## Chapter 7

# INTER-RELATIONSHIPS OF PLANTS AND ANIMALS

**by Stephen van Leeuwen, Andrew A. Burbidge and Stephen D. Hopper**

Department of Conservation and Land Management, Western Australian Wildlife Research Centre, P.O. Box 51, Wanneroo, W.A. 6065.

**Abstract**

The Lesueur Area provides an opportunity for essential ecological inter-relationships between plants and animals to continue. Two recent studies highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds that are dependent upon them.

Banksia tricuspis is a Declared Rare species endemic to the Lesueur Area. It shows a strong preference for microclimatically favourable sites and may be a relict species from wetter times. Pollinators, including birds, mammals and insects are essential for seed set in this outbreeding species. Moth larvae and cockatoos reduce the reproductive success of B. tricuspis through predation. However, because cockatoos destroy more moth larvae than flower heads, the latter of which they damage 'in error', the cockatoos have a positive effect. The ability of B. tricuspis to cope with fire is influenced by fire frequency, which effects plant survivorship, and seasonality which influences seedling recruitment. Management of B. tricuspis should ensure that all organisms involved in its inter-relationships are catered for. In the cockatoos' case this is extremely important and will require protection of wandoo woodlands, kwongan and fresh water sources throughout the Lesueur - Coomallo region.

Black Kangaroo Paws (Macropidia fuliginosa) are dependent on honeyeaters for pollination and sustain some nectar loss from honey bee activity.

The ecological links that exist between these plants and animals in the Lesueur Area highlight the need to not only manage and conserve rare and restricted species but also to conserve the organisms that interact with them. To achieve this a larger area of native vegetation than that occupied by a rare plant is often required.

One of the most important attributes of the Lesueur Area is that by its size it affords an opportunity for ecological processes to continue. Provided surrounding native vegetation remains uncleared, this may happen even for organisms that require large areas to survive. Such organisms include Black Cockatoos and nomadic honeyeaters. In this section two recent studies are discussed that highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds that are dependent upon them.

The findings of these studies emphasize that plant and animal species do not exist in isolation. All species are dependent on complex inter-relationships with other species in their ecosystems. Much more work on these inter-relationships is needed to give a clear picture of the web of life in the Lesueur Area.

## 7.1 *BANKSIA TRICUSPIS*: BIOLOGY, INTERACTIONS AND MANAGEMENT

Seven species of Declared Rare Flora occur within the Lesueur Area. One of them is the Pine Banksia, *Banksia tricuspis*. This section will describe aspects of the biology and ecology of the species, with emphasis on its relationship with other species. Considerations relevant to the development of a management plan for this species are then discussed.

*B. tricuspis* is a lignotuberous, emergent shrub or tree up to 4 m tall that has an irregular, gnarled form. The foliage is distinctly conifer-like, the bark wrinkled and grey, and the orange-yellow inflorescences cylindrical. Anthesis occurs in a downwards direction and the styles are hooked with a terminally located stigma. Flowering commences in March, peaks in May-July and extends through to September. Plants produce on average $6.9 \pm 1.1$ (SE) inflorescences per

**Table 7.1.**
**Distribution of *Banksia tricuspis* populations and individuals by the landform units represented within the proposed Lesueur National Park.**

| Landform | Number (%) of populations | Number (%) of individuals |
|---|---|---|
| Lesueur Dissected Uplands | 9 (12.5) | 3608 (18.9) |
| Gairdner Dissected Uplands | 38 (52.7) | 13924 (73.2) |
| Bitter Pool Rises | 2 (2.8) | 55 (0.3) |
| Banovich Uplands | 16 (22.2) | 1178 (6.2) |
| **Total** | **65 (90.2)** | **18765 (98.6)** |

**Table 7.2.**
**Summary of effects of pollination and predation constraints on the reproductive success of *Banksia tricuspis* (inflorescences through to cones).**

| Sequence of events | Mean number of inflorescences per plant | Percentage of inflorescences remaining |
|---|---|---|
| number per plant | 6.9 ± 1.1 (SE) | 100.0 |
| 4.4% of inflorescences not pollinated | 6.6 | 95.6 |
| 2% of inflorescences predated by nectar-foraging ringnecks | 6.4 | 92.7 |
| 69% of inflorescences predated by moth larvae and cockatoos | 2.6 | 37.7 |
| 12% of inflorescences predated by cockatoos 'in error' | 2.2 | 31.9 |

year (Table 7.2) but this may vary from 0-45. The woody fruits and seeds mature within six months of flowering and are green initially, turning grey with age. Cone production per plant varies from 0-15 per year with a mean of 2.2±0.1 (Lamont and van Leeuwen 1988).

The species is placed within the Section *Oncostylis* Series *Spicigerae* of the genus *Banksia* (George 1981). This group is characterised by having cylindrical inflorescences, hooked styles and a descending pattern of floral opening. There are eight species within this Series, six endemic to south western Australia and two occurring in eastern Australia. *B. tricuspis* is distantly allied to *B. verticillata*, *B. seminuda* and *B. littoralis* but is distinguished from them by its narrow tricuspate leaves which have revolute margins.

## 7.11 Distribution and habitat.

*B. tricuspis* is endemic to the Gairdner Range, growing most abundantly in the headwaters of Cockleshell Gully between Mt Lesueur and Mt Peron. The species has a geographic range of 13 km north-south and 8.5 km east-west (Figure 3.3). It is the second most geographically restricted *Banksia*, eclipsed only by the recently discovered narrow endemic *B. epica* (Taylor and Hopper 1988).

A total of 72 populations representing about 19 031 individuals have been identified with the smallest and largest population containing 1 and 4 150 plants respectively. All but seven populations are confined to the Lesueur Area. The remaining seven are on private property.

Populations are located on four of the five landforms recognized for the Gairdner Range (Table 7.1, Figure 3.3), but the species is most abundant on the Gairdner Dissected Uplands.

The distribution of the species appears to be determined by edaphic and microclimatic influences. It is found growing on hill tops, breakaways, scree slopes and gullies, which are comprised of a lateritic or sandstone bedrock overlain by a gravelly skeletal soil. In a few rare instances individuals have also been located growing in the deep grey sands on the valley floors.

The species shows a strong preference for southerly slopes and other sites, such as mesa tops and gullies. It has been argued by Griffin and Hopkins (1985a) that such sites are microclimatically favourable, offering a more mesic environment than found elsewhere at Lesueur. These sites provide refugial habitats for relictual species and those at the limits of otherwise more mesic distributions. Evidence supporting this argument is provided by the preference for southerly sites by the relictual species *Hakea megalosperma* and the disjunct outliers of *Eucalyptus marginata*.

The preference of *B. tricuspis* for microclimatically favourable sites along with several character-states that are considered to be primitive (George 1981) suggest that it is a relictual species. George (1981) speculated that the Section *Oncostylis* evolved early in the evolution of the genus, before the onset of aridity and the edaphic changes associated with the formation of the Nullarbor Plain. The Series in which *B. tricuspis* is a member, the *Spicigerae*, is considered the oldest within the Section, as is evident by the presence of two species from the Series in eastern Australia.

## 7.12 Pollination Ecology

*B. tricuspis* requires pollinators to effect seed set (van Leeuwen 1985). It is not apomictic and its protandrous flowers prevent selfing in the absence of pollinators. It is pollinated by a number of different animals.

The most important pollinator groups are the vertebrates, namely birds and marsupials. A number of bird species, all honeyeaters, and the honey possum have been observed foraging on *B. tricuspis* inflorescences and all were found to carry pollen (van Leeuwen 1985). Birds seen at inflorescences from the most active observed foragers to the least, include the Brown Honeyeater (*Lichmera indistincta*), Tawny-crowned Honeyeater (*Phylidonyris melanops*), White-cheeked Honeyeater (*P. nigra*), the Western Spinebill (*Acanthorhynchus superciliosus*), the Western Silvereye (*Zosterops lateralis*), and the Pied Honeyeater (*Certhionyx variegatus*) .

The levels of pollination success achieved by vertebrate pollinators, when measured in terms of the numbers of seeds produced, is significantly higher than those achieved by invertebrates (62% of open seed set versus 38%). The difference between the two vertebrate pollinator types in achieving seed set is not significant (van Leeuwen, unpublished data). Of the invertebrates, the most important appear to be thynnid wasps and the introduced honey bee (van Leeuwen 1985).

Ants are also regularly observed visiting inflorescences but are too small to effect pollination. Rather, they play an important role in suppressing predators of inflorescences, particularly the larvae of moths. Survivorship of inflorescences which have been experimentally manipulated to exclude ants is zero (van Leeuwen 1985).

All pollinator groups frequently move from plant to plant while foraging. Such behaviour would promote outbreeding pollination events. This is especially so in the vertebrates which are extremely mobile. The mean and maximum observed foraging bout distances for honeyeaters are 7.6 m and 75 m, and for the honey possum are 9 m and 59 m respectively.

## 7.13 Breeding System.

Pollen-ovule ratios and multilocus outcrossing estimates based on isozyme electrophoresis indicate that this species is facultatively xenogamous, i.e. mainly outbreeding, but selfing does occur (S. van Leeuwen and D. Coates, unpublished data). Multilocus outcrossing estimates of the breeding system indicated that the levels of outcrossing within a population is on average 70-75%. However, in the case of a population consisting of one individual isolated from its nearest neighbour by 800 m, the level of outcrossing was calculated to be as low as 35% (van Leeuwen, unpublished data).

## 7.14 Biotic Constraints on Reproductive Success.

Apart from spatial, resource and genetic constraints which may operate to limit the reproductive success of *B. tricuspis*, there are several external constraints. Pollination success is one of these constraints. On average, 4.4% of inflorescences per plant are not successfully pollinated. However, this value may vary from 0-8.9% (van Leeuwen, unpublished data).

External constraints have the most significant effect on the reproductive success of *B. tricuspis* and are mainly manifested as predation on inflorescences, cones and seeds. The most significant constraints on the reproductive success of the species occur as a result of floral predation by the Port Lincoln Ringneck, *Barnardius zonarius*, the larvae of the moth *Arthrophora diadela* and Carnaby's Black Cockatoo, *Calyptorhynchus funereus latirostris*. Predation of an inflorescence by any of these agents results in the failure of an inflorescence to set seed.

Ringnecks attack inflorescences by removing all the perianth parts except the bracts, ovaries and nectaries that are attached to the rachis. The nectaries continue to produce nectar, which is harvested by the ringnecks over subsequent days. Ringnecks attack a mean of 2% of the inflorescences on plants (Table 7.2), but this varies from 0-15%.

Larvae of the moth *A. diadela* have the largest impact on the reproductive success of *Banksia tricuspis*. The moth larvae enter the rachis via the bracts and commence burrowing throughout the length of the rachis. When ready to pupate, the larvae exit via the bracts. The mean number of larvae present in an inflorescence is four, but can vary from 1-11 individuals. Larvae can damage 0-100% of the inflorescences produced by a plant. Most plants sustain 90-100% damage. However, the mean value for such predation is $59.3 \pm 29.7\%$. The mean value is lower than the modal value because larval predation increases as the number of inflorescences produced by a plant increases. Larval-predated plants have significantly more inflorescences ($8.1 \pm 2.2$) than those not affected ($2.1 \pm 0.5$, $p < 0.001$ by t-test) (Lamont and van Leeuwen 1988).

Carnaby's Black Cockatoo, the final floral predator, accidentally destroys inflorescences in its search for the larvae of *A. diadela*. The cockatoo has the ability to predict with reasonable accuracy which inflorescences have larvae present. It attacks about 89% of all larval-bearing inflorescences, while only 42% of those without larva are attacked ($p < 0.001$ by $X^2$ test). The little corella, *Cacatua sanguinea*, has also been observed predating the larvae of *A. diadela* on rare occasions.

As is the case for moth larvae, predation by cockatoos increases significantly as the number of inflorescences on a plant increases. The mean number of inflorescences on damaged plants is $9.6 \pm 7.8$, compared with $3.0 \pm 1.4$ on those plants which are not damaged ($p < 0.001$ by t-test) (Lamont and van Leeuwen 1988). This preferential visitation to plants with the most inflorescences increases the cockatoos' chance of locating the larvae, which are also relatively more abundant on these plants.

The overall effect of these three agents on floral predation is a significant reduction in the reproductive success of the *Banksia*, to a level where cones with follicles is only 31.9% of the original number of inflorescences (Table 7.2). The net effect of predation by cockatoos is positive because they destroy more moth predated inflorescences than they damage inflorescences 'in error' (Lamont and van Leeuwen 1988).

Predation of seeds by beetle larva of the family Cleridae is another constraint operating to limit the reproductive success of the *Banksia*. Such predation is only minimal, the effect being a 15% reduction in the number of seeds present in the canopy-stored seed crop over a four year period. Without the destructive effects of birds and the larvae of moths and beetles, the canopy seed store of *B. tricuspis* would be about four times greater.

## 7.15 Fire Ecology.

*B. tricuspis* is a fire tolerant species that has the ability to resprout from both the lignotuber and epicormic buds. However, young plants are susceptible to fire. A major proportion of the Lesueur Area was burnt in 1985, which resulted in the death of 27 of the 41 known 18-year-old plants (van Leeuwen 1985). Mortality rate also increased in adult plants immediately after the fire from 0.005% pre-fire to 0.1% in the year immediately after the fire. Hence, during the pre-fire period and up to one year after, the net change to the overall population of *B. tricuspis* has been a decrease by about 66 individuals (n = 19 031 plants, van Leeuwen, unpublished data).

The extent to which a plant retains its seed within the canopy over time is a measure of its degree of serotiny. Species that release their seeds once mature are nonserotinous while those that retain their seed indefinitely are highly serotinous. Seed release in highly serotinous species only occurs after the death of the plant or branch supporting the fruit. Death of plants and branches occurs after events such as fire.

*B. tricuspis* is weakly serotinous, beginning to release its seeds once mature and continuing to do so until, at four years post flowering, all the seeds have been released. However, seedling recruitment has not been recorded in between fire periods. Recruitment of individuals appears to occur only after the habitat has been burnt and the highest levels of seedling recruitment occur after summer-early autumn fires. Seedling recruitment is considerable after such events because the time lag between follicle rupture and the onset of suitable conditions for seed release from the cone, for germination and for seedling growth are minimal. This reduces the amount of time that seeds are exposed to predators and to extreme surface soil temperatures, both of which significantly reduce seed viability. It also maximises the length of the growing season available to seedlings.

Several years after a fire the initial increase in population size resulting from the influx of seedlings becomes negligible. Seedling mortality is mainly induced by summer drought stress. Field observations indicate that as few as 0.4% of the seedlings in a seedling population pool of 550 survive to be five years old (van Leeuwen unpublished data).

Seedling recruitment and survivorship may also be enhanced by minimal competition from other plant species, especially in the immediate post-fire period. Comparison of seedling survivorship *in situ* with different levels of competition, i.e. natural heathland versus cleared tracks, indicates that seedling survival is highest on the tracks. Five years after initial recruitment, 54% of the seedlings on the track site were surviving, while only 0.4% of those in ten natural heathland sites survived (van Leeuwen, unpublished data).

## 7.16 Management implications.

The main considerations in a management program designed for *B. tricuspis* should be to ensure the maintenance of existing populations, if not to endeavour to increase their size. Such a management program should ensure that:

1. pollinators remain abundant in the Lesueur Area,
2. a viable population of Carnaby's Black Cockatoo is maintained,
3. fire regimes are prescribed to minimize mortality and maximise recruitment, and
4. dieback disease is not introduced into the Lesueur Area.

It is obvious that it is necessary to maintain viable populations of the pollinating agents within the Lesueur Area. Without such animals, *B. tricuspis* is unable to produce seed and therefore will lose the ability to recruit new individuals into the population when conditions become suitable.

Similarly, it is extremely important to maintain viable populations of Carnaby's Black Cockatoo within the Lesueur Area. Carnaby's Black Cockatoo is a declining species that will require special management in its own right. It is declining in number as the vegetation associations in which the birds forage and nest are cleared for agriculture. It has already become locally extinct in a number of wheatbelt localities (Saunders and Ingram 1987). Foraging mainly occurs in heathland vegetation communities (Saunders 1980), which have abundant fruits and seeds of proteaceous and myrtaceous species, the main food sources. Nesting occurs in *Eucalyptus wandoo* woodlands where there are numerous, suitably-sized nesting hollows. Such sites are usually close to free water, which is essential to nesting and summer-roosting birds. It is also necessary for the nest sites to be close to the food resources so that adult birds can find enough food for nestlings without travelling great distances (Hopkins and Saunders 1987).

The Lesueur Area currently fulfills all the requirements of Carnaby's Black Cockatoo, including suitable woodlands with nesting hollows along water courses, rich heathland communities for foraging and short flight distances from nest sites to foraging sites and free water. The Lesueur Area has been identified as a major breeding and summer roosting site for Carnaby's Black Cockatoo (Hopkins and Saunders 1987).

Management of Carnaby's Black Cockatoo and the places it utilizes within the Lesueur Area must not be considered in isolation. If remnant native vegetation outside the Lesueur Area is dramatically reduced through clearing then increased pressure will be placed on those resources within it. Such pressures will come from displaced populations of Carnaby's Black Cockatoo and other species such as the Galah (*C. roseicapilla*) and Long-billed Corella (*C. pastinator pastinator*). Saunders *et al.* (1985) have demonstrated that the Galah and the Long-billed Corella are already increasing in abundance in the Lesueur Area. Both species will compete with Carnaby's Black Cockatoo for nest hollows and may reduce their numbers in the absence of appropriate management.

If Carnaby's Black Cockatoo became locally extinct or numbers were severely reduced through clearing and/or competition for food, nesting and water resources, this may further reduce the seed reserves of *B. tricuspis*. Such a reduction may occur as a result of the substantial increase in the number of *A. diadela* larvae reaching adulthood and therefore, the amount of predation on *B. tricuspis* inflorescences.

The most desirable fire management program for *B. tricuspis* should prescribe a regime of early autumn burns at intervals of no less than 25 years. Bell *et al.* (1985) suggests a burning interval at 25-50 years for the northern kwongan. Such a regime would ensure that burning occurred at an optimum time for the release and germination of seeds and establishment of seedlings, at an intensity that would cause follicles to rupture and at an interval that should not adversely effect seedlings recruited after the last fire.

The Lesueur Area is currently free from dieback disease and any management plan should aim to maintain this situation. The susceptibility of *B. tricuspis* to the disease has not been determined but information available for other south western Australian species in the same Series indicate that it may be moderately to highly susceptible (McCredie *et al.* 1985). Two of its closest allies, *B. seminuda* and *B. verticillata*, have been demonstrated to have 42% and 54% mortality during a 395 day trial. A more detailed discussion of the susceptibility of the Lesueur plants to dieback is provided in Section 8.4 and 8.5.

The management plan for the Lesueur Area should not be designed and implemented in isolation but should be formulated in a regional context. The management plan should not only consider *B. tricuspis*, but all the other species which occur within its bounds, particularly those which are rare, endangered, restricted or disjunct outliers.

The close ecological link between *B. tricuspis* and Carnaby's Black Cockatoo highlights the fact that conservation of rare, highly localised species requires more than just protecting and managing the known populations of the rare plant. A larger area supporting a viable population of Carnaby's Black Cockatoo is essential for the long-term persistence of *B. tricuspis*.

## 7.2 BLACK KANGAROO PAWS

The Black Kangaroo Paw, *Macropidia fuliginosa*, has a limited distribution in the northern kwongan (Hopper 1978) and is well represented within the Lesueur Area. It has specific habitat requirements, favouring well-drained lateritic slopes and breakaways and is rarely found in valleys except where sands are thin and overlie laterite. Apart from being a conspicuous and attractive plant in the kwongan, the species is a favourite food for kangaroos.

The pollination ecology of Black Kangaroo Paws has been studied by Brown (1988) on the slopes of Mt Michaud and at another site to the east. She found that Black Kangaroo Paws were exclusively pollinated by honeyeaters, particularly the Tawny-crowned Honeyeater (*Phylidonyris melanops*) and the Singing Honeyeater (*Lichenostomus virescens*). Honey bees (*Apis mellifera*) visited the flowers, but did not effect pollination, robbing the flowers of their nectar. The Kangaroo Paws' flower shape and biology is highly adapted to honeyeater pollination. Morphological changes in flower structure and orientation on the stem are used as cues to encourage visits by honeyeaters when nectar is produced, and maximum nectar production coincides with pollen release and maximum stigma receptivity.

In order to maintain Black Kangaroo Paws in the Lesueur Area it is necessary to maintain viable populations of honeyeaters and keep honey bee numbers at a low level.