Disruption of gene flow by drains constructed through native vegetation

David C. Paton, Orietta Surace, Lisa Harris and Danielle Rundle
School of Earth and Environmental Sciences
University of Adelaide SA 5005

Report to the Native Vegetation Council
January 2005

Background

An extensive drainage scheme is being implemented throughout the Upper South East of South Australia as part of reducing the impacts of dryland salinisation on agricultural production. Some of these drains have been dug through native vegetation and as such are likely to disrupt the movements of fossorial (ground-dwelling mammals). The drains may also act as conduits for weed dispersal, and facilitate feral animal movements (along drains and into native vegetation). For native plants and animals these drains are likely to act as barriers and so disrupt local gene flow. The effects on gene flow are difficult to assess with respect to animals but may be more easily documented for selected plant populations. This project aims to document patterns of movements of pollinators in the vicinity of drains in the Upper South East and so assess whether the construction of the drains disrupts gene flow in native plant populations.

The fieldwork for this project consisted of two tasks. The first was to locate one or more populations of plants that had been fragmented by the construction of a drain and to determine if adequate numbers of pollinators were visiting flowers to fully service the pollination requirements of the plants. This assesses whether the disturbance has disrupted pollinator availability to an extent where plants near the drains may set few seeds. The second task involved documenting if the pollinators moved between plants on either side of the drain (i.e. crossed the drain) at a similar frequency and over similar distances to their movements between plants on the same side of the drain. To adequately assess this requires plant species that are abundant and evenly distributed on either side of the drain such that patterns of movements were unlikely to be influenced by the patchiness of the plants as opposed the drain. Only a few plants and areas are potentially suitable, and for the past two years the flowering of key plants has been poor –

The original intention was for this project to be conducted as part of an Honours research program. As yet no suitable students have been available and the opportunities to conduct the study limited by a lack of suitable sites (plant species at appropriate densities) for the study, poor flowering of targeted plants, and seasonal patterns to flowering (not ideal for research by an Honours). However, in 2004 a group of third students, supervised by Dr Paton commenced the project.

The original intention was to use plant species like *Melaleuca halmaturorum*, *M. brevifolia* or Cape Weed (*Arctotheca calendula*) for these assessments because these species are largely if not entirely insect pollinated, often occur in dense populations and are prominent in the vicinity of drains. Although Cape Weed is an introduced plant it frequently forms dense populations that would be ideal for these assessments because of the ease at which insect pollinators can be observed and tracked on prostrate plants relative to more complex (3 dimensional) shrubs like *Melaleuca*. However in spring 2004 *Arctotheca* had few flowers in the selected study area (Deep Swamp) in part because of heavy herbivory and trampling of flowers. In September 2004 when field work for this project was conducted only one species, *Acacia longifolia* was flowering adequately with some plants in flower on both sides of the drain. These plants had re-established on the spoil banks (2-3m high mounds of soil) left on either side of the Fairview Drain that runs through Deep Swamp. This report assesses the adequacy of pollinator activity for servicing the flowers of *Acacia longifolia* and whether the major floral visitor, now the introduced honeybee, moves between flowering plants on either side of the drain.

Methods

Assessing pollinator abundances

A 300m section along the Fairview drain was selected for study and all of the flowering *Acacia longifolia* present on either side of the drain were individually tagged and mapped using a GPS to record their position to within a few metres accuracy. Each hour from 0730h to 1730h each tagged plant was visited and the numbers of honeybees, native bees and other insects foraging at the flowers of that plant were counted and recorded. Between these hourly counts we counted all of the inflorescences (flower heads) on each plant and timed with a stopwatch the length of time taken by different floral visitors to forage at up to 10 consecutive inflorescences. These times were then converted to foraging rates for each type of visitor and expressed as inflorescences visited per minute. These three sets of data were then combined to estimate the average number of times an inflorescence was visited over a day. This was done by tallying the number of bees counted during each hourly census, multiplying this by the interval (60minutes) between counts and the foraging rate and then dividing this by the total number of inflorescences on the plants. The assessment of the ability of pollinators to service a plant is then based on the frequency with which individual flowers are visited.

Movements of pollinators between plants

This was assessed in two ways – by following individual honeybees for as long as possible and recording when they moved between plants (and when they did move between plants the details of the plants (tags) were recorded. In addition we selected three of the larger plants that were attracting large numbers of honeybees and caught bees from these bushes and painted them with small amounts of coloured enamel paint on their thoraxes and released them. A different colour (red, white and green) was used for each f the plants. We then regular searched all the bushes and particularly the bushes near each of the targeted bushes for coloured bees recording the numbers of tagged and untagged bees at each bush at approximately hourly intervals.

Results

A total of 36 flowering *Acacia longifolia* plants (or clumps of 2-3 plants) were marked along an approximately 300m length of drain (Fig 1). These plants differed in size and in the size of their floral displays (Fig 1). Some plants had almost finished flowering and had few flowers, others were still to reach peak flowering and had many flowers opening and shedding pollen.

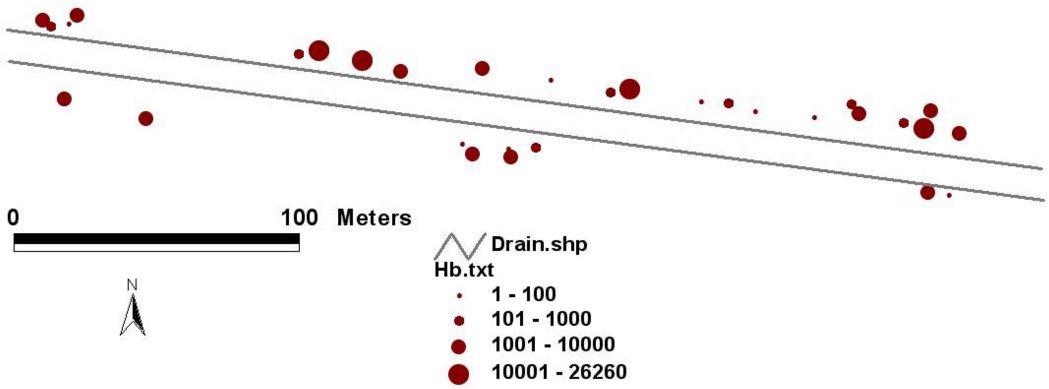

Figure 1. Size of individual *A. longifolia* plants, as determined by the number of inflorescences counted on each plant along a section of the Fairview Drain in Deep Swamp.

Introduced honeybees (*Apis mellifera*) and at least 3 species of native bees (probably including species of *Exoneura* and *Leioproctus*) were detected visiting the flowers of *Acacia longifolia* at Deep Swamp. Honeybees accounted for 94% of the 899 floral visitors recorded at the flowers of marked plants during the hourly counts. Since honeybees visited more flowers per unit time than native bees (Table 1), they accounted for 97% of all floral visits. The numbers of honeybees visiting each plant also varied and not necessarily in direct correlation to the number of inflorescences presented by plants. This variability in their abundances along the drain is shown in Figure 2.

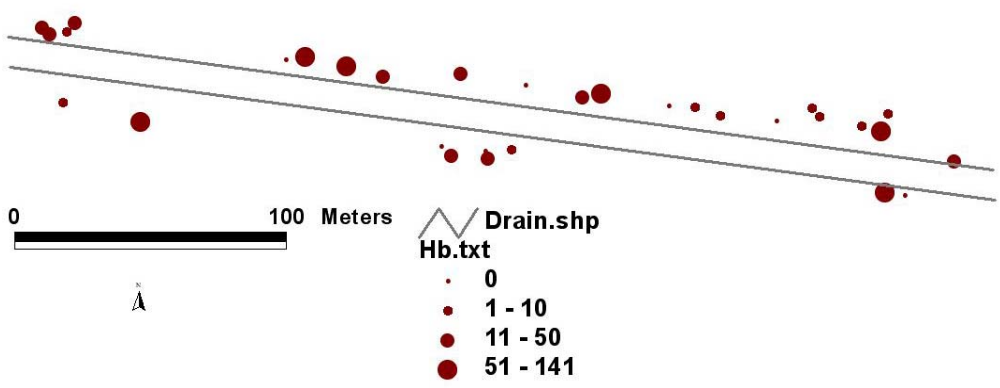

Figure 2. Number of visits by honeyebees to individual *A. longifolia* plants during hourly counts tallied for a day.

Honeybees commenced foraging around 9:30am approximately 2 hours earlier than native bees with the activity of both types of bees peaking around the middle of the day (Fig. 3). All the bees that we observed were harvesting pollen from the flowers. On the day that we scored the use of flowers by insects, most bees had stopped visiting the flowers by mid-afternoon, in part because cooler conditions and because there little pollen left to be harvested from the flowers.

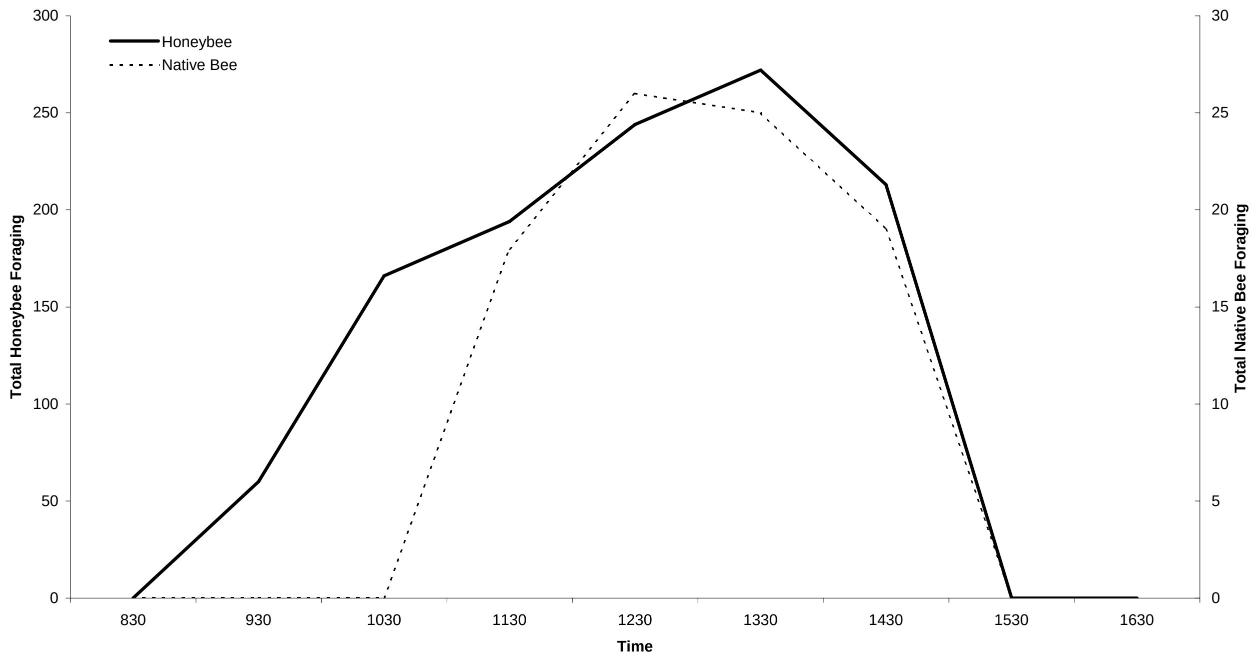

Figure 3. Diurnal visitation rates by honeybees (solid line) and native bees (broken line) to flowers of Acacia longifolia along Fairview Drain in Deep Swamp in September 2004.

The speeds at which honeybees and native bees visited inflorescence varied with time of day (Table 1), with honeybees and native bees visiting more inflorescences per minute as the day progressed. On average honeybees visited 9.3 ± 0.6 inflorescences per minute and native bees 4.4 ± 1.0 inflorescences per minute. Native bees were difficult to time over extended periods because of their smaller size (ca 6 mm), more rapid flight and because they were sometimes disturbed or displaced by honeybees. In general honeybees visited around 10 flowers on each inflorescence while native bees only visited 1—4 flowers. The increased foraging rate during the day coincided with the bees initially spending lengthy times at several individual flowers on inflorescences harvesting pollen but as the day progressed most visits to inflorescences involved quickly assessing flowers on inflorescences for pollen and then moving on in search of inflorescences with flowers shedding pollen.

Table 1. Diurnal changes in foraging rates (inflor/min) of honeybees and native bees harvesting pollen from the flowers of Acacia longifolia at Deep Swamp in September 2004. Data are means ± s.e. (n)

Time of day	**Foraging rates (# inflorescences per minute)**	
	Honeybees	Native bees
0900	5.0 ± 0.5 (12)	
1000	8.2 ± 0.6 (14)	
1100	11.9 ± 0.7 (15)	5.5 ± 1.2 (3)
1200	12.3 ± 1.5 (10)	2.8 ± 0.4 (2)
overall	9.3 ± 0.6 (51)o	4.4 ± 1.0 (5)

The overall rates at which individual flowers were visited varied between plants but overall honeybees made 4.17 visits/inflorescence/day and native bees 0.12 visits/inflorescence per day. This high rate of visitation by honeybees is indicative of providing a substantial pollinator service to this plant.

While tracking individual honeybees there were only four occasions when honeybees were observed shifting between plants, this involved 1 movement of approximately 15m between plants on the same side of the drain and three movements between two large plants across the drain and approximately 20m apart. All of these movements were detected in the first hour of honeybee foraging at the plants, when the bees appeared to be searching for plants with flowers that had opened sufficiently to harvest pollen. In comparison on at least 20 occasions the bees were observed to depart for their hives with heavy pollen loads and on over 30 occasions the individual bee was lost while still foraging on the same plant.

In all a total of 80 honeybees were painted with one of three enamel paint colours on each of three *Acacia longifolia* with high levels of flowers (30 with white paint at one plant; 30 with red at another plant and 20 with green paint at a third plant). During subsequent observations these tagged bees were frequently resighted on the plants on which they were tagged where they typically accounted for 25% of the bees seen at any one time (i.e. 75% of the bees seen were unmarked). The tagging of individual honeybees with enamel paint confirmed that at least two honeybees foraging on one side of the drain were subsequently detected on the other side foraging at the flowers of another plant (these two plants were the same two plants involved in the three observed movements of honeybees across the drain). No other movements between plants of tagged honeybees were detected.

Discussion

The results of this study were not unexpected. Honeybees are now frequent visitors and often greatly outnumber native insects at the flowers of many Australian plants (Paton 1996). Honeybees are unlikely to be deterred from flying across narrow bodies of water, like a drain, since honeybees typically forage out to distances of 1-2km from their hives and will regularly have to cross areas that contain few floral resources. Despite doing this while commuting between foraging areas and the hive, individual honeybees usually forage within small areas (dependent on floral densities) that may not extend beyond a few cubic metres and so limit their foraging to one or few adjacent plants, and return to these areas regularly to forage for periods of several days. Our observations show that these introduced bees provide an adequate rate of visitation to the flowers of *Acacia longifolia* to secure pollination and that they will move over drains and over distances of 20m while foraging (at least for pollen), and so they are likely to transfer pollen between plants on either side of the drain. Thus some level of gene flow over the drain for this plant species is likely.

In this system we could not determine if the rates of movements were reduced, in part because of the patchy distribution of the plants, that meant that there were often few plants directly opposite flowering plants on the other bank (Figure 1) and sometimes few plants that were at an appropriate stage of flowering nearby on the same bank. The tagging of honeybees also can only detect the existence of a minimum number of movements of tagged bees between plants (set by the maximum number of tagged bees seen foraging at one time on another plant (in our case this was 2). Tagging each bee individually might increase the number of interplant movements detected.

Although we have detected the movements of honeybees across narrow drains where the flowering plants were separated by a distance of approximately 20m, these data should not be extrapolated to areas where the drains are wider or to species of plants that have not re-colonised the disturbed areas like the spoil heaps that line one or both sides of the drains. In some areas the excavation works for the drains are more than 100m wide (e.g. Stoneleigh Park) and in these areas even honeybees, although they may cross the drain when commuting between their hives and their foraging areas, are unlikely to cross while they are actually foraging and so gene flow for plant populations in these areas is likely to be disrupted. In addition all of the bee movements that we detected were between flowering plants that were conspicuous. Plants that exist on either side of the drain but outside the 3m high spoil banks are not visible by line of sight and bees may not be able to detect the presence plants the other side of these banks, not move to them, and consequently gene flow may be disrupted.

In summary, our study has demonstrated that honeybees while foraging will move across a narrow drain and between flowering Acacia longifolia plants approximately 20m apart and this should secure gene flow for this species. Additional work is required for other plant species that may be separated by greater distances as a consequence of drain construction.

Acknowledgments

We thank the Delfabro family for allowing access to Deep Swamp for this study.

References

Paton, D.C. 1996. *Overview of feral and managed honeybees in Australia: distribution, abundance , extent of interactions with native biota, evidence of impacts and future research*. Australian Nature Conservation Agency, Canberra.