Acacia* species have 'parasitised' dispersal mutualisms in Cape fynbos vegetation of Southern Africa. *Senna acclinis* seed dispersal mutualisms were not investigated but the dry seeds, though not possessing ant-attracting elaiosomes, have a small peripheral indentation that could facilitate dispersal by ants. Ants are unlikely to disperse seeds over large distances but they potentially disperse seeds to microsites that are advantageous for germination and seedling recruitment (Horvitz 1991).

Conservation action plans aimed at preserving *Senna acclinis* populations need to address possible impacts to plant reproductive ecology posed by sympatric populations of exotic *Senna* species. In addition it may be necessary to artificially manipulate the availability of canopy gaps so that *Senna acclinis* seedlings can continue to recruit within the rainforest community.

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