

NATIONAL FERAL ANIMAL CONTROL PROGRAM



Australian Government
Bureau of Rural Sciences

**REPORT TO THE BUREAU OF RURAL SCIENCES,
DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY**

Bird Damage to the Wine Grape Industry

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NSW AGRICULTURE**

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PART A: PROJECT OUTLINE

1. PROJECT INFORMATION

1.1 Project Name

Bird damage to the wine grape industry

1.2 Details of Applicant

(a) Organisation Details

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1.3 Period of Project

Commencement date: 1 / July / 1999 Completion date: 30 / June / 2002

1.4 Project Aim

The aim of this research was to investigate and accurately define the bird damage to wine grapes problem in the Orange Region of New South Wales using established best practice management procedures; review current advances in bird pest management and starling ecology and behaviour; and improve advisory services for bird pest problems.

1.5 Acknowledgements

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1.6 Summary

- Optimal efficiency for estimating bird damage to vineyards was achieved using stratification, sample size predictions and a progressive sampling strategy (3.1.3). This approach (3.1.3) and the technique developed for selecting bunches (2.1.1) greatly improved efficiency of estimating block damage without compromising accuracy.
- Bird damage levels to vineyards in the Orange Region are significantly effecting the economic viability of many vignerons, with average blocks losing 15% of their harvest to birds. Total losses occurred in some blocks. However, the severity of bird damage varied significantly (range= 0.3-83%), and was influenced by a range of variables. Overall, there were no clear preferences for particular varieties, although within vineyards some varieties were damaged significantly more than others.
- Large sample sizes are necessary for evaluating management strategies in vineyards. For example, greater than 83 vineyards was estimated as sufficient to ensure that a 10% reduction (in absolute terms) is detected with 95% confidence. This is a reflection of the large variance between vineyard block estimates and emphasises the difficulties and considerable resources needed to accurately assess management techniques.
- Benefit cost analyses indicate:
 - vineyards are uneconomic where bird damage is greater than 40% per annum, which occurred in 8% of blocks in 2000 despite considerable management efforts.
 - Investment in double-row drape-over bird netting is cost effective where bird damage is consistently greater than 10%.
 - Permanent netting requires greater up front costs and was cost effective where damage was over 25%. Associated risks of investment in netting are discussed (4.4).

- Common starlings (*Sturnus vulgaris*) were the most abundant species recorded in vineyards. But bird species composition and abundance varied considerably on spatial and temporal scales. Density estimates reveal differences in the main pest species between seasons (especially Noisy Friarbirds -2000 and Pied Currawongs 2001); inconsistent trends of bird abundance within seasons; and that particular bird species have clear preferences for certain habitat types. Different bird species were also shown to damage separate grape varieties within the same vineyards.
- Honeyeater movements were highly varied between seasons but preliminary information from local apiarists indicates tracing nectar flows using honey production could lead to predictive patterns.
- Trapping techniques were generally labour intensive with opportunistic methods such as hand capture at nests more efficient but often not applicable. Capture was more efficient for one trap type at urban sites. Four capture techniques are compared and results discussed.
- Intensive monitoring of starling movements during the breeding season suggest they use a range of habitat types, prefer eucalypts with nest sites for perching, spend the majority of their time nesting, feeding and perching, are observed in greater flocks during the ripening season and average flock size increases gradually over the day.
- Recommendations from radio tagging trials include:
 - The back-pack harness design is preferred to the glue-on technique.
 - Training and practice with harness tension is recommended prior to release.
 - A lighter transmitter of around 1.65 grams is recommended to allow tagging of all birds encountered and to reduce the effects of the transmitter.
 - Aerial tracking is recommended in studies where large scale movements are apparent and detecting isolated dispersal over greater than 10 kilometres is essential.
- Movements monitored by radio tags during the ripening period suggest starlings remain sedentary despite fluctuating grape availability. Although small scale movement patterns suggest starlings will relocate their foraging efforts following harvesting of particular blocks, movements between vineyards of greater than 5km was not recorded.
- The nesting study suggests starlings are highly opportunistic and dominant users of available nest hollows in vineyards.

2. PROJECT DESCRIPTION

2.1 Background

Birds have long been recognised as a pest of agricultural production. However, the research conducted into the levels of impact, methods of control and the ecology of the various pest species in Australia largely remains as ‘grey’ literature (see Fleming *et al.* 1990; Bomford 1992). Fleming *et al.* (1990) produced recommendations including those which identified the need for a coordinated approach to the planning and organisation of future bird pest research in Australia, more realistic appraisals of the cost benefits of solutions to bird problems, more quality research on the ecology and behaviour of pest birds, better damage assessment techniques and improvements to a deficient network of advisory services for bird pest problems.

While many of these issues have been addressed in isolation, there has been no real progress in terms of a coordinated approach to the problem in the 10 years since these recommendations were drafted. This probably arises from the following:

- There are numerous bird species involved (many of which are native and thus protected),
- There are many different crops being affected,
- Regional variations in the way crops are grown, the habitats in which they are grown and the behaviour of the pest species extends the number of variables to contend with,
- There is a growing number of bird control measures which are being commercially produced yet which remain largely untested in any scientific way,
- There is a very limited pool of research funds available for pest bird research.

In this project we propose to follow the guidelines outlined in *Managing Vertebrate Pests: Principles and Strategies* (Braysher 1993). To avoid some of the above problems, research will concentrate on one crop and one geographical region. While there may be differences in other instances via species ecology, region and crop, we believe that damage to grapes in the Orange Region would serve as a good model to investigate damage severity and pest species and the various management strategies currently employed in many situations and without proper scientific evaluation. The project would also act as a demonstration and hopefully serve as an impetus for the production of long needed guidelines on best practice management of bird pests.

2.1.1 Problem Definition for the Orange Wine Industry

The viticulture industry in Australia has experienced exponential growth in the last five years, with projected production for 2002 reaching 1.51 million tonnes and an export value of over \$1.63 billion (Spencer 2002). One of the most rapidly growing areas is the Central Ranges which includes the viticultural regions of Cowra, Mudgee, Orange and Forbes with over 5,000 ha of established vines. The 1998 vintage of some 15,000T is valued at around \$15M or even more when value added to wine. This value is expected to increase dramatically when recent plantings come into full production.

Birds are increasingly being recognised as a major pest to wine grape production and can be responsible for total losses in some vineyards. In a survey of 30 local producers by Orange Agricultural College (OAC) it was found some unprotected crops commonly lost up to 45%

through bird damage with an average total loss per producer of 9.4% or \$16,924. The common starling (*Sturnus vulgaris*) is the major bird pest of the wine grape industry in the Central Ranges of NSW, where it is perceived to cause 80-90% of all bird damage.

Damage is effected by crop removal and/or the development of secondary spoilage through moulds, yeast, bacteria and insect damage via bees and coprophilous beetles etc. For 6-8 weeks of the year starling damage can also result in unnecessary early harvest and subsequent downgrading of premium fruit. Most vignerons try to protect their grapes from bird damage with nets, acoustic devices and general harassment. The OAC survey revealed a bird management cost of over \$500 per ha. Appropriate assessment techniques and baseline biology, behaviour, breeding habits and movement patterns underpin any future research and management efforts to quantify or ameliorate damage.

2.1.2 Damage Assessment and Management

Few techniques are currently available for managers or researchers to accurately and efficiently assess bird damage. Standard sampling procedures and counting or weighing are constrained by time and cost. Visual assessments are more efficient and have been used successfully for various crops, including grapes (Dehaven and Hothem 1979; Stevenson and Virgo 1971), corn (De Grazio *et al.* 1969) and sunflowers (Dolbeer 1975), but are still labour intensive. The need for an accurate and efficient sampling technique is an essential first step before effective research and management evaluation is possible.

Despite a large number of techniques and devices available to vignerons for bird management, these are rarely subject to objective assessment. Appropriate evaluation of management strategies requires clearly defined response variables and influencing factors; an equal number of replications per treatment (including nil treatments); and sufficient replication of treatments to cover the range of natural variability (Caughley and Sinclair 1994).

2.1.3 Breeding Habits

The increased number of starlings observed during the ripening period (February to May) in vineyards and orchards is generally believed to be a result of increased food availability. However, studies on breeding biology suggest that starlings may lay up to three broods per year, with four to six per clutch (Feare, 1984). This allows a potential 6-fold increase in starling populations just prior to ripening. Control programs in this period are therefore unlikely to reduce populations in the long term due to the large number of juveniles and high rates of natural mortality in the first year. Control programs that target breeding birds however have the potential to result in a more effective and longer term reductions of starling numbers.

At present there is very little information available in Australia on the timing of breeding, reproductive processes or potential rates of increase of starling populations, which are necessary to develop effective control techniques for starlings in the breeding season. Overseas studies provide baseline information for comparative purposes but nesting behaviour and breeding success can vary substantially throughout their range. For example, in southern England, starling flocks have 3 phases of breeding with first, second and intermediate broods (Feare, 1984). Starlings in northern extremes of their range breed later in

the year, have a shorter breeding season and seldom lay second broods (Feare and Craig, 1999).

Starlings are also thought to have a significant effect on the success of native species in Australia, in particular due to competition for nesting sites (Smith 1975; Green 1983; Weitzel 1988; Pell and Tideman 1997; Garnett and Crowley 2000; Gibbons and Lindenmayer 2002), but the impact on native populations remains unquantified. Further information is required on starling nesting behaviour and nest site selection to lead to improved management of starlings that is relevant for both conservation and agriculture.

2.1.4 Movement Patterns

There is also very little published information on the movements and activity patterns of starlings in Australia. Overseas studies indicate starling movement patterns are widely varied according to geographic location. For example starlings of North America and Northern Europe are largely migratory and will move large distances for the winter (e.g. Bray *et al* 1975; Spaans 1977), but many starlings in southern Europe will remain in the same areas throughout the year (e.g. Summers and Feare 1995). Movements of starlings, particularly in relation to vineyards, have not been previously studied in Australia and are an important aspect of planning for and implementing effective control programs.

2.1.5 Management Constraints

- Horticulturalists and other primary producers find it difficult to effectively manage bird pests in Australia as there is very little objective advice and few simple, nationally applicable solutions available. Management solutions are rarely suited to all bird species, crops and situations.
- Despite increasing concern raised by horticulturalists, many industry organisations are reluctant to invest in research into reducing damage caused by birds. This may be partly due to the current lack of information available on the severity and distribution of the problem and a lack of evidence of efficacy of damage reduction techniques.
- There is anecdotal evidence of large spatial and temporal variation in damage, bird species and density within crops, within properties, between crops, properties, regions, and states with few attempts made to predict these patterns. To implement best practice management or evaluate management options more baseline information is needed on bird pest species and the impacts they have on horticultural production.
- Current management techniques include large up-front investment in netting, shooting or use of a diverse range of scaring devices including acoustic and visual deterrents. Horticulturalists accept that lethal control and scaring regimes have limited effectiveness but are continually confronted with claims of effectiveness from manufacturers, and are also attracted by their comparatively lower up-front costs. Little objective or scientifically sound advice is available.
- Habitat modification or enhancement is often seen as a desirable alternative but again there is little reliable advice available and few demonstrated examples.
- Bird netting offers an opportunity for near total exclusion from bird damage. Hence, the critical criterion for deciding to invest in netting is economic. Netting is being increasingly used as technologies improve, but its long-term economic benefits are often not adequately considered.

2.2 Project Objectives

1. Define the problem (starlings and grapes in the Orange Region) and identify management options (B, C and D),
2. Develop direct measurement techniques and quantify bird density and damage to vineyards in the Orange region (B and C),
3. Examine the spatial and temporal variability between bird damage and abundance, and the range of factors which influence damage severity (B),
4. Conduct preliminary cost-benefit analysis on bird netting (B),
5. Determine the feasibility of testing bird management strategies in vineyards (B),
6. Intensively investigate the local movements and breeding behaviour of a starling population in a vineyard environment (B),
7. Review developments in bird pest management with particular emphasis on starlings and wine grapes (D),
8. Contribute to national guidelines for managing birds in horticulture (E),
9. Initiate contact and information sharing between bird pest experts within Australia (F),
10. Facilitate extension and education of research results and involve wine grape producers to ensure longer term adoption (F).

These objectives are addressed in parts B to F .

2.3 Study Area

The Orange region (149⁰22', 33⁰24') falls within the Central Ranges zone which spans an elevation from 245m at Forbes to 1100m at Oberon and also includes the viticultural regions of Cowra, Mudgee and Forbes. The zone has a variety of soils suitable for viticulture. The other main agricultural enterprises in the region are merino wool, prime lamb and beef cattle production and winter cereal cropping.

Vineyards of Orange surround Mount Canobolas at 990m above sea level and are interspersed with scattered eucalypts (*Eucalyptus macrorhyncha*, *E. seeana*, *E. tereticornis*, *E. viminalis*), pine (*Pinus radiata*) plantations, mixed farming, apple and stone-fruit orchards and sheep and cattle grazing country. The area has a cool climate with medium to high rainfall. Vineyards range in size from 0.3 to 480 hectares, but the majority are less than 20 ha. Most vineyards have five or more varieties, with cabernet sauvignon, cabernet franc, merlot, shiraz, pinot noir, sauvignon blanc and chardonnay the primary varieties grown.

PART B: INVESTIGATING BIRD DENSITY, BEHAVIOUR, DAMAGE AND MANAGEMENT TECHNIQUES IN ORANGE VINEYARDS

1. INTRODUCTION

The following sections address project objectives 1-6 and report on investigations into bird density and species composition, damage severity, starling movement and breeding behaviour and management techniques in vineyards of the Orange Region.

2. METHODS

2.1 Damage Assessment

2.1.1 Random Bunch Selection

To avoid over-sampling of more visible bunches we developed a technique for selecting random bunches on each vine. A pole marked at 10cm intervals was placed vertically in one of seven (0-6) locations on each selected vine. Random numbers were generated between 7 and 12 (10 cm intervals) for the vertical axis and 0 and 6 for the horizontal axis. The vertical numbers corresponded to all harvestable bunches occurring between a vertical distance of 70 and 120 cm. Grapes were grown within this height for all vineyards sampled, except one which had lower trellises for which a height of between 50 and 100 cm was selected. A horizontal number of 3 required placement of the pole at the vine stem; 0 at the left hand edge; 6 at the right hand edge; 1 at a third of the distance from the edge; 2 at two thirds and so on (see Figure 1.). Occasionally bunches were not located in the exact location so the closest bunch was then selected and position recorded. All vines were trellised in this study and bunches were rarely equidistant from selected locations (<0.01%).

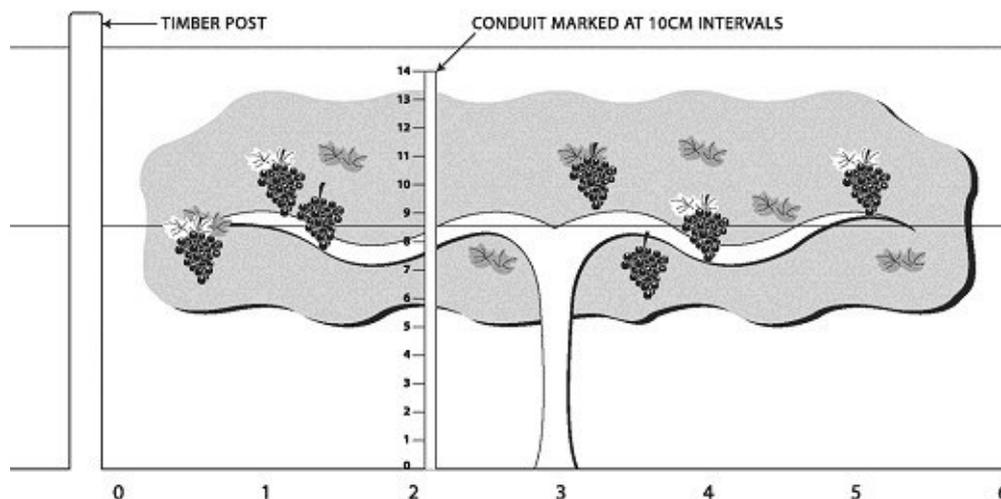


Figure 1. Technique for selecting random bunches

2.1.2. Visual Assessment

Over 26500 grape bunches were visually assessed by eleven observers to determine mean percentage bird damage. In 2000, estimates were made to the nearest 1 percent. After analysing 2000 calibration data it was decided to estimate to the nearest 5 percent from 10 to 90 and the nearest 1 percent <10 and >90, as accuracy was higher at lower and higher levels of damage. Estimating percent damage directly, rather than applying ranking scales, typically used in other studies (e.g. Dehaven 1974; Stevenson and Virgo 1971; Somers and Morris 2002), avoids errors associated in transforming ranks into percentages without sacrificing sampling efficiency. To minimise estimation error, observers practiced on bird damaged bunches and used a chart of bunches with simulated damage.

The visual assessment procedure was then examined in both seasons by comparing 594 visual estimates with actual percent damage. In 2000, 76 bunches were examined by 4 observers and 62 bunches by one observer and in 2001, 38 bunches were examined by 6 observers. These estimates were carried out under identical field conditions towards the completion of the study. In this case bird damage was not simulated. Actual percentage damage was calculated after sampling by cutting bunches and counting the number of missing, pecked and remaining grapes on each bunch. Great care was taken to ensure grapes did not fall off the bunches by placing each into a bag before it was cut.

2.1.3. Sampling Strategy 2000

In 2000, sixty blocks on nine vineyards were sampled for bird damage. All blocks were sampled immediately prior to harvest, twenty-one of which were also sampled between veraison and one week before harvest. The first and last rows from each block were sampled sequentially from a randomly chosen vine. Interior rows and vines were also systematically sampled. One bunch was selected from each interior vine and two bunches from all edge vines on sampled rows.

To estimate the mean percent damage within a vineyard we stratified each block into 5 strata (Figure 2.).

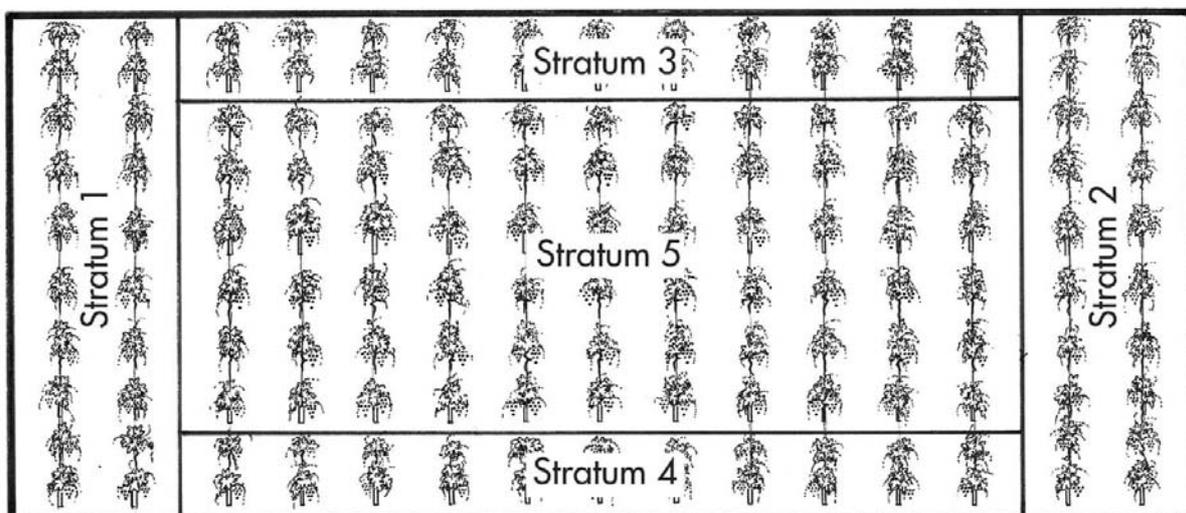


Figure 2. Stratification scheme for vineyard blocks.

Stratum 1: First two rows of the block.
Stratum 2: Last two rows of the block.
Stratum 3: First two vines of rows not in Stratum 1 or 2.
Stratum 4: Last two vines of rows not in Stratum 1 or 2.
Stratum 5: All other vines

The stratification scheme above (Figure 2) is based on the following. First, an examination of the percent damage indicated that damage was more severe at the boundaries of the block than towards the centre (Figure 5, page 27). Second, the damage at each boundary within a block was not always uniform and was probably dependent upon a range of other factors, including proximity to adjacent habitat and perching sites. In particular, end rows of a block that are contained within rows of other grape varieties appear not to be as severely attacked as outside edge rows. Hence the separate strata for each of the four boundaries.

For each block/sampling date combination the mean bunch damage for bunches within each stratum were estimated separately. Here we assumed that the percent damage per bunch is a linear combination of overall mean percentage damage, a random component due to the vine and the bunch. These means, and associated standard errors, were estimated using ASREML (Gilmour *et al.* 1999).

2.1.4 Sampling Strategy 2001

To improve sampling efficiency we developed and used a progressive sampling strategy based on data collected in 2000. This technique is justified and described in detail in the results below. Briefly, in 2001 one bunch was randomly selected from 10 systematically selected vines in each outside stratum (1-4). This was carried out working in a smooth action around the block. If mean damage exceeded 5% in any outside stratum 10 samples were also taken from the interior of the block (Stratum 5). If damage was greater than 10% in any of the 5 strata, additional bunches were also sampled from those strata. In each case, Table 1 (page 30). was used to determine the extra number of samples required.

2.2 Economics of Bird Netting

A series of vineyard development budgets were developed to investigate the profitability of netting scenarios at different levels of bird damage. These include all costs associated with setting up and maintaining a vineyard in the Orange region. Values are discounted which allows benefit-cost ratio (BCR), the net present value (NPV) and the internal rate of return (IRR) to be calculated. More simplistic methods of analysis include direct comparisons of benefits and costs associated with bird netting. Analysis indicate drape-over netting is cost effective over a ten year period for vineyards which receive >10% bird damage per annum (see Results).

A benefit-cost analysis (BCA) for bird netting was also conducted using this budget information and estimates of bird damage in the Orange region. BCA enables investments such as bird netting to be compared over time where the control options involve different flows of costs, returns and risk levels. Time and risk are important considerations when planning control because the initial decisions will usually have economic effects in subsequent periods.

BCA involves discounting procedures which must be used to account for declining monetary values over the period of the control decision. Discount rates measure the effects of inflation and the perceived risk of the control options. Higher discount rates reflect riskier control situations. Discounting allows the main BCA criteria to be calculated. These are the benefit-cost ratio (BCR), the net present value (NPV) and the internal rate of return (IRR). The BCR is the ratio of discounted benefits to discounted costs and indicates the potential return per \$1 invested over the period. NPV is the present day value of the discounted benefits less the discounted costs. The IRR is the discount rate which equates discounted benefits and costs over time, ie., the discount rate at which $NPV = 0$. Profitable control options will have a BCR greater than one, a positive NPV and an IRR greater than the discount rate. Wherever possible, benefits and costs should be valued at current market prices as these values are known and allow direct comparison over time.

The BCA evaluated four bird netting options and compared these to a no-netting option that sustained damage levels of between 15-30% of annual yield. No damage was assumed to occur under the netting options. Average annual damage levels in the Orange district are about 15%. District yield averages of 13 tonnes per hectare and an average price of \$1,300 per tonne were also used. The period of the BCA was ten years with a real discount rate of 5%.

2.3 Bird Abundance

2.3.1 Index of abundance

An index of bird density for 9 vineyards was determined for both seasons by recording species as they were seen and heard along the same rows systematically selected for damage estimates. Species were then ranked using a three tiered ranking scheme similar to that described and used by Marnett and Haydock 1963 and Jones and Hargreaves 1979, and allocated a low, medium, high, or very high abundance rating.

2.3.2 Variable Circular Plots

In 2001, more intensive and independent bird counts were used for density estimates in 12 vineyards. Birds were counted (13060 observations) using the variable circular plot (VCP) technique providing estimates of absolute abundance (Buckland *et al.* 1993; Bibby *et al.* 2000). Bird observers counted all species seen or heard for 10 minutes at randomly placed locations within 4 main habitat types (vineyard, open, eucalypt and introduced) (e.g. Figure 3.). Distances were also recorded to allow calculation of detection probabilities and for comparison between observers, habitats and bird species. These counts will enable clarification of the main pest species in the Orange area; comparison between spatial and temporal distribution of bird density and damage; and habitat preferences of different species. In this study initial comparison were made between bird species and habitats at different levels of complexity. Future analysis using Distance 4.0 (Thomas *et al.* 2001) will be used for detection functions and probabilities.

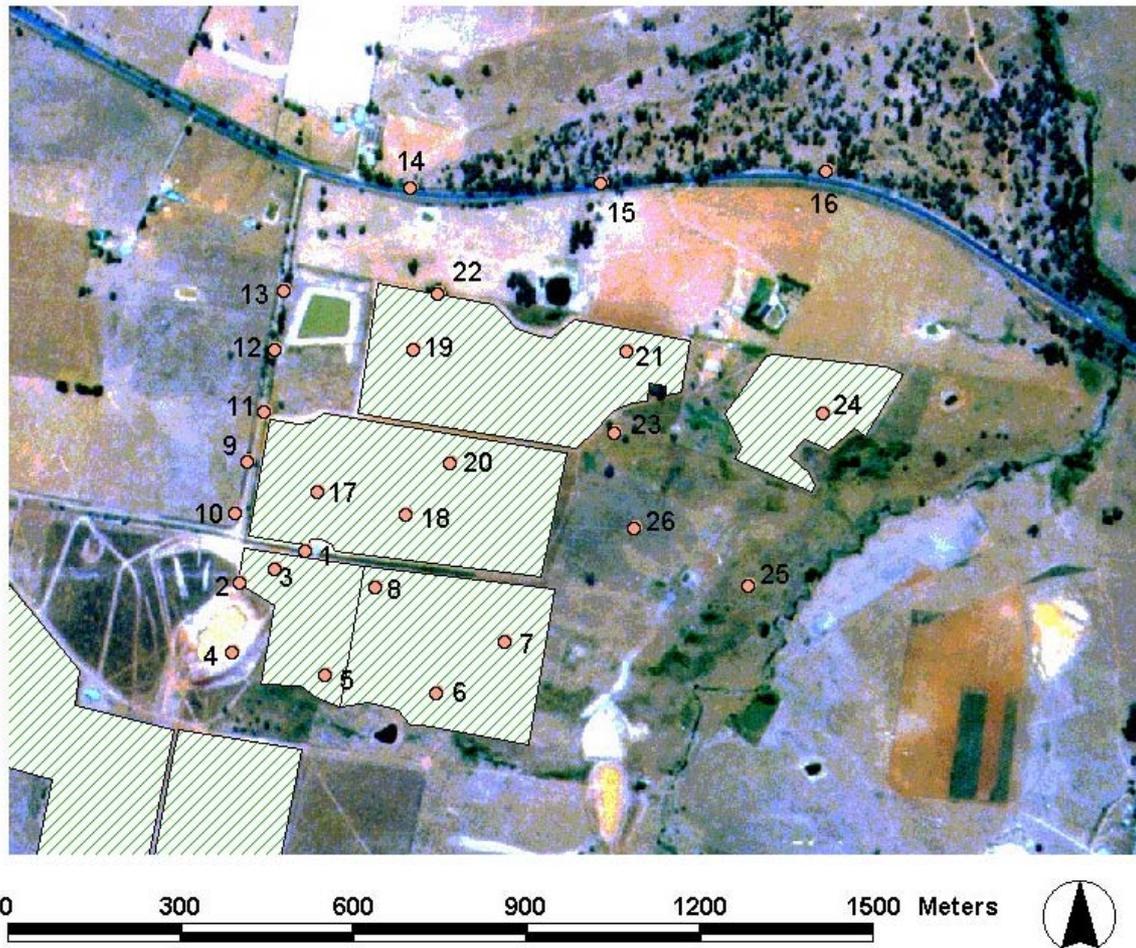


Figure 3. Placement of the variable circle plot (VCP) locations in Vineyard E, monitored February 2001 to March 2002.

2.4 Capture Techniques

To establish trapping techniques for starlings in vineyards and to catch individuals for tagging and radio tagging, five techniques were trialled; modified Australian crow (MAC) traps, walk in traps, mist netting, nest box traps and capture by hand at nest nests.

To reduce capture of non-targets, mist nets and traps were placed in areas that were frequented by starlings and not other species. This was confirmed by direct observations prior to setting traps and free feeding to attract starlings. Nets and traps were regularly checked and monitored during trapping periods. They were not used over night, during the middle of the day, or during inclement weather. Starlings captured in a net or trap were processed and released at the capture location. All non-target birds were released immediately. Capture stress from MAC and walk-in traps was minimised by providing adequate food and water, and placing traps away from direct sunlight.

2.4.1 Modified Australian Crow Trap

The Australian crow trap has a V-shaped upper entrance and is commonly used for trapping corvids. The same design with a modified entrance can be used for smaller species, such as

starlings, mynas and sparrows (Gadd 1996). This modified entrance design is commonly used by the staff of Agriculture Western Australia to catch large numbers of starlings on the South Australian - Western Australian border each year. The trap in this study was designed and built (2.4 x 1.8 x 1.8m) to allow transportation in the tray of a 4WD utility. An entrance diameter of 38mm for starlings was cut into a removable section of marine plywood and bolted in place at the top of the trap. This plywood board was the upper entrance and feeding platform. Sultanas, grapes, chick starter pellets, grain and bread soaked in water were used to attract birds to free feeding areas before trap placement. For free feeding, approximately 2.5 loaves of bread or other bait material were dispersed over an area of around 4 m². Once traps were in place the same food types were used on top of and inside the traps. As a further attractant between 2 and 5 starlings were kept in separate catches within the traps.

2.4.2 Walk-in Cage Trap

The walk-in cage trap used in this trial was 460 x 460 x 150mm. The trap was triggered by a treadle plate with a drop-down door. The trip mechanism was similar to that used in the standard commercially available cage traps for capturing live mammals. In comparison, these traps are smaller and have two separate compartments for capturing up to two starlings. These walk in traps were trialled in three different locations: (1) open pasture, (2) pasture under starling roost trees, and (3) in between the vine rows, (approximately 10m in from the edge of the vines). The traps were free fed for approximately five days before setting.

2.4.3 Nest-box Trap

The nest-box trap used in the study was based on the design of Dehaven and Guarino (1969). The nest box (300 x 300 x 500mm) has an entrance diameter of 35mm. An access door was also included in the front of the box to allow observation and retrieval of captured birds. The trapping device was a spring loaded trap door, triggered by a treadle made of 6mm craft wood. The nest box was attached to a Red Stringybark (*Eucalyptus macrorhyncha*), a known roost of starlings and rosellas. To allow birds to become familiar with the nest box the entrance was left open for three days following trap placement.

2.4.4 Capture by Hand

Starlings were captured at nest boxes and natural hollows using a 2m timber pole and a handheld net. The timber pole was used to keep starlings inside the box until the net was put in place. Attached on one end of the pole was a small flat piece of plywood with foam, large enough to cover the entrance hole. Birds were subsequently captured in a hand held net when attempting to leave the nest. This method has been found to increase the likelihood of the birds returning to their nest (Coleman, personal communication), possibly because they do not associate capture with next box. However, in some cases birds were also taken directly from the nest box.

2.4.5 Mist Nets

Mist netting was carried out, following the detailed procedure outlined in the Australian Bird and Bat Banding Manual (Lowe 1989). Mist nets were placed near areas of starling activity and feeding. Passerine nets (mesh size 31mm) of up to 18m long were used. The nets were opened each morning and late afternoon for a period of two hours. They were left closed

overnight and during the middle of the day to avoid capturing non-targets and to minimise stress during the heat of the day. Nets were not used in excessively windy or hot periods or during rain and were monitored continuously throughout trapping periods.

2.5 Local Behaviour Observations

The foraging and movement behaviour of starlings and their interactions with native parrots (*Platyercus elegans* and *P. eximius*) were monitored on the Rosemount study site via intensive field observations between August 2000 and November 2001. Local activity patterns, preferred roosting and perching sites, and movements in relation to bird damage were quantified as part of this project component. Visual observations on the behaviour of starlings were recorded during regular searches of the vineyard. Observations included recording of time of day, flock size, activity, habitat, length of activity and grid coordinates. Detailed observations were conducted on focal individuals within a flock, which were selected at random.

2.6 Banding and Radio Tagging

To remove effects of acclimatisation all radio tagged birds were captured on the Rosemount study site. Trapped birds were removed from the net or trap and held in a calico bag, while the nets and traps were closed. Non-target species were released immediately at the capture location. Starlings were weighed in the holding bag. Standard measurements of head-body (HB), bill (BK) and tarsus with foot (TZ) lengths were then taken as described in the Australian Bird Banders Manual (Lowe 1989). The radio tags were supplied by Titley electronics and Sirtrack NZ, and consisted of a single stage miniature transmitter and a mercury battery. Transmitter weights with cloth, glue and/or harness averaged 3 grams (n=10; 2.8-3.36).

Two types of radio tags were investigated; a glue-on tag and a back-pack harness. Both designs have been used in the past on small and medium sized birds, the methods for each are discussed below. For both techniques the following actions were taken to minimise stress from handling and radio tagging:

- Handling time of all birds was kept to a minimum.
- Expert bird handlers supervised all procedures until other staff were competent.
- Two people were involved in handling birds, one to hold the bird and the other to take measurements. This reduced handling time and restricted the bird's movement.
- Tags and harnesses were prepared and trialled prior to capture to further reduce handling time.

For both types of transmitter, radio tracking commenced immediately after release and continued daily until the transmitter was recovered or no longer detected. The only exceptions were those harnesses which persisted greater than 3 weeks when tracking was reduced to once every three days. Handheld aerials and vehicle mounted telemetry systems were used to locate birds.

2.6.1 Glue-on Tag

The glue-on tag procedure used was initially developed for radio tagging the endangered eastern bristlebird (*Dasyornis brachypterus*) (Baker and Clarke 1999). The bird's head was enclosed in a draw-string bag 80 x 100mm which acted as a hood, made from black, open-weave cotton.

This has been shown to have a noticeable calming effect (Baker and Clarke 1999). The feathers of the inter-scapular area were trimmed to 1mm over an area approximately 10mm wide and 20mm long using round nosed scissors and an artist-sized-4 paint brush wet with 70 percent ethanol. The round nosed scissors were assumed less likely to result in accidental injury than pointed scissors. When the attachment area was clean and dry, a fresh smear of glue was applied to the radio tag which was then held firmly to the bird for five minutes. The positioning of the tag was aligned with the bird's dorsal axis.

The glue used was a fast setting cyanoacrylate (e.g. 'Supa Glue'). This has been found to be safe for use with 128 birds from four passerine species (Johnson *et al* 1991), and also the most successful type of adhesive to use with birds (Perry *et al* 1981), including starlings and endangered species. Prior to catching the birds, a piece of gauze (cotton material 0.5mm thick) was attached to the radio tag using cyanoacrylate, and trimmed to overlap the tag by 1mm. This has been shown to enhance the adhesion to the bird (Baker and Clarke 1999). The hooded bird was then placed in a 100mm x 200mm x 300mm holding box for 10 minutes to allow additional time for the adhesive to strengthen, before releasing close to the point of capture.

2.6.2 Back-pack Harness

Nine starlings were captured and fitted with a backpack 'Figure of eight' type harness (Kenward 2000). The design used was a slight modification from that developed for regent honeyeaters (David Geering, personal communication). Two small tubes of 1.6mm heat shrink were attached by epoxy resin adhesive at the top and bottom of the transmitter, with hat elastic as the harness material. When attaching to the bird, a single piece of hat elastic was looped around both wings and through top and bottom tubes, then sewed together with cotton. Cotton (not polyester) was used as the weak link so the transmitters eventually fell off. This allowed for adjustment for time according to the strength of cotton used.

2.7 Nesting Behaviour

There is very little information available in Australia on the timing of breeding, reproductive success or potential rates of increase of starling populations, which are necessary to develop the effective control of starlings in the breeding season. To investigate the reproductive potential of starling populations and interactions with native species; natural nest searches, nest box monitoring and interaction observations were studied intensively at the Rosemount study site.

2.7.1 Natural Nest Searches

In October 2000, a complete census of starling nests was conducted following two weeks of continuous searching of all likely locations within the study area. This was achieved by climbing into trees using a 5m extendable ladder and investigating all likely nesting locations. Investigation of nests was aided by a micro video camera mounted on a flexible arm with around 10m of cabling. The camera unit was battery operated and attached to a small portable monitor to allow nests to be viewed on the ground. In instances where hollow entrances were too small to fit the camera inside, a small torch was used to light the inside of the cavity. Starling activity, the numbers of eggs and offspring found in each nest were recorded. This provided an instantaneous census of nests and nesting hollows on the study site.

The same methods were used in the following season (August 2001 to April 2002) over a longer duration and in greater intensity. In both seasons, every likely nest location was searched within the study site including fence posts and all tree species. In two cases hollows were located in inaccessible parts of a tree, so while the existence of these hollows was recorded no measurements could be taken. In all other nesting sites; cavity height (A), entrance diameter (B), cavity depth (C), internal cavity diameter (D), circumference of tree below nest hole (E), hole orientation (F), (Figure 4.), tree species, tree position and nesting activity was recorded. Previous studies of hole nesting species have used similar methods to define nest characteristics (e.g. Pinkowski 1976; Saunders *et al.* 1982; Mawson and Long 1994).

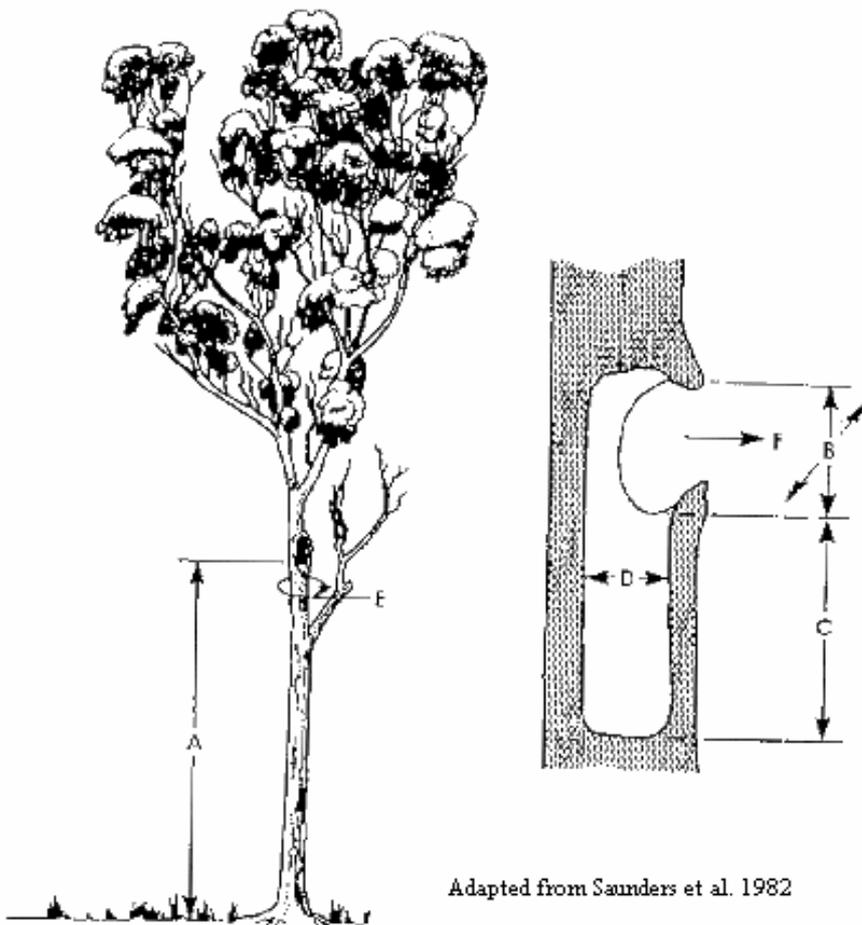


Figure 4. Nest cavity measurements: A, cavity height; B, entrance diameter; C, cavity depth; D, internal cavity diameter; E, circumference of tree below nest hole; F, hole orientation.

Tree species were also aged using a rating scale designed for eucalypts (RACAC 1997). The 'growth stage' rating system is based on the characteristics that eucalypts gain as they mature. Therefore some younger trees had more mature characteristics due to other factors which restrict their growth and health, such as diseases or loss of limbs. Although the system was designed for eucalypts, weeping willows and acacias were also rated with this system because they also gain similar structural characteristics as they mature, i.e. hollows and dead limbs.

2.7.2 Nest Boxes

In August 2001, fifty artificial nesting boxes were placed in suitable locations around the Rosemount study site. Nest boxes were attached to mature eucalypts (*Eucalyptus macrorhyncha*, *E. seeana*, *E. viminalis*, *E. tereticornis*) on southern aspects at a height of 4 metres. Trees were selected randomly throughout the study site, but were at least 10 m apart. All nest sites were checked every two weeks from August-December 2001 and nest checking continued until April 2002.

Nest boxes (40 x 25 x 25 mm) were constructed from 10mm plywood and painted to increase weather protection. Perches of 12mm dowel were attached below the 80mm diameter entrances. A hinged roof allowed investigation of nesting activity. Boxes were fastened to trees using tech screws and holes were drilled in the base of the boxes for drainage purposes. For consistency with other studies (Pell and Tidemann 1997) all boxes were attached with a southern facing orientation.

3. RESULTS

3.1 Damage Assessment Technique

3.1.1 Random Bunch Selection

The selection procedure we developed was simple and efficient in selecting random bunches. The same length of conduit could be used in vineyards of any trellis height, provided random numbers were generated separately for different heights. Once the vine was located, one observer could locate and assess a bunch in approximately 20 seconds. This was an improvement on previous techniques which took between 30 and 60 seconds with two or three observers (DeHaven and Hothem 1979; Martin and Crabb 1979). The score sheet technique described by Sinclair (2000) would also provide a rapid, efficient method of unbiased bunch selection.

3.1.2 Evaluation of Visual Assessment Methods

Observers were found to be significantly different in estimating bird damage using Wald tests for fixed effects and an Analysis of Variance (ANOVA) (df=10 P<0.05) but all consistently under-estimated, particular at mid percentages (Figure 3). There were no differences between seasons (df=3, P>0.05), or between bunches with pecked and missing grapes (P>0.05). To allow correction of damage data and applicability to other studies observer effects were treated as random and data was pooled for all observers. An inverse estimator for the calibration data was also used for simplicity in calculating confidence intervals (Armitage and Colton 1998).

To determine a correction model, percentages of actual (X) and estimated (Y) damage were first logit transformed to linearize the response and to remove variance heterogeneity.

$$\log it(X) = \log\left(\frac{X}{100-X}\right) \quad \text{and} \quad \log it(Y) = \log\left(\frac{Y}{100-Y}\right)$$

The model then was,

$$\log\left(\frac{X}{100-X}\right) = (0.708 + 0.811) \log\left(\frac{Y}{100-Y}\right)$$
$$X = \frac{100}{1 + e^{-0.708\left(\frac{y}{100-y}\right)^{0.811}}}$$

3.1.3 Progressive Sampling Strategy

In 2000, bird damage was estimated for 129 Property/Block/Variety/Sampling Date (PBVD) combinations. In all cases damage inside the block was less than the maximum damage observed on the boundary, except when overall damage was small (less than 5%) (Figure 5).

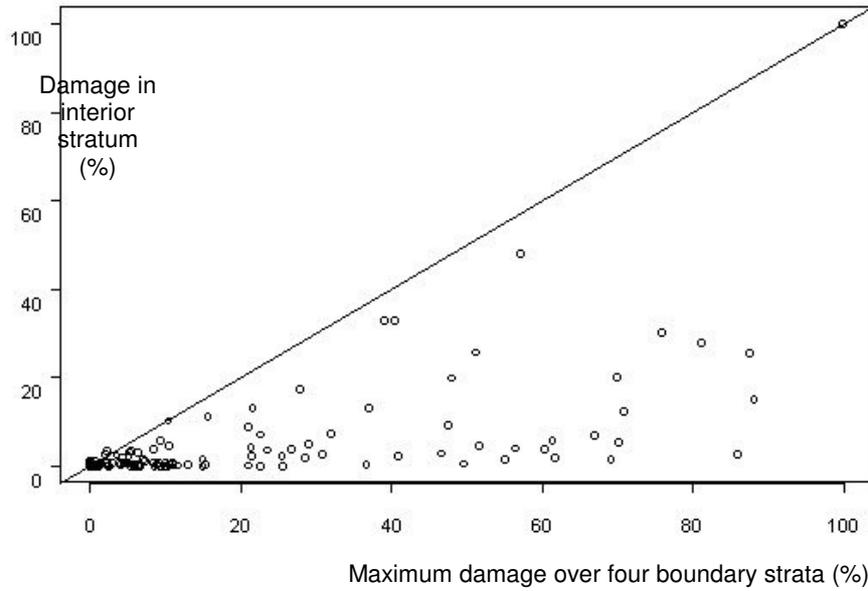


Figure 5. Percent bird damage in the interior stratum (5) versus the maximum percent bird damage estimated in any outside stratum (1-4).

To estimate the mean percent damage for a PBVD we assumed an equal number of bunches per vine in each block. A weighted average of the estimated means within each stratum was then evaluated, with the weights proportional to the number of vines in each stratum;

$$D = \sum_{i=1}^n d_i p_i$$

D = Percent damage of the block

V_T = Total number of vines in the block

d_i = Mean percent damage in stratum i $d_i = \frac{\sum_{i=1}^n b}{n}$

b = Percent bunch damage in stratum i

n = Number of vines sampled in stratum i

v_i = Number of vines in stratum i

p_i = Proportion of vines in stratum i $p_i = \frac{v_i}{V_T}$

To determine appropriate sample sizes required we examined first the standard deviation of the results versus the mean. In Figure 6. below is plotted the standard deviation of percentage damage versus mean percent damage for each PBVD/Stratum combination observed. Here the standard deviations are calculated assuming that the percent damage variation within and between vines is equivalent within strata. Also included on Figure 5 is the least squares fit for the line

$$SD = \alpha [Mean(100 - Mean)]^\beta$$

Estimates of parameters are: $\alpha = -2.542$

$$\beta = 0.0165$$

Based on the above model for the variation of results within strata we can determine the minimum sample size needed to estimate the mean percentage damage within a Stratum so as to place an upper bound on the standard error. For example, should the mean percent damage within a Stratum need to be estimated with a standard error of 2% or less, then the sample needed, n say, must satisfy

$$0.0165 \text{ Mean } (100 - \text{Mean}) / \sqrt{n} \leq 2$$

Hence n must be $[0.00825 \text{ Mean } (100 - \text{Mean})]^2$ or larger. If Mean is 20% say, then n must be at least 175. Figure 3 plots the minimum sample size versus mean for when the standard error of the mean equal 3%, 5%, 7% and 10%.

When estimating the percentage damage of a block based on a weighted average of the mean damage within each of the separate strata, the standard error of the overall mean estimate will depend on the relative sizes of the Strata. Let p_i denote the proportion of vines in Stratum i ($i = 1, 2, \dots, 5$) relative to the total number of vines in all five strata and τ_i equal the corresponding standard error of the percent damage estimate in that stratum. Then the standard error of the mean percent damage for the block, τ say, is given by

$$\tau = \sqrt{\sum_i p_i^2 \tau_i^2}$$

Hence τ is influenced by the maximum p_i ($i = 1, 2, \dots, 5$).

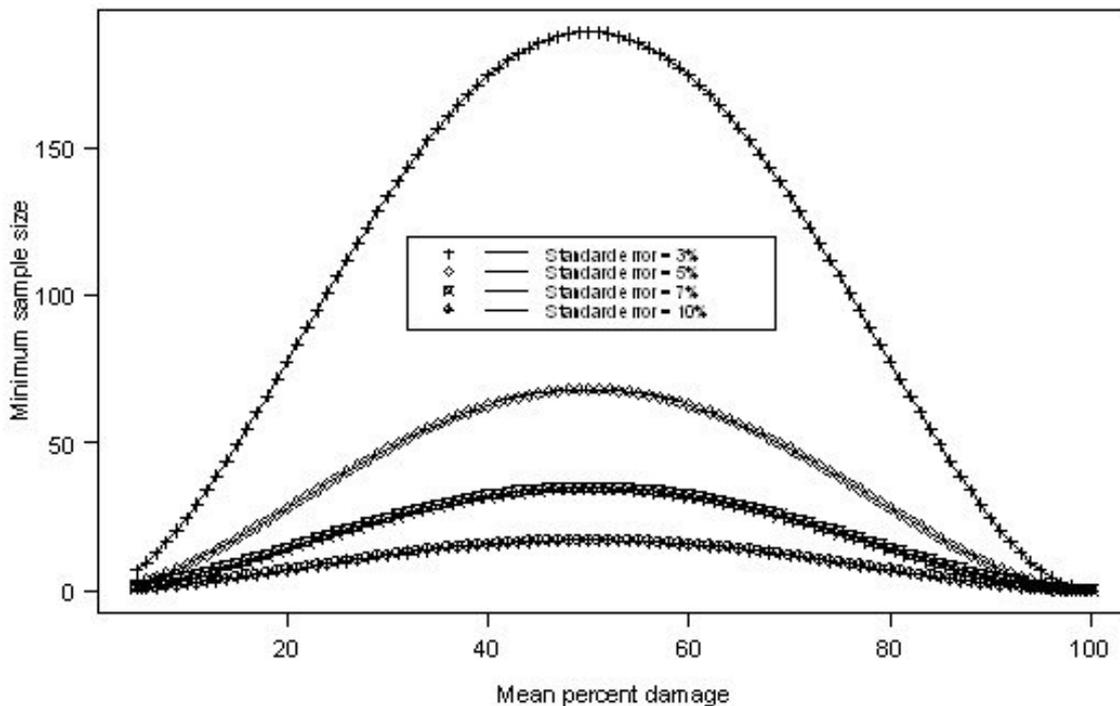


Figure 6. Predicted minimum sample sizes for estimating percent bird damage within strata with a 3, 5, 7 and 10 % standard error.

The progressive sampling procedure is based on the results of Figure 6 for any desired standard error. We aimed at achieving an accuracy of 5% and assumed the underlying percent damage was 10%. Hence chose n=10 vines from each outside stratum (1-4). If damage was less than 5% in any outside stratum, then no more sampling was necessary as we could be confident that overall damage was less than 5% (Figure 1). If any stratum was greater than 5% in any outside stratum, the interior of the block was also sampled in the same way (Stratum 5). If damage was greater than the assumed 10% in any stratum then more samples were taken from that stratum relative to the estimated percent damage (Table 2).

Table 1. Sample sizes needed to estimate percent damage with 5% standard error (derived from Figure 6 Results)

Percent damage	5	10	20	30	40	50	60	70	80	90	95
Sample Size	4	10	24	37	46	49	46	37	24	10	4

3.2 Damage Estimates

In 2000 and 2001, percent bird damage was estimated in 146 blocks, 13 varieties in 16 vineyards (See Figure 7). Estimates of block damage for the Orange region for both seasons averaged 15.7% just prior to harvest (n=146, $\sigma=20.9$, range=0-95%). Bird damage varied significantly between vineyards (n=13, $\sigma^2=236$, range 0.3-83%) and between blocks (n=38, $\sigma^2=132$, 0-95%). There were no clear preferences for particular varieties, although within vineyards some varieties were damaged significantly more than others (n=13, $\sigma^2=20$, Figure 8.).

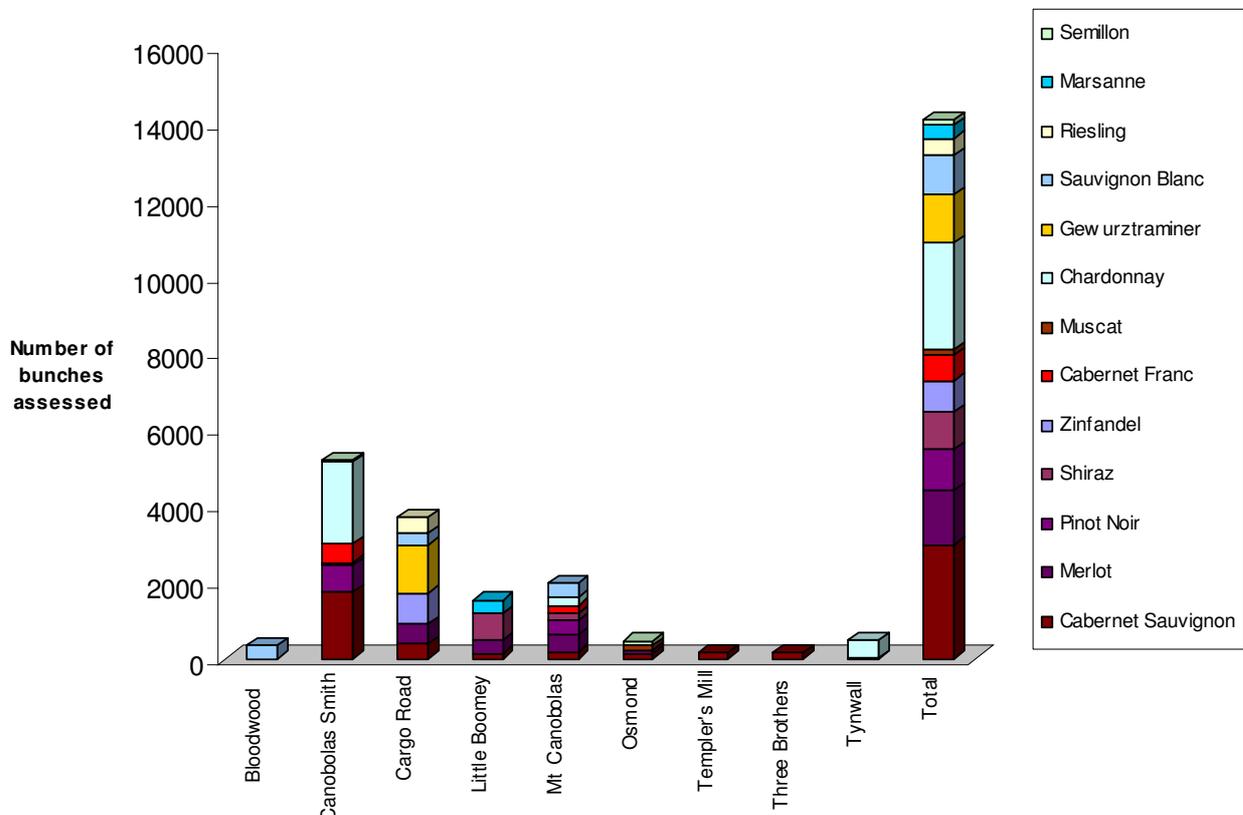


Figure 7. Number of bunches assessed by vineyard and variety (Feb-May 2000)

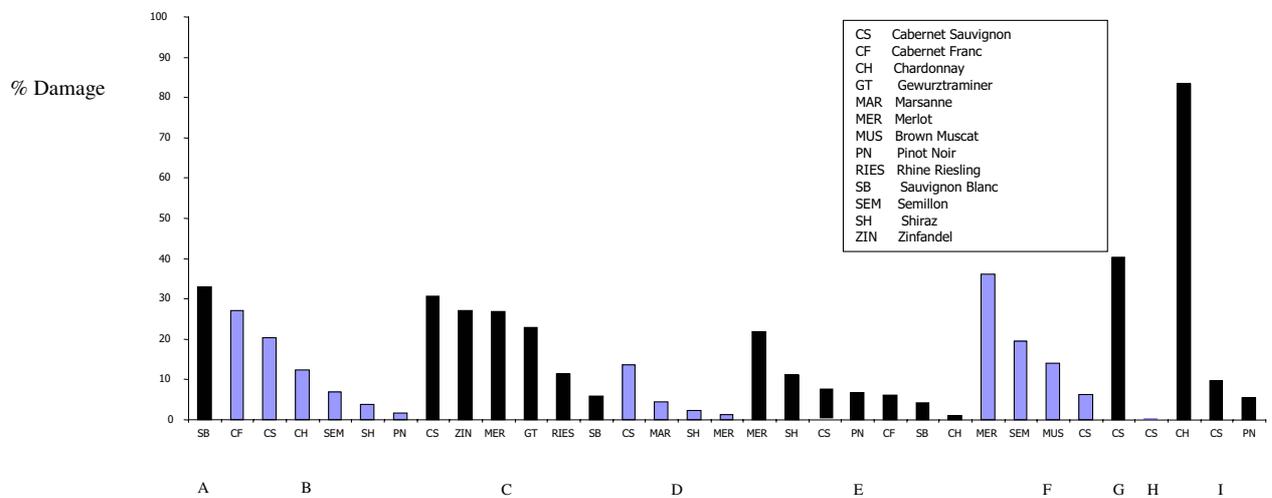


Figure 8. Percent bird damage at 2000 harvest by vineyard (A to I) and variety.

In addition, eleven blocks in two vineyards were sampled more intensively during both seasons. In these blocks repeated estimates were calculated from veraison to harvest to investigate temporal fluctuations in damage. These trends were markedly varied for different varieties (Figure 9. and Figure 10.). Damage did not increase consistently, some varieties displayed gradual increases in damage throughout the season, other experienced large increases in damage at particular stages of grape maturity (Figure 9. and Figure 10.).

Future study will incorporate explanatory variables such as bird species, length of ripening, distance to perching sites, landscape and habitat features (e.g. Figure 11.), with the assistance of a geographic information system, spatial queries and predictive modelling.

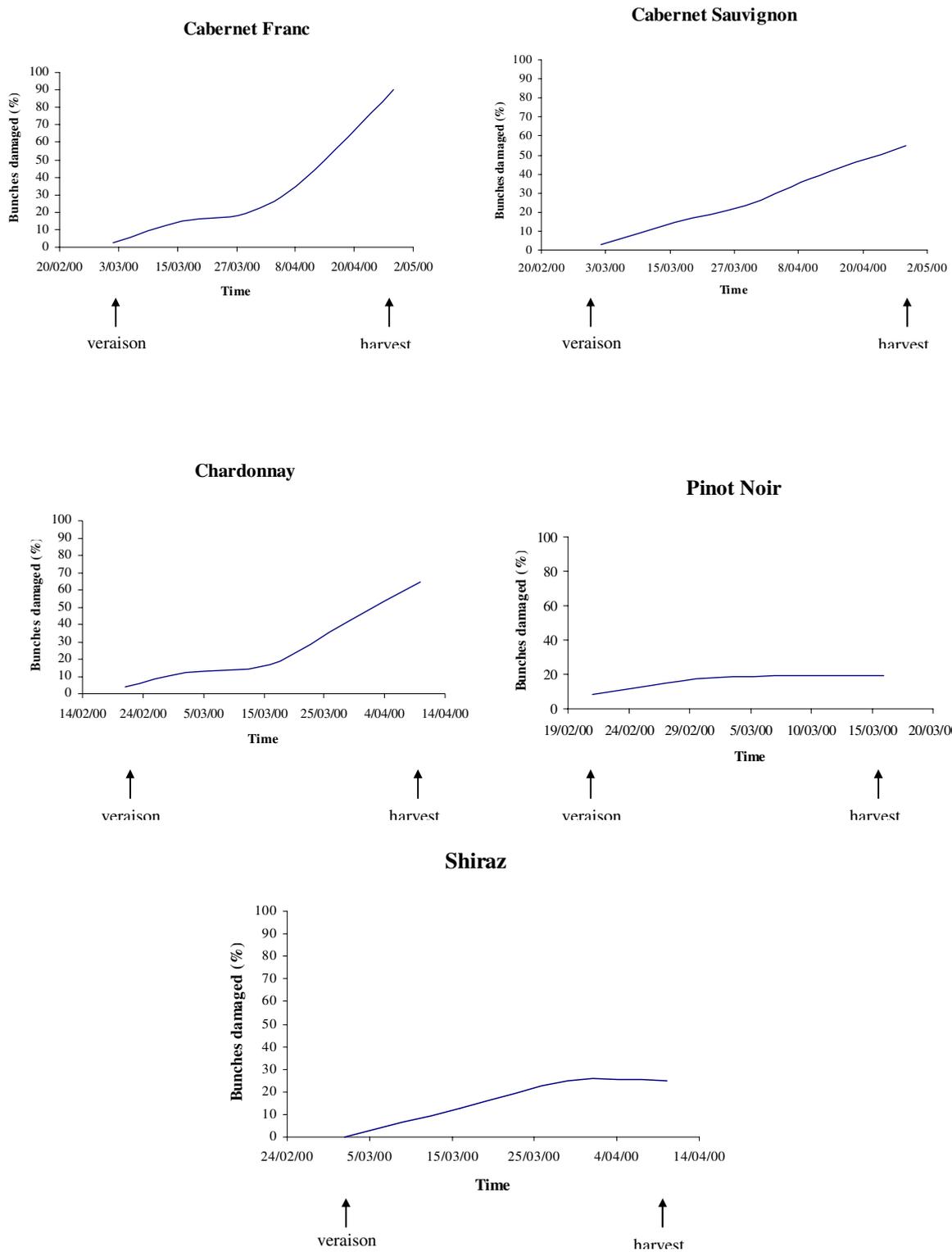


Figure 9. Cumulative bird damage during the ripening season (February to May 2000) in Vineyard B.

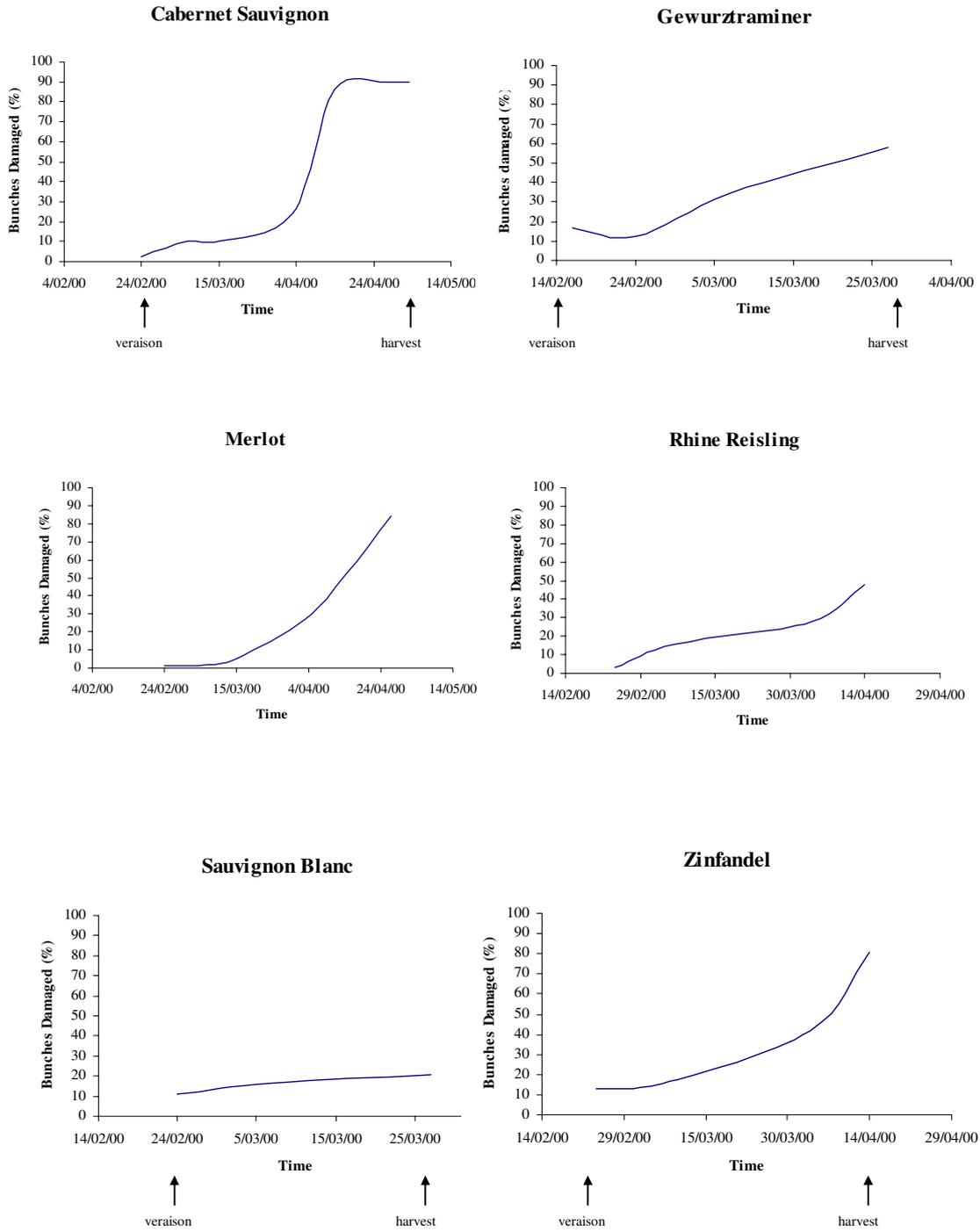


Figure 10. Cumulative bird damage during the ripening season (February to May 2000) in Vineyard C.



500 0 500 1000 1500 2000 Metres

- | | |
|------------------|------------------|
| Acacia Hedge | Open Forest |
| Building | Open Woodland |
| Casuarinas | Orchard |
| Closed Forest | Pine Forest |
| Cottonwood Hedge | Pine Hedge |
| Dam | Race track |
| Exotics | Residential |
| Hazelnut Hedge | Tea Tree Thicket |
| Native Hedge | Vineyard |
| Native Windrow | Willow Trees |
| Neighbouring Vin | Windrow |
| Open | Woodland |

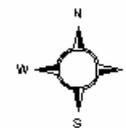


Figure 11. Habitat features mapped for Vineyard B.

3.3 Sample Size Estimates for Management Evaluation

To examine the feasibility of testing management treatments we estimated the number of replicates required to detect a difference in bird damage (%D) with confidence (%P) (Table 2). We assumed that n randomly chosen property/block combinations are allocated to each of two treatments and that the percentage damage within a property/variety/block can be estimated without error. Using the variance estimates between vineyards, the variance of the mean percent damage for n results will be $(236+132)/n$. Hence the probability that the

difference between the two means will indicate that a treatment significantly reduces damage is approximately

$$P\{Z > 1.65 - 10\sqrt{n} / \sqrt{(2 \times 368)}\} \text{ where } Z \text{ is a standard normal variate.}$$

Hence we need $n \geq 83$ to ensure that a 10% reduction (in absolute terms) is detected with 95% confidence. Table 2 shows the minimum number of replicates required to detect 5 and 10% difference in bird damage with 50%, 75%, 90% and 95% confidence.

Table 2. The minimum number of replicates required to detect an absolute difference D (D = 5% and 10%) with confidence P (P = 50%, 75%, 90%, 95%) across vineyards.

Difference (D)	P = 50%	P = 75%	P = 90%	P = 95%
5%	81	160	253	320
10%	21	40	64	80

These values illustrate that a very large number of replicates are needed to detect meaningful differences with any degree of confidence. This is a consequence of the large variation across properties. In reality the number of replicates will need to be larger as we have assumed that the estimation of the damage within a Block can be estimated without error when generating the table above. The number of replicates required could be reduced if comparisons could be made on the same variety within properties (Table 3).

Table 3. The minimum number of replicates required to detect an absolute difference D (D = 5% and 10%) with confidence P (P = 50%, 75%, 90%, 95%) within vineyards.

Difference (D)	P = 50%	P = 75%	P = 90%	P = 95%
5%	29	58	91	115
10%	8	15	23	29

3.4 Economics of Bird Netting

Results indicate investment in double row drape-over netting is profitable where bird damage is >10% per annum. Average bird damage for vineyard blocks sampled in Orange in 2000 and 2001 was 15.7% (n=146, $\sigma=20.9$, range=0-95%), indicating investing in netting may-be cost effective for many vineyards in the Orange area. Investment in netting is significantly more cost effective for vignerons with higher levels of damage. For example, vignerons who consistently experience bird damage of greater than 50% will receive over 6 times (Figure 13.) their investment in netting or a net present value of over \$35 000 (Figure 12.) over a 10 year period.

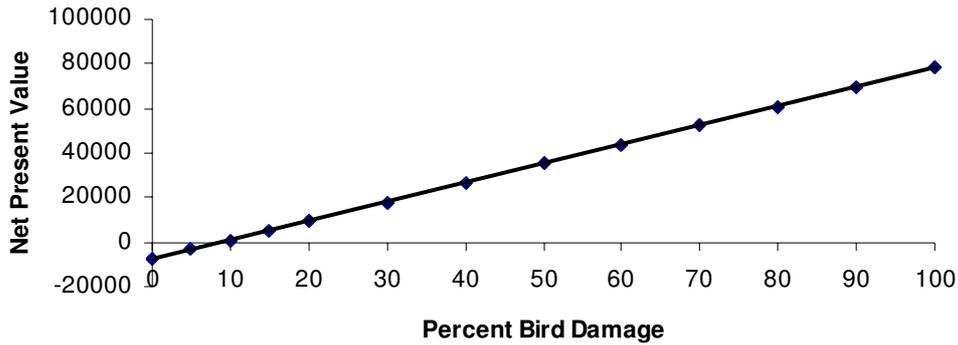


Figure 12. Percent bird damage vs the net present value for investment in double –row drape over bird netting. The break-even point for investment in bird netting is where the net present value = 0.

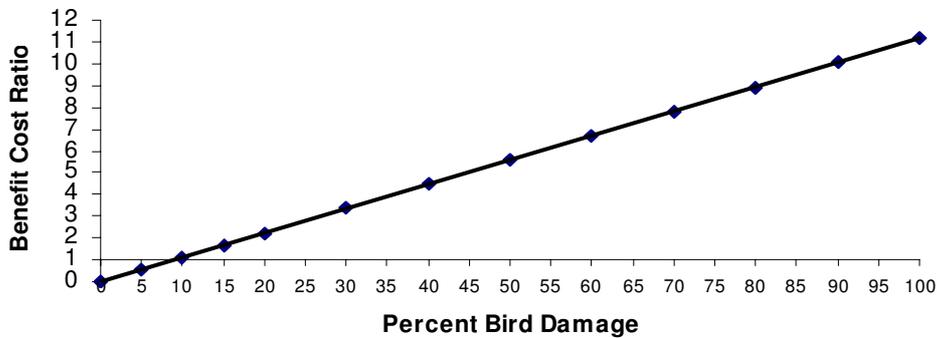


Figure 13. Percent bird damage vs the benefit cost ratio for investment in double row drape-over bird netting. The break-even point for investment in bird netting is where the Benefit cost ration = 1.

A Benefit-Cost Analysis (BCA) was also conducted to compare a vineyard without netting with four different netting scenarios at 15, 20 25 and 30% bird damage levels. The BCA results are given in Table 4. The base no-netting option generated positive BCA criteria and has a unitary (1:1) BCR at an annual damage level of about 40%, beyond which a vineyard operation without netting would be an uneconomic proposition. This occurred in over 8% of block sampled during 2000 season (5 of 60), despite considerable efforts and costs to manage birds. This base no-netting option was profitable at the district average damage level (15%) but long-term returns were significantly reduced as damage increased. Each of the netting options generated positive economic returns. Permanent netting was the most expensive control option but it had sound BCA criteria over the 10-year period. Direct comparison with the no-netting option suggests that permanent netting is only an economic investment if bird damage averages about 25% over time. The drape netting options are more profitable. The BCA for the drape netting options are of a similar magnitude but favour the 4-row option. While no bird damage is assumed to occur when nets are installed, the unitary BCA estimates indicate that damage levels up to 19% for permanent netting and between 30-33% for the drape netting options could be absorbed by investment in netting.

Sensitivity analysis was undertaken to determine the break-even prices and yields for each of the options (Table 4.). Price was sensitised against the base yield, as was yield against the base price. Permanent netting remained marginally profitable at a tonnage price of \$1,100 at

the budgeted yield (13 tonnes), or a yield of 10.5 tonnes per hectare at the budgeted price of \$1,300 per tonne. This indicates that the price/yield margins are narrow for this option when compared to the base values, ie., a price fall of 15% and a yield decrease of about 20%. The drape netting options have much higher tolerances for price or yield reductions in comparison. Comparative tolerances without netting are between \$990 to \$1,160 per tonne and 9.4 to 11.4 tonnes per hectare for increasing levels of damage.

Table 4. Benefit-cost analysis of bird netting options (10 years at 5% real discount)

	Benefit-cost criteria			Sensitivity analysis		
	NPV (\$'000)	BCR	IRR (%)	Maximum damage level (%) ^a	Minimum price at base yield (\$/t)	Minimum price at base yield (t/ha)
No netting				39.1		
15% damage	19.19	1.31	15.5		990	9.4
20% damage	15.14	1.25	13.5		1,045	10.0
25% damage	10.09	1.18	11.5		1,100	10.6
30% damage	7.03	1.12	9.3		1,160	11.4
Permanent netting	15.20	1.19	10.5	19.2	1,100	10.5
Drape netting – 1 row	24.09	1.34	15.3	30.1	975	9.1
Drape netting – 2 row	25.66	1.37	16.3	32.2	950	8.9
Drape netting – 4 row	26.97	1.39	17.2	33.4	930	8.7

^a level of bird damage that generates a unitary (1:1) BCR

3.5 Bird Abundance

Bird abundance estimates indicate large variability between vineyards (Figure 14.) and seasons (Figure 15.) which may partly explain differences in damage. Noisy friarbirds (*Philemon corniculatus*), red wattlebirds (*Anthochaera carunculata*) and yellow-faced honeyeaters (*Lichenostomus chrysops*) in particular were less abundant in vineyards in 2001. Conversely during the 2001 season larger numbers of pied currawongs were observed (Figure 15). Vignerons also noted the unusually high numbers of noisy friarbirds during the 2000 season, and indicated these were not perceived a pest at all prior to this year.

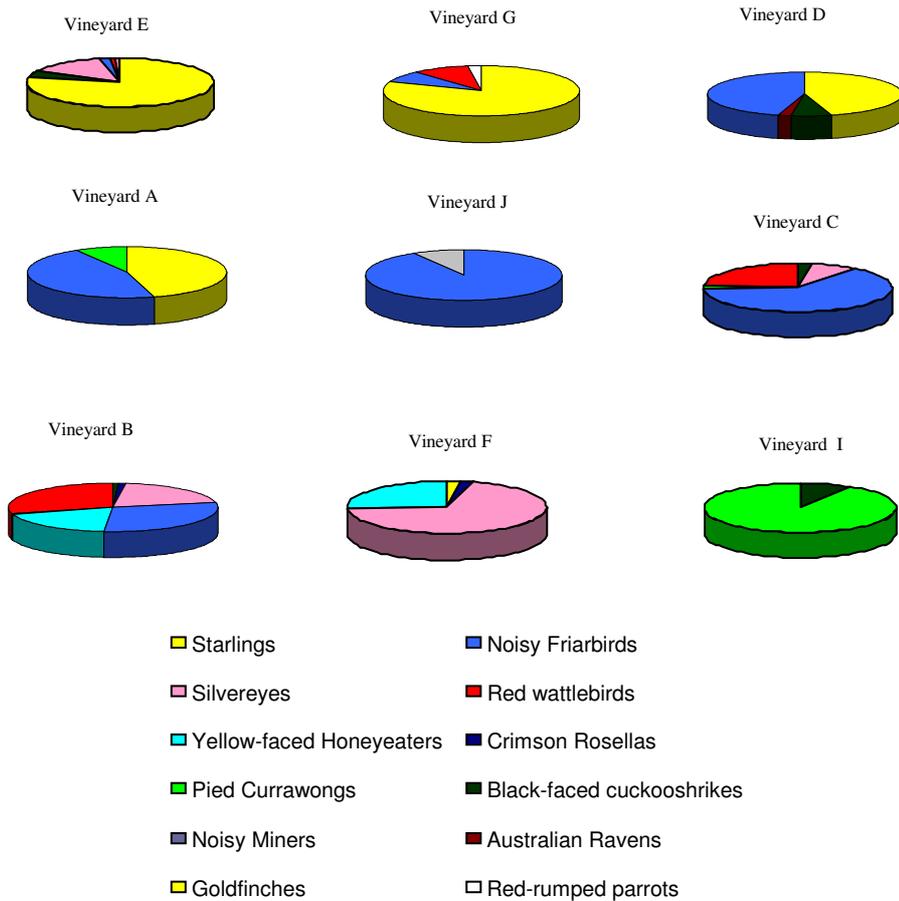


Figure 14. Bird species composition in nine vineyards in the Orange Region during the ripening season February to May 2000

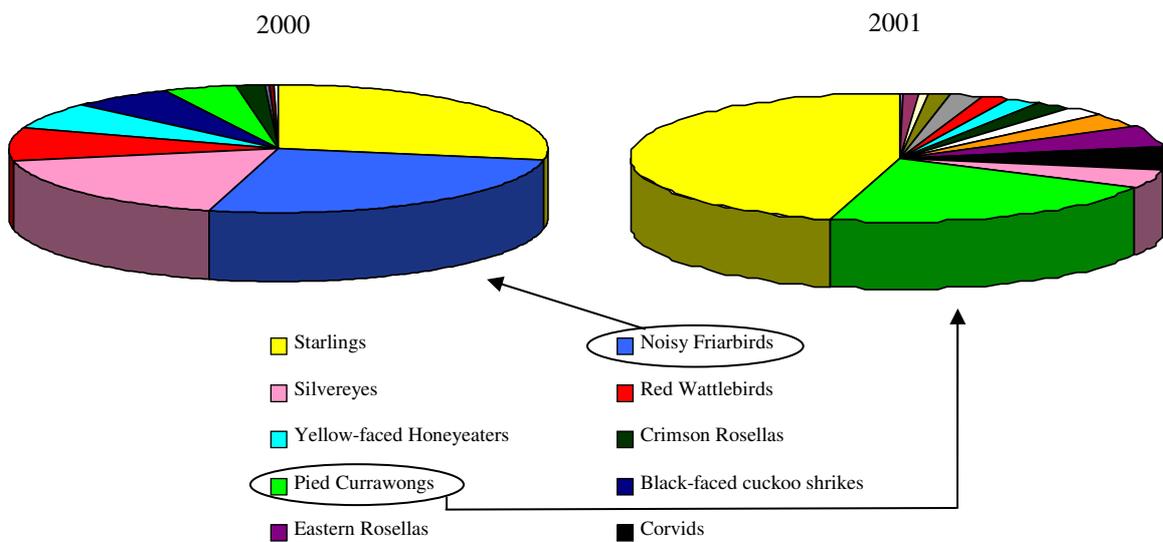


Figure 15. Proportion of bird species observed in Orange vineyards during the 2000 and 2001 ripening season (February to May).

In 2000, noisy friarbirds were the second most common species observed (26%; Figure 15.), while in 2001 they comprised less than 1% of total bird observations. This trend was also apparent across vineyards with this species commonly observed (>46%) in four of the nine vineyards investigated (Table 14.). Investigation of Birds Australia data during this period (February to May) also suggests larger numbers of friarbirds in western regions during 2000 (Figure 16.).

Table 5. Most common bird species regarded as pests on Orange vineyards during the 2000 season.

Vineyard	1st Most Common Species	Observed (%)	2 nd Most Common Species	Observed (%)
A	Starlings	46	Noisy Friarbirds	46
B	Noisy Friarbirds	30	Red Wattlebirds	29
C	Noisy Friarbirds	62	Red Wattlebirds	23
D	Starlings	46	Noisy Friarbirds	46
E	Starlings	79	Silvereyes	14
F	Silvereyes	70	Y-F Honeyeater	25
G	Starlings	81	Red Wattlebirds	10
H	Noisy Friarbirds	91	Noisy Miners	9
I	Pied Currawongs	91	Crimson Rosella	9

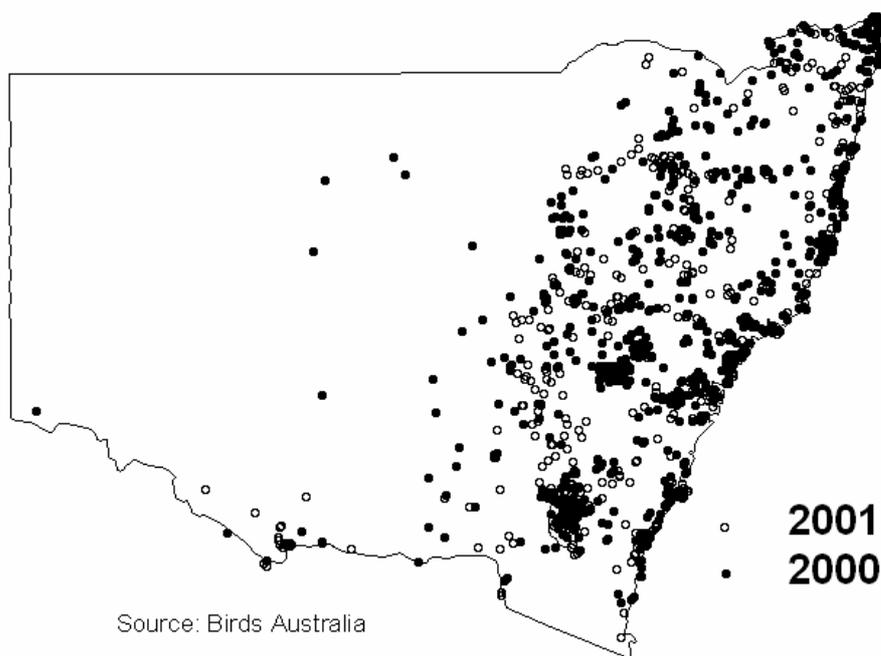


Figure 16. Noisy friarbird distribution February to May 2000 and 2001.

Similar to fluctuations in damage over the ripening period, the temporal changes in bird abundance were also erratic between vineyards. Individual vineyards showed marked increases in abundance, slight decreases, or both steep increases and declines during the season (Figure 17.).

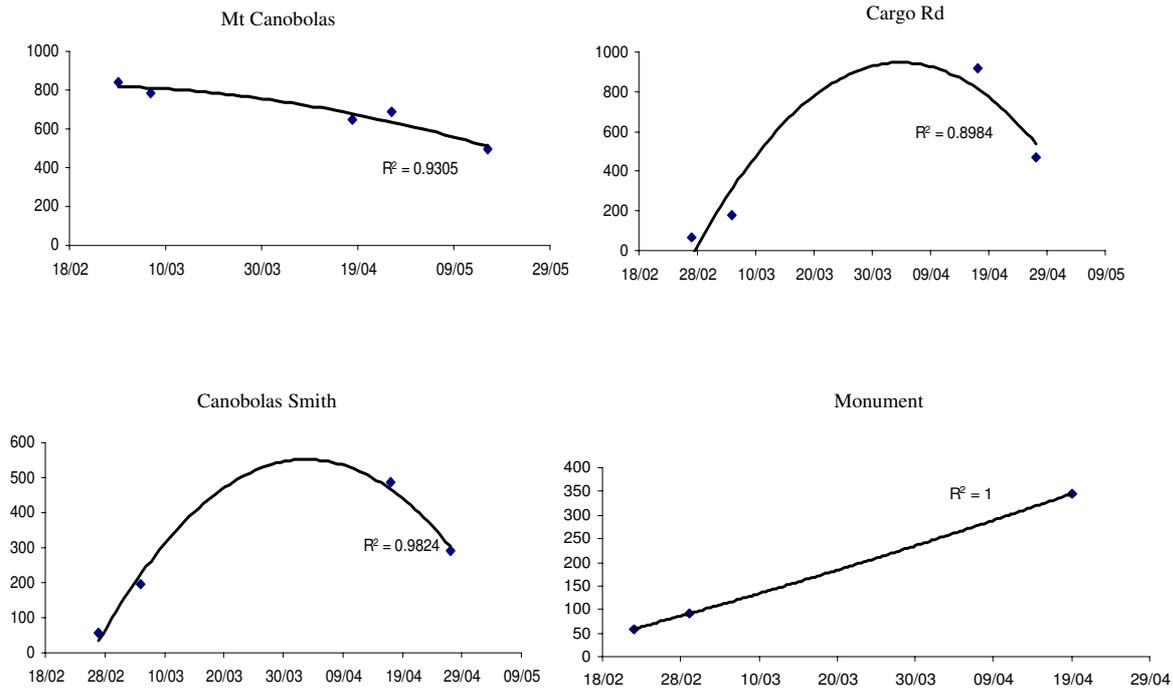


Figure 17. Changes in pest bird species abundance in Orange vineyards during the ripening season, February to May 2001.

Simultaneous temporal observations of damage and abundance allowed closer investigation of the relationship between abundance and damage for different species (Figure 18.). Figure 18 shows a rapid decline in the abundance of Silvereyes and Yellow-faced Honeyeaters following the harvest of Chardonnay (10/4/00). This coincided with increased numbers of Noisy Friarbirds and Red Wattlebirds and a subsequent increase in bird damage levels to Cabernet Franc. Bird species also showed clear preferences for different habitats (Figure 19.).

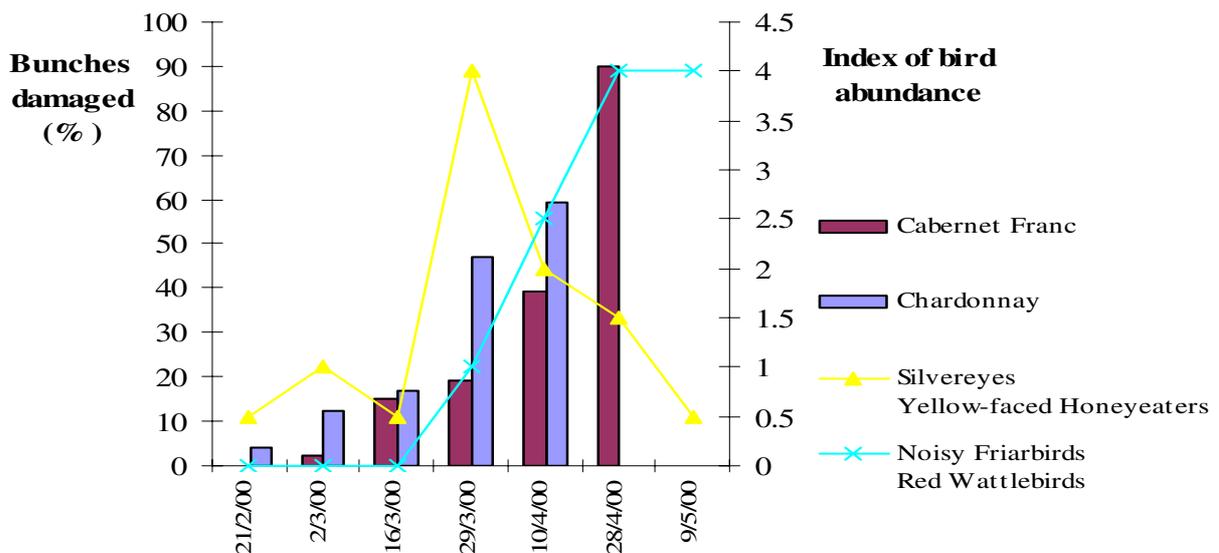


Figure 18. Temporal changes in bird abundance and damage in Vineyard B over the ripening period (February to May 2000).

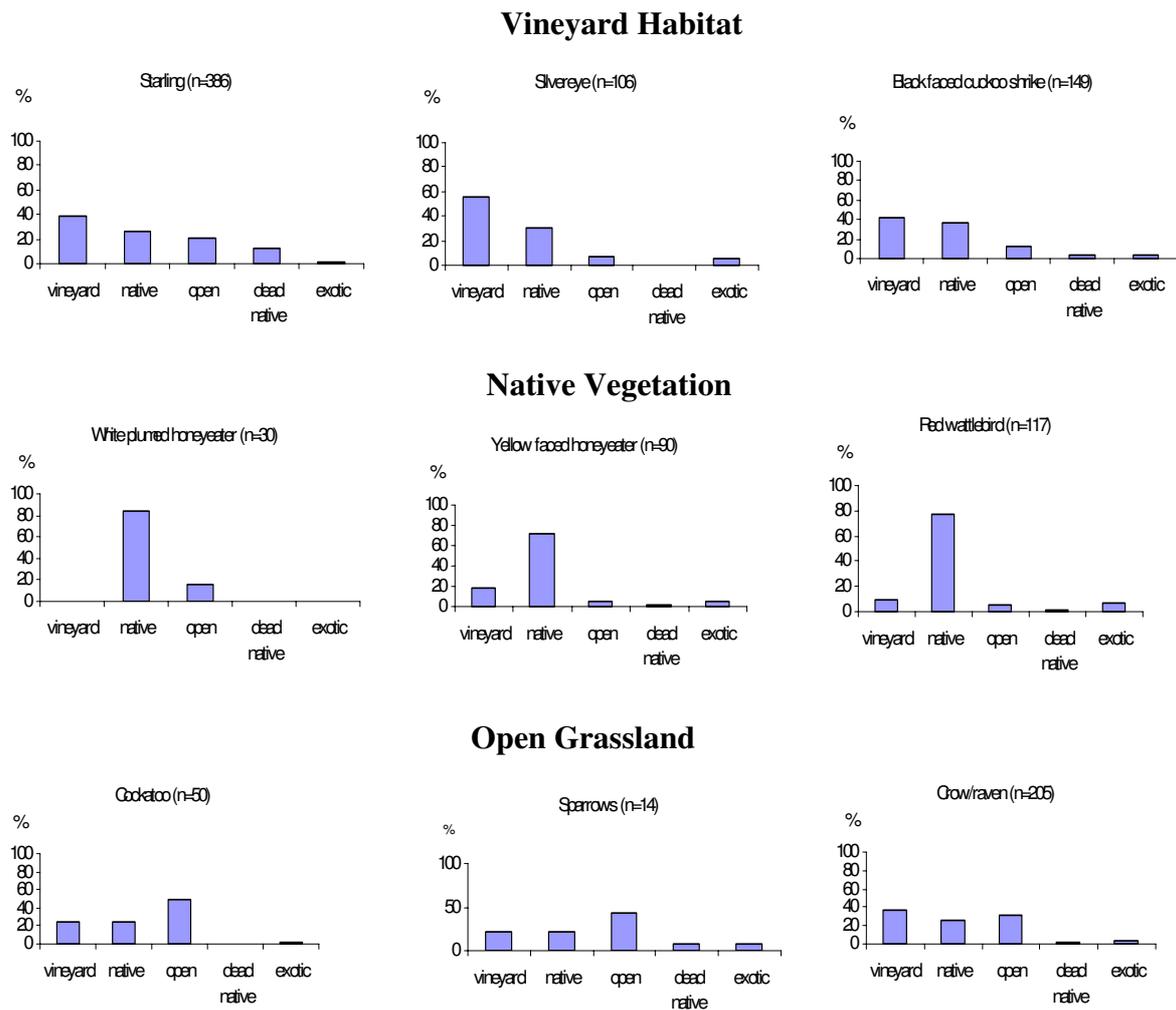


Figure 19. Percentage of observations for nine species in five habitats from bird point counts using the variable circular plot technique during the 2001 ripening season (February to May).

3.6 Comparison of Trapping Techniques

During vineyard trapping (December 2001 and April 2002), Modified Australian Crow (MAC) traps (83 trap days), walk-in traps (41 trap days) and mistnets (4 trap days, equivalent to 15 hours, two nets on 2 trapping occasions) were used to capture starlings. A total of 33 starlings were captured using these techniques during this period. Non-target captures included 2 magpie larks (*Grallina cyanoleuca*) and 1 blackbird (*Turdus merula*) (walk-in traps); 1 superb fairy wren (*Malurus cyaneus*) (MAC trap); 2 goldfinches (*Carduelis chloris*), 1 yellow-faced honeyeater (*Lichenostomus chrysops*), 1 silvereye (*Zosterops lateralis*) and 1 sparrow (*Passer domesticus*) (mistnets). No parrots were captured as part of this project. A further 19 juvenile (fledged) starlings were captured by hand in nest boxes, banded using ABBBS guidelines and released. Two of these were subsequently recaptured. A summary of the known fate of captured and radio tagged individuals is displayed in Table 6.

Table 6. A summary of captured and radio tagged starlings and eastern rosellas 2001-2.

Species	No captured and monitored	No surviving
Starling (<i>Sturnus vulgaris</i>)	69 captured 36 nests monitored	66 (3 of the radio tagged birds recovered dead; remainder fate unknown; 7 of 9 transmitters recovered).
Eastern Rosella (<i>Platycerus eximius</i>)	0 captured 9 nests monitored	No dead adults or nestlings observed.

Walk-in traps were also used to catch starlings at two residential sites in Orange. Seventeen starlings, six sparrows, three blackbirds and a willie wagtail were captured over 31 trap days.

No injuries or adverse behavioural consequences were evident to starlings, parrots or any non-target species from trapping, handling or radio tagging. The duration between checking traps varied with the technique used. Mist netting was carried out, following the detailed procedure outlined in the Australian Bird and Bat Banding Manual (Lowe 1989). In this case mist nets were monitored continuously, and birds removed within 5 minutes of capture (20 minutes recommended). Nets were assembled near starling activity centres, in shaded areas, closed over night and during the middle of the day to avoid non-target capture and to minimise heat stress. Walk-in traps were checked every four hours and also placed in shaded areas. MAC traps were checked daily in most cases but occasionally every second day (twice weekly recommended). The large aviary type design (1.8 x 1.8 x 2.4m) with perches, clean food, water and shade would have easily allowed for less regular checking.

Suggested improvements to the MAC trap, which were adopted over the course the study, include providing; multiple perches, and shelter which was achieved by a supplying length of 80mm PVC pipe and attaching shade cloth around sections of the trap. The PVC pipe allowed birds to escape occasional adverse weather conditions.

The MAC trap was the most commonly used technique (83 trap days) and resulted in the majority of captures (Figure 20 a), but was not as efficient as other capture techniques (Figure 20 b). Hand held capture and mist nets were most efficient but were only used on a few number of occasions. However mist nets resulted in a higher proportion of non-target captures. The walk-in trap was least efficient in the vineyard but more successful in urban areas (Figure 20 b). Although bait uptake rates and free feed occasions are not presented starlings appeared to consume bait more readily, and required less free feeding at urban sites. This may explain the greater efficiency apparent in these areas (Figure 20 b).

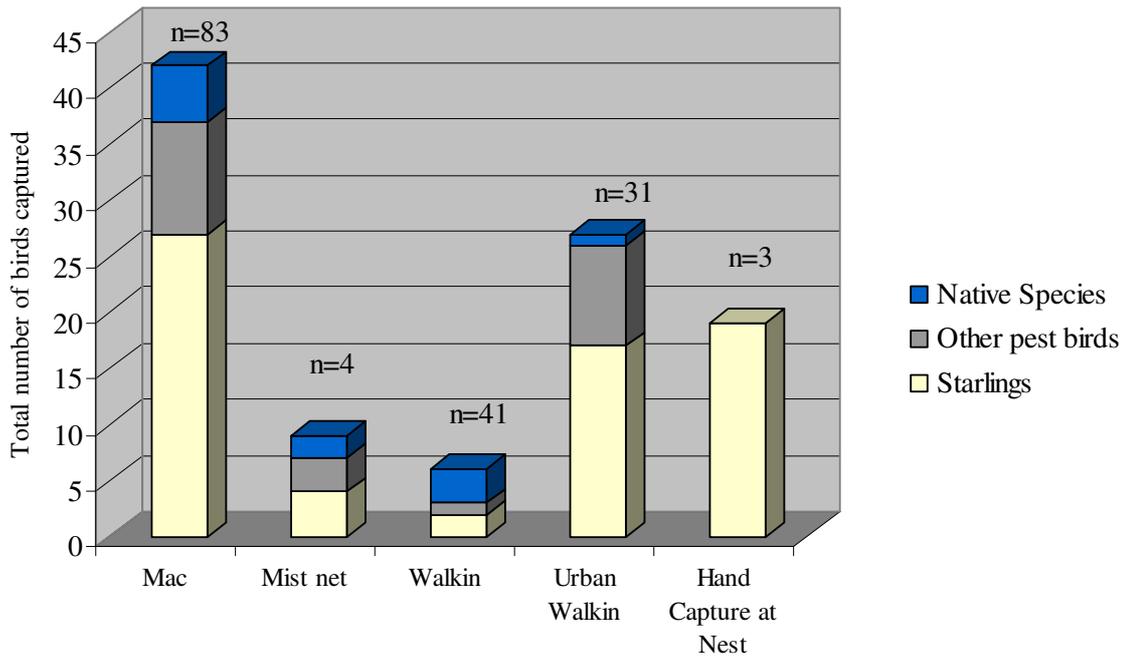


Figure 20 a: Total number of starlings, other pest birds and native species captured using four techniques. The walkin was the only trap trialled in an urban area, and was identical to those used in vineyards. n=the number of trap days.

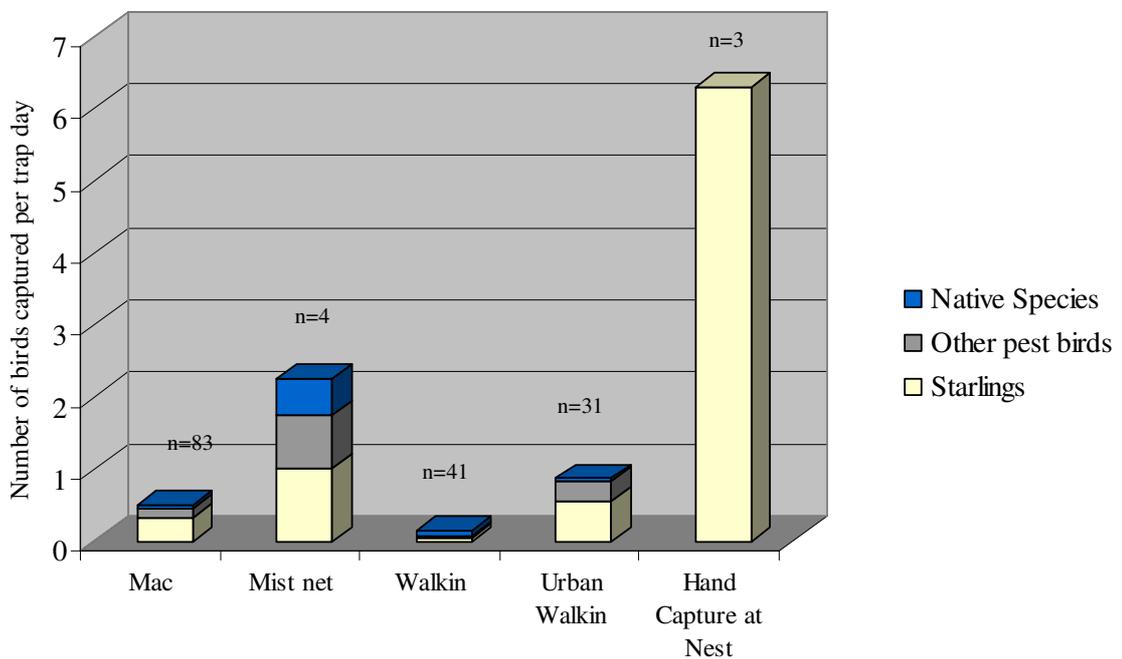


Figure 20 b: Number of starlings, other pest birds and native species captured per trap day using four techniques. The walkin was the only trap trialled in an urban area, and is identical to those used in vineyards. n=the number of trap days.

3.7 Starling Movement Patterns

During spring 2000 (September to November), a total of 328 observations were recorded on starling activity on the Rosemount study site. This information was used to investigate habitat use and foraging and movement activity of starlings during the breeding season. Results and Discussion for data collected 2001 is presented in Appendix 1.

3.7.1. Habitat use

During spring, starlings were most commonly observed in eucalypt foliage or branches, in the vineyard on posts or between vines, at nest cavities and in open pasture (n=212 Figure 21). Eucalypts were favoured perching sites (Figure 22), despite a higher availability of cottonwoods ($\chi^2= 174.7, P<0.01, df=5$). However, these eucalypts were highly associated with availability of nest sites ($\chi^2= 796.5, P<0.01, df=1$).

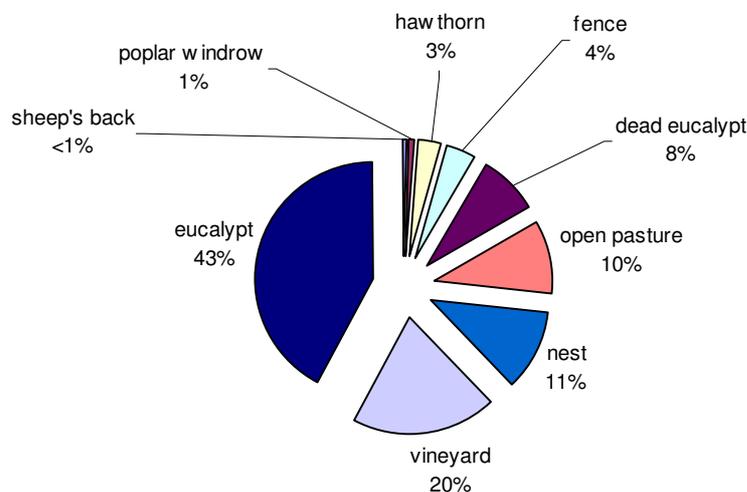


Figure 21. Percentage of starling observations in each habitat type.

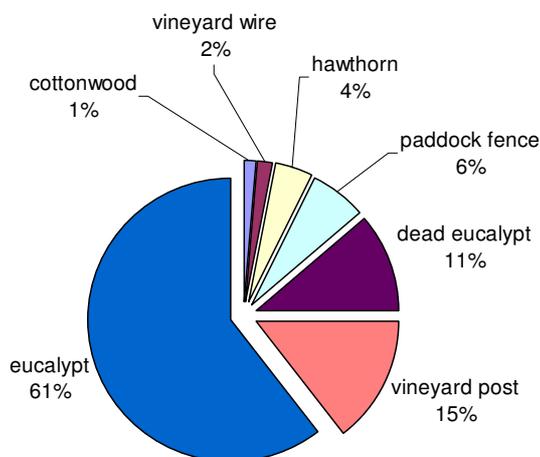


Figure 22. Percentage of day-roosting observations on various perch types.

The number of occasions starlings were observed probing in open pasture and between vineyard rows was proportional to their availability on the study site ($\chi^2 = 0.236$, $P = 0.43$, $df=1$). However, the average time starlings spent probing in vineyard rows (1.9 minutes) was less than in open pasture (3.9 minutes), but this effect was not significant ($t = -1.295$, $P = 0.204$, $df=33$).

3.7.2 Activity

Starlings were most commonly observed perching (44%, $n=328$) and flying (35%, $n=328$), but flying observations were significantly shorter than all other activities ($P < 0.05$, $df=4$, Figure 23) and comprised only 7% of the total observation time of 583 minutes, (Figure 24).

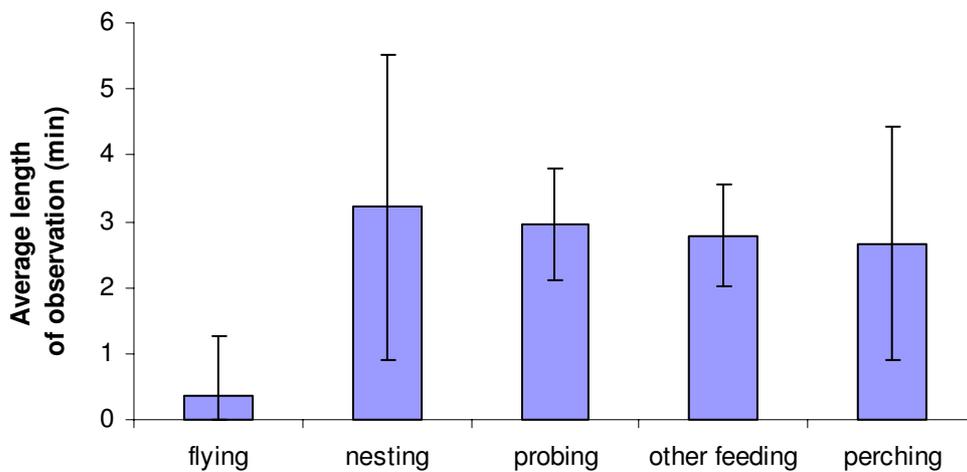


Figure 23. Average length of observation for each starling activity.

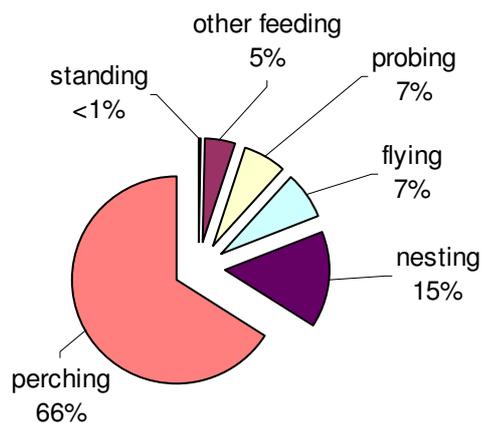


Figure 24. Percentage of total observation time each starling activity

The average flock size during the breeding season was 3.5. Many individuals and pairs were observed near nest sites. Average flock sizes increased gradually over the day with highest numbers aggregating before sunset (Figure 25).

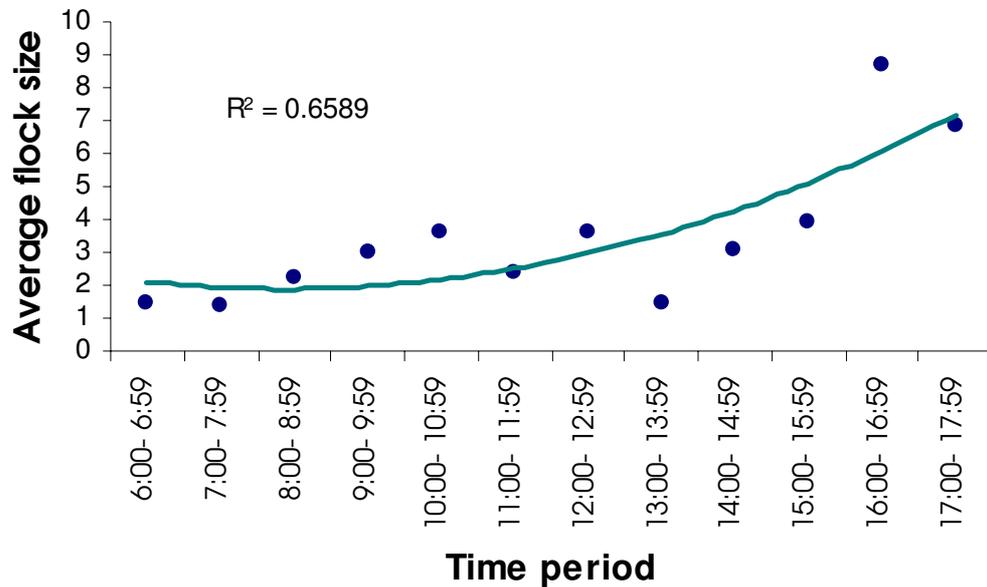


Figure 25. Change in average starling flock size during daylight hours (6:00 – 18:00).

3.8 Radio Tagging

The single glue-on transmitter, attached to a wild starling October 2000, was recovered 430 metres from the release site 3 hours after the release time. Continuous tracking 1 hour following release indicated this transmitter was either removed by the bird or fell off between 1 and 3 hours after its release. The transmitter still had the clipped feathers attached, including the calamus, which suggests removal by the bird was more likely. This has also been observed in other studies where transmitters have been glued directly to plumage (e.g. Cochran 1965).

Following cage trials and training to calibrate tension, a back-pack harness was attached to nine field-captured starlings which were released at capture locations. This harness remained attached to birds for greater than 5 days and in some cases up to 2 months. Sewing the hat elastic together with cotton during handling was found to be more efficient than tying ends together, and may also have result in longer persistence. Tension was an important consideration. Excessive tightening of the harness was found to hinder movement, while lack of tension would've increased the possibility of the harness catching or may have resulted in movement around the starling. Tension adjustments were required, which was achieved by placing tagged individuals into an enclosure, large enough to allow flight (i.e. a closed MAC trap) for several minutes prior to release. Flexibility of wing movement could then be observed and adjustments made. It is also recommended any further study with back-pack harnesses for attaching radio tags include checking the harness tension before release.

In this study, with the exception of one individual, which showed evidence of rubbing and slight thickening of the skin under one wing, no adverse clinical signs were apparent as a

result of the harness in recapture events or cage trails. Gluing the hat elastic with cyanoacrylate ('supaglu') to prevent movement and conceal the join inside the hat shrink, may alleviate this 'rubbing' effect in future studies. Alternatively, material such as synthetic absorbable suture (e.g. Andrew Woolnough, Agriculture Western Australia, personal communication) could be trialled in place of hat elastic.

Observations following release indicated that some starlings initially laboured with the added weight of the transmitter. Initial exertion and undulating flight was apparent in three of the nine tagged individuals. One tagged starling was also observed pecking at the transmitter whilst perching 2 minutes after release. However, after 5 to 10 minutes they appeared to resume normal flight and often rejoined flocks. A short 'acclimatisation' period following release of tagged birds has been reported in previous studies (e.g. Bray *et al.* 1975; Naef-Daenzer 1993; Runciman 1996). Transmitters including harnesses weighed an average of 3 grams which fell between 3.6 and 4.5 % by body weight. These were all below the currently recommended 5%. Average starling weight in this study was 69.7 g (range 55-84 n=43). Hence birds of less than 60 grams were not tagged to ensure weights were below the 5% threshold. However, six of the nine individuals were fledged juveniles which may have also influenced irregular flight following release. A lighter transmitter would allow tagging of all individuals and possibly lessen the initial effects evident here. Assuming 3% of body weight, this would reduce the preferred overall weight (transmitter + harness), to around 1.65 grams (assuming a 55 gram individual). However, reducing battery weight will directly reduce the life of the transmitter, which may require consideration.

Local starling movements of radio tagged starlings were monitored by hand-held and vehicle mounted radio telemetry systems. The nine radio-tagged starlings (3 adults, 6 fledged juveniles) all displayed considerable site fidelity, with all movements recorded within a radius of 5 kms. The maximum distance for detection ranged between 400 and 2000 metres, fluctuating according to terrain and interference from powerlines, which was considerable in certain sections of the study area. To improve detection and investigate dispersal into local surrounding areas, intensive searching was regularly conducted within a radius of 10 kilometres from capture locations. Hence any dispersal of greater than 10 kilometres may not have been detected. Extending the search area was not technically feasible due to the considerable time and labour involved to investigate the required 400m search grid pattern necessary. Aerial tracking is recommended in studies where large scale movements are apparent and detecting isolated dispersal over greater than 10 kilometres is essential.

3.9 Nesting Behaviour

The nest cavity measurements (Table 7) taken in October 2000 were used to investigate the characteristics of cavities preferred by starlings for nesting. During an intensive two week search 15 active starling nests were observed in 14 of the 760 trees searched and in one fence post. Others species also observed nesting included crimson rosellas, eastern rosellas, wood ducks, magpies and magpie larks. Of the starling hollows located, the majority were in tree trunks (58%, n=19), while six were located in the outer edge of dead limbs.

Table 7. Summary of nest cavity characteristics

	Mean of all cavities	Mean of cavities used	Range of all cavities	Range of used cavities
Entrance Height (m)	4.42	4.5	1.45-7.25	1.45-7.25
Cavity Depth (mm)	279	364	110-1000	140-1000
Internal Diametre (mm)	126	137	40-250	85-250
External Diametre (mm)	456	462	169-1273	169-1273
Minimum Entrance Diametre (mm)	72	74	20-450	45-120
Average Entrance Diametre (mm)	130	137	55-575	55-575

Two of the fifteen nest sites had multiple entrances. The majority of entrances had a NE orientation (Figure 26), which mainly reflected the natural occurrence of cavities on the study site. Cavity entrances ranged from 200 to 250 mm, those with starling nests were more restrictive, 45 to 120 mm (Table 7).

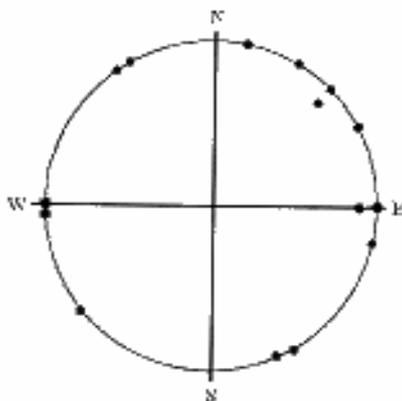


Figure 26. Orientation of entrances to starling nest hollows.

Starling nests were found in cavities ranging from 110 to 850 mm deep, which were also the minimum and maximum depth of all cavities recorded. Cavities selected by starlings had an internal diametre of greater than 85mm although cavities with an internal diametre of less than 45 mm were available (Table 7).

A significantly greater number of cavities were evident in *Eucalyptus macrorhyncha* and *E. nicholii* ($\chi^2=32.8$, $P<0.05$, $df=9$), and this effect was not correlated with age, although only trees which were rated mid mature or older had active starling nests.

Table 8. Species and age of trees with cavities

Cavity Number	Common Name	Species	Age Rating	
1	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
2	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
3	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Over Mature	*
4	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Over Mature	
5	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
6	Red stringybark	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
7	Narrow-leaved red gum	<i>Eucalyptus seeana</i>	Late Mature	*
8	Manna gum	<i>Eucalyptus viminalis</i> ssp. <i>viminalis</i>	Mid Mature	*
9	Narrow-leaved black peppermint	<i>Eucalyptus nicholii</i>	Late Mature	*
10	Narrow-leaved black peppermint	<i>Eucalyptus nicholii</i>	Late Mature	
11	Narrow-leaved black peppermint	<i>Eucalyptus nicholii</i>	Late Mature	*
12	Narrow-leaved black peppermint	<i>Eucalyptus nicholii</i>	Late Mature	*
13	Broad-leaved peppermint	<i>Eucalyptus dives</i>	Late Mature	*
14	Forest red gum	<i>Eucalyptus macrorhyncha</i>	Late Mature	*
15	Forest red gum	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
16	Forest red gum	<i>Eucalyptus macrorhyncha</i>	Mid Mature	*
17	Fence post	NA	NA	*
18	Weeping willow	<i>Salix babylonica</i>	Late Mature	
19	Dead Eucalyptus sp.	NA	Dead	

* Successful starling broods raised

In August 2001, natural nest searching was more intensive and included marking and recording cavities of more varied sizes. Fifty natural hollows were described and marked after searching of all likely areas on the Rosemount study site. Fifty nest boxes were also attached to mature eucalypts and monitored. All nest boxes and 33 natural nest sites showed signs of nesting activity. Thirty-six starling and nine eastern rosella (*P. eximius*) broods were successfully raised.

4.0 DISCUSSION

4.1 Damage Assessment Technique

Despite training, all eight observers consistently underestimated percent damage to selected bunches, particularly at mid percentages. This emphasises the importance of calibrating visual estimates. Most other studies which visually estimated bird damage to wine grapes used either a damage class or a pre-transformed ranking scale (see Table 9). In those studies which compared against bunches with known damage most concluded that damage was being accurately classified after a period of training. However, with the exception of Somers and Morris, accuracy within classes has not been reported. Estimating percent damage overcomes difficulties with uneven distribution of damage within classes (Dehaven and Hothem 1974), allows more detailed analysis and better comparison between studies.

Table 9. Studies which have estimated bird damage to wine grapes.

Type of assessment	Accuracy Measured	Source
Counting	NA	Askham 1992
Counting	NA	Toor and Ramzan 1974
Weighing	NA	Porter and McLennan 1995
Ranking scale, counting and weighing	No, NA	Hothem and DeHaven 1982
Percent estimate	No	Chambers 1993
Percent estimate	No	Curtis <i>et al.</i> 1994
Percent estimate	Yes (n=594, 8 observers)	This Study
Questionnaire	No	Boyce <i>et al.</i> 1999
Questionnaire	No	Graham <i>et al.</i> 1996
Questionnaire	No	Cruse and DeHaven 1973
Ranking scale	Yes	Martin and Crabb 1979
Ranking scale	No	DeHaven 1974
Ranking scale	No	Bailey and Smith 1979
Ranking scale	Previously tested	Martin and Jarvis 1980
Ranking scale	Yes (n=10 85% of bunches scored within the damage class)	Stevenson and Virgo 1971
Ranking scale	No	Yim and Kang 1982
Ranking scale	Yes (n=400 2 observers)	DeHaven and Hothem 1979
Ranking scale	Previously tested	DeHaven and Hothem 1981
Ranking scale	Previously tested	Hothem <i>et al.</i> 1981

An observer's ability to estimate actual bird damage may also differ from bunches with simulated damage. This may partly explain the underestimation evident in this study. The most obvious difference is the prevalence of pecked grapes, although not shown to be significantly different here. Bird damage will also have occurred at different stages of grape growth so will often be less obvious than freshly removed grapes. If damage classes are to be used we suggest testing the accuracy and distribution of estimates within classes and using,

where possible, bunches with actual rather than simulated damage. The calibration model allows for rapid correction of damage data pooling the effects of observer.

4.2 Damage Estimates

Bird damage levels to vineyards in the Orange Region (block damage averaging 15%) are significantly effecting the economic viability of many vignerons. In some cases entire blocks were un-harvestable. However, the severity of bird damage varies significantly (range= 0.3-83%), and is influenced by a range of variables. Overall, there were no clear preferences for particular varieties, although within vineyards some varieties were damaged significantly more than others. In addition, no vineyards grew the same combination of grape varieties. The level of damage to a particular variety may also be influenced by the presence or absence of other varieties in that vineyard eg. the sequential ripening of certain varieties may encourage continuous damage. On sites with different varietal combinations it will therefore be more difficult to predict which varieties will suffer greater damage and more difficult to detect changes in damage as a result of imposed control programs.

Future study is required to investigate these explanatory variables and their relative importance in influencing bird damage. Grape maturity, vineyard size, length of ripening, distance to perching sites, landscape, and habitat (e.g. Figure 11) features in particular, are likely to be important in predicting damage and warrant further investigation.

4.3 Sample Size Estimates for Management Evaluation

Selecting replicates for evaluating control strategies should not involve selecting sites with similar levels of damage, instead should reflect the natural range of variability (Caughley and Sinclair 1994). However, in this study, bird damage varied so significantly within vineyard blocks and between vineyards that the predicted number of replicates required is substantial (Table 2). A reduced number of replicates may be used if treatments are applied within vineyards (Table 3). However, this may raise concerns about independence and pseudo-replication (Hurlbert 1984). The variability between vineyards is further complicated by major changes in bird species and abundance.

The main pest bird species were considerably different between vineyards (see Table 5). These species are likely to cause varying levels of damage and will respond differently to management techniques. For example, scaring devices around the perimeter of the vineyard are likely to illicit a different behavioural response from silvereyes that move within the vineyard foliage compared to starlings that usually fly into the vineyard from above. In these circumstances where the same control program is imposed throughout the ripening season and the suite of species causing the damage is variable, the effectiveness of damage reduction will be reduced.

In this study bird species were not only significantly different between vineyard locations but also varied temporally within the same vineyard (Figure 17). Temporal changes in bird species and subsequent changes in percent damage may demonstrate a species preference for a particular variety or may be a response of a bird species' seasonal movements. For example, recent broad scale studies of seasonal abundance in Victoria showed significant decreases in the numbers of insectivores and nectarivores in most habitats during winter (Kennedy *et al.* 2000), suggesting these species may be migrating north in large flocks for the summer.

Clearly, the changes in bird abundance and damage in vineyards is complex and requires careful consideration before attempting control evaluation. The high number of replicates required is technically very difficult to achieve, particularly when attempting to find an appropriate number of nil treatments. Vignerons are seldom willing to undertake no bird control on their vineyards especially if they are receiving moderate to high levels of damage. This study suggests that where possible, fewer well-designed studies to evaluate control strategies with greater numbers of replicates are preferable to a large number of anecdotal studies which lack adequate experimental design. However, the technical difficulties and amount of resources required to conduct an adequate evaluation need to be considered carefully.

4.4 Economics of Bird Netting

Results suggest drape-over bird netting is cost effective over a ten year period if damage is greater than 10 percent per annum. However, variations in damage will be difficult to predict, hence a high degree of risk is associated when deciding to invest in netting. Netting also has large upfront costs which may be prohibitively expensive. Costs associated with netting were based upon information on all labour, materials components from Orange vignerons. Different wine growing regions may result in different costs. For example, the absence of pasture between rows in many vineyards of South Australia requires vignerons to fasten nets beneath the vines, which is a significant added labour component (Sinclair, R. personal communication). Cooler regions in particular, may also need to consider increases in disease prevalence due to restricted air flow and/or changed microclimatic under netting. In addition, these calculations assume bird netting completely protects from bird damage. However, in many cases slight damage can still occur when birds enter through gaps or where smaller species are confined within nets. Consideration of net diameter is necessary to ensure smaller species such as silvereyes are excluded. In some situations bird species can be particularly persistent and greater damage can occur despite netting. For example in one vineyard block with drape over netting, damage by pied currawongs was estimated at 15%. This was caused by birds sitting and swinging on nets to access and remove grapes. Total losses were observed in adjacent blocks of this vineyard without netting. In this case permanent netting was used successfully in subsequent years despite their higher upfront costs.

4.5 Bird Abundance

During both seasons, common starlings (*Sturnus vulgaris*) were the most abundant species recorded. As discussed the density of other species was highly variable with season and between vineyards. In 2000 noisy friarbirds (*Philemon corniculatus*) were the second most commonly observed species in vineyards, but were at negligible levels during 2001. Silvereyes were abundant during both seasons but reached significant levels in different vineyards between seasons.

Explanations into fluctuating density are complex and vary with species. The erratic changes in noisy friarbird density examined in section (3.5), is one example. Noisy friarbirds are highly migratory and can travel large distances to seek flowering eucalypts with high volumes of nectar, which is their preferred food source. Hence increases in density evident in vineyards in 2000, maybe a result of poor flowering and/or low quality nectar. To investigate

this further, local apiarists were contacted in an attempt to trace nectar flows of eucalypts with a view to developing predictive patterns of honeyeater movements.

Preliminary investigations with the Central Ranges Apiarists Association into hive locations, nectar sources and production information indicated high volumes of honey were produced from heavy flowering red stringybark (*Eucalyptus macrorhyncha*) in the area. Peak flowering occurred from December 1999 to March 2000, finishing by early April. Noisy friarbird abundance in vineyards gradually increased after this period reaching highest densities by 28th April (Figure 18).

Typically the majority of fruit is harvested prior to this date. Hence a combination of the delayed ripening period in 2000 with decreasing nectar loads during in this period is one likely explanation for the increased abundance of noisy friarbirds in vineyards. However, these trends are mainly anecdotal and further research is required to develop prediction patterns, but as an example this provides an indication of the complex nature of bird density and damage relationships.

4.6 Comparison of Trapping Techniques

Capture by hand at nest sites was the most efficient capture technique used. However, this was an opportunistic technique and did not take into account the time spent monitoring, marking and searching for nests which was a separate component of the project. Capture at nest sites also resulted in biased samples of juvenile birds, and could only be attempt during the breeding season (i.e. September-February).

Despite few attempts, mist netting appears more effective than the other trap types. However, these require continual monitoring, expert handling, restricted permits from the ABBBS and NPWS, and result in an increased likelihood of non-target capture.

Results suggest the walk-in trap was more effective in urban areas than in the vineyard. Possible explanations include; a familiarity with the food source, difference in starling density, or the abundance of invertebrates. The Modified Australian Crow trap was not as effective as other techniques but required little maintenance.

4.7 Starling Movement Patterns

Local movements were monitored during spring, at the commencement of starling nesting season. Hence the main activities during the period were nesting and perching. Starlings are known to select exposed perch sites during the day (e.g. Feare 1984), which may explain the preference for eucalypts evident in our study. However, the focus of activity around nesting sites and the large number of hollows in eucalypt species would also partial explain these preferences. Although perching activity and selection of particular perch sites may change in the ripening period, other studies have found starlings appear to select sites according to individual security rather than for the proximity to feeding sites (Salvi, 1987).

When foraging on the ground, no significant differences were apparent between sites, although feeding forays between vines was generally shorter than in open pasture. This is consistent with previous studies which have shown starlings prefer feeding in areas that are further away from 'hedges' (Whitehead *et al.* 1995).

Starlings are also known to become more solitary and spend more time foraging in small groups during the breeding season (Feare 1984; Wright and Cotton, 1994), which is consistent with the relatively small group sizes observed during this period (average 2.8 whilst perching). Conversely starling flocks of up to 620 were observed during the ripening period which also includes a large proportion of juvenile birds. During breeding, average flock size increased during the day, presumably before aggregating at night roost locations.

Movements monitored by radio tags during the ripening period suggest starlings remain sedentary during this time despite fluctuating grape availability. Although small scale movement patterns suggest starlings will relocate their foraging efforts following harvesting of particular blocks, movements between vineyards of greater than 5km was not recorded.

4.8 Radio Tagging

As only one glue-on transmitter was used, statistical comparisons between the two types of attachment techniques were not possible. However, the back-pack harness appeared to cause less distress to birds than the glue-on technique, and avoids damage to feathers from clipping or from glue exposure. The following recommendations are suggested for future tagging studies for starlings:

- The back-pack harness design is preferred to the glue-on technique.
- Training and practice with harness tension is recommended prior to release.
- The hat elastic may be glued to the heat shrink to limit movement of the transmitter and conceal the join. Care should be taken to avoid exposing feathers to the glue.
- A lighter transmitter of around 1.65 grams is recommended to allow tagging of all birds encountered and to reduce the effects of the transmitter (see section 3.8 for details).

4.6 Nesting Behaviour

During the 2000 breeding season, 15 of the 19 potential nest hollows were occupied, which emphasises starlings are opportunistic in their selection of nest sites. Starlings built nests in cavities with average entrance diameters of up to 575mm (100 x 1050mm), which is larger than previously suggested (Coleman 1974). Cavities with entrances smaller than 41mm or deeper than 110 mm were not used which is consistent with other studies (Zeleny 1969; Pinkowski 1976). In contrast to Coleman (1974) who found starlings preferred nest boxes away from human activity, many nests were built within metres of high access tracks or houses. Nests were mainly facing a north east direction, which has been attributed to birds selecting hollows orientated towards the rising sun (Verheyen 1980; Lawrence 1967; Dennis 1969). However, in our study orientation is more likely to be correlated with the availability of nest hollows rather than a particular preference. Findings of a two year study in Ontario also found starlings showing no preference for a particular orientation (Rendell and Robertson 1994). *Eucalyptus macrorhyncha* and *E. nicholii* had a significantly greater number of cavities than other tree species despite variable age categories.

In 2001, all nest boxes and 33 natural nest sites showed signs of nesting activity. Thirty-six of these supported successful starling broods. This baseline information in conjunction with density estimates calculated for this study site will enable future predictions on potential rates

of increase. Knowledge of starling breeding behaviour will assist in assessing the feasibility of controlling starlings using nest monitoring and artificial nest sites.

PART C: QUESTIONNAIRE TO ORANGE VIGNERONS

The following section is not a scientific report but is presented in a readable form targeted and circulated for the respondents of a questionnaire and other land managers.

1. INTRODUCTION

Forty three vigneron from the Orange district, representing 595 ha of producing vineyard and ranging in size from 0.25 ha to 108 ha, responded to a bird damage questionnaire following the 2000 harvest. This questionnaire was developed for the purpose of gaining a better understanding of current bird damage levels to vineyards, primarily as a result from increased regional concern. Results from the 2000 questionnaire will quantify the perceived impacts of pest birds on grape varieties, examine the perceived effectiveness of control techniques, and discuss ways in which vigneron can reduce the impacts of birds.

This section presents the following:

- Estimated bird damage under current management (2000);
- Number of crop damaging birds observed in vineyards;
- Contribution of bird species to overall bird damage;
- Number of grapes pecked as opposed to number of grapes removed;
- Relationship between grape variety and bird damage;
- Effect of habitat features on the degree of bird damage;
- Most commonly used control techniques;
- Total area of vineyard managed under current control techniques;
- Most effective control technique in the control of crop damaging birds.

2. RESULTS AND DISCUSSION

2.1 Estimated bird damage under current management (2000)

During the season of 2000, the majority of vineyards experienced between 1 and 30 percent crop damage. Some experienced no damage and others experienced complete loss of production (Figure 27). There are many methods available for controlling pest birds and despite these, many vineyards are continuing to experience damage. This implies that current control methods are not reaching their objectives. While it is relatively easy to gain an estimate of bird damage levels for vineyards, it is not so easy to assign any one mechanism of control. The relative difference in grape varieties, size of vineyards, influence of habitat features, varying ripening periods (Boume levels), fluctuations in seasonal conditions, movements of migrating birds, and other influential factors make the task of 'control' incredibly challenging.

The development of a more strategic and planned approach to managing the damage birds cause to the local wine industry may be required. This may encourage coordination of control across several neighbouring vineyards, or the use of control techniques to address each vineyards particular conditions and circumstances.

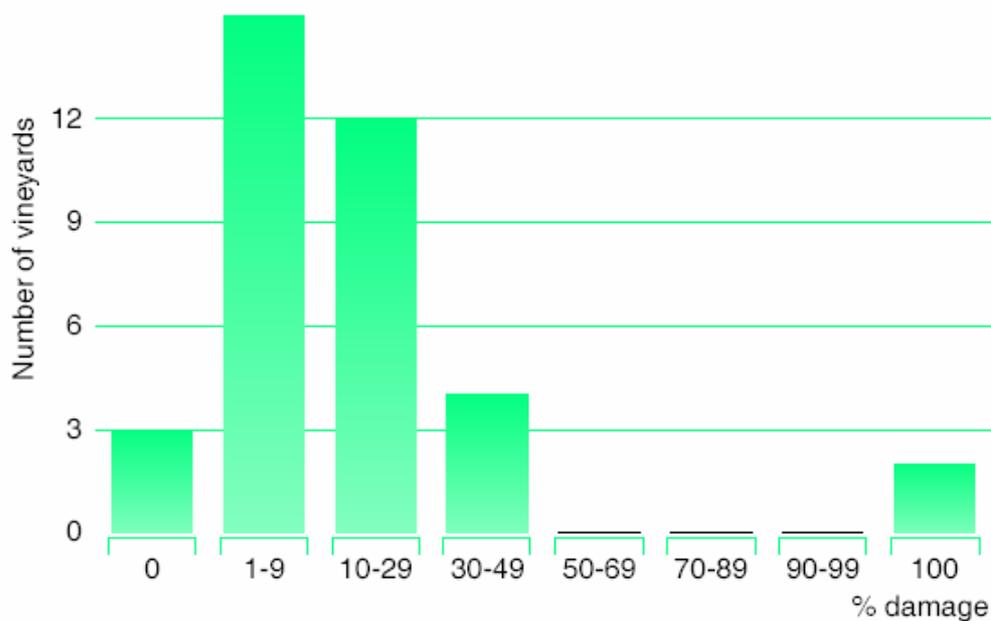


Figure 27. Estimated bird damage under current management. This graph presents the amount of damage experienced by local vigneron during 2000. A high number of vineyards experience damage between 1-30% total crop damage.

2.2. Number of birds, that cause crop damage, observed in vineyards

There were substantially more birds observed in vineyards during the ripening period (Figure 28). If we consider that birds are opportunistic, highly mobile and often migratory, it is understandable that their numbers decline when grapes are absent. Many bird species exhibit transient and migratory behaviour, allowing them to exploit short term resources (such as ripe grapes). Honeyeaters, in particular, are well known to travel large distances throughout the year. It is important to recognise what species are present in the vineyard, when they occur and what damage they do. It is understood that different bird species respond to different control techniques, and that bird species vary throughout the ripening period. Some birds arrive late in ripening, while others arrive early. This information is very important and will likely influence how control strategies are employed

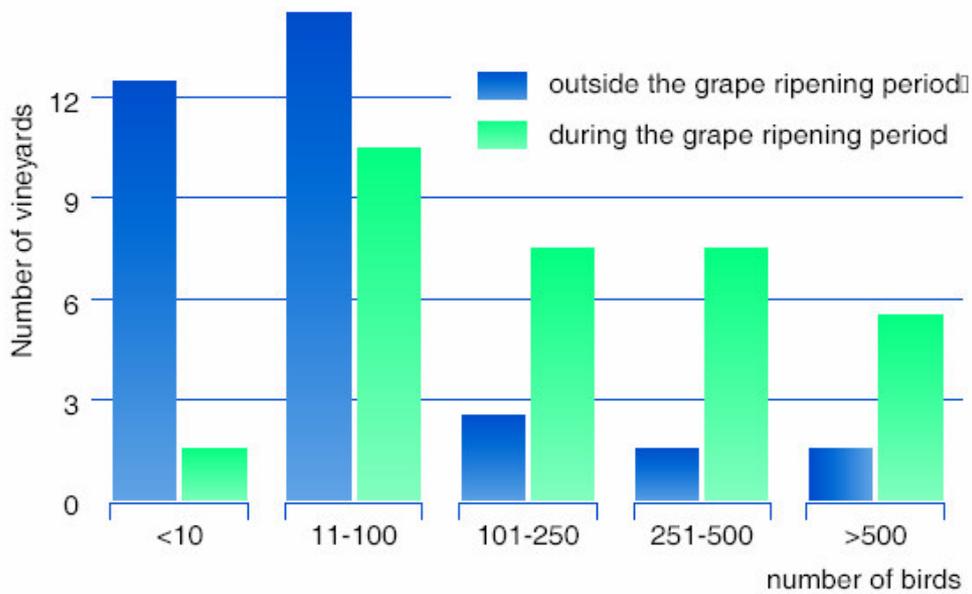


Figure 28. Number of crop damaging birds observed in vineyards during 2000. There were considerably fewer birds observed in vineyards outside the grape ripening period compared to during the grape ripening period. Outside the grape ripening period the number of birds ranged from less than 10 up to 100 birds seen per day. During the grape ripening period the number of birds ranged from 11 up to 500 birds seen per day.

2.3 Contribution of bird species to overall bird damage

There are many species thought to contribute to overall bird damage. Silvereyes were perceived to contribute almost 25% of total bird damage. Further, Silvereyes, Starlings, Pied Currawongs and Noisy friarbirds, combined, are believed to contribute approximately 75% of total bird damage (Figure 29). As we've established, each vineyard has a different composite of bird species, and it should be recognised that results may not necessarily reflect the contribution of damage experienced in all vineyards. Some birds may cause damage more than others, and some may not even occur. What this data provides, is an indication that there are many bird species that contribute to overall damage throughout the Orange region.

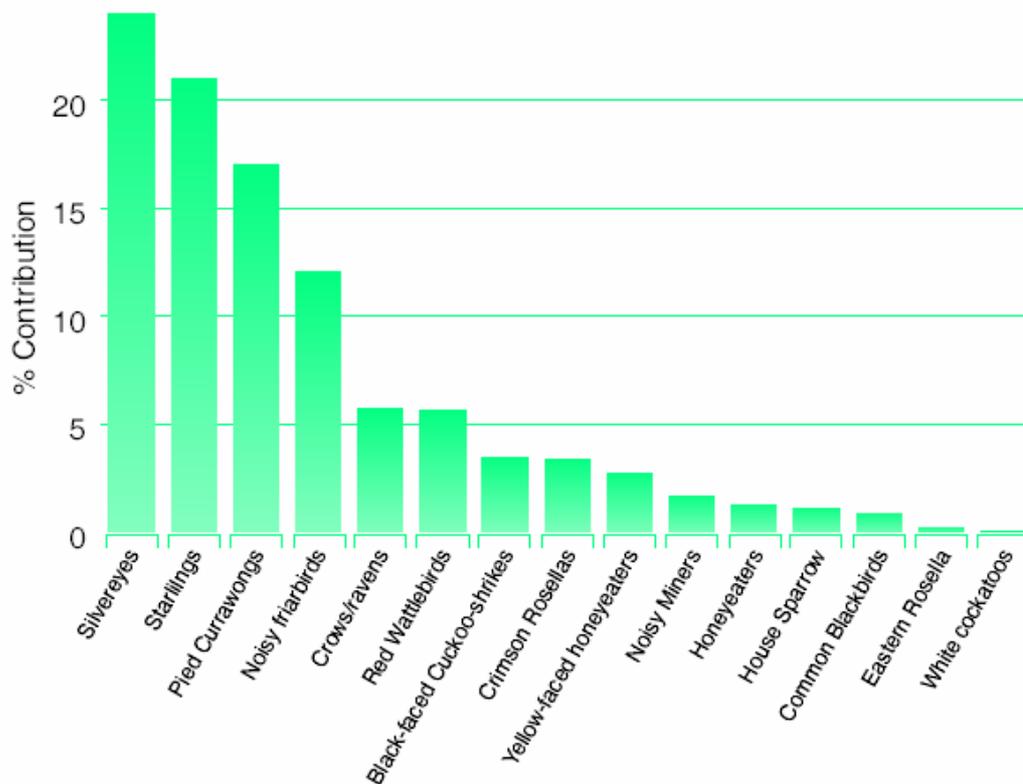


Figure 29. Contribution of bird species to overall bird damage. Silvereyes are regarded as the number one threat to wine grape production, contributing almost one quarter (24.27%) of total bird damage.

2.4 Number of grapes pecked as opposed to number of grapes removed

A relationship between the number of pecked grapes and the number of removed grapes has also emerged. Vignerons are experiencing crop losses in varying amounts. However, these losses are incurred by birds in different ways. For example, 10 out of 36 vineyards indicated that 80% of their total crop damaged was pecked as opposed to removed. Another 7 indicated 60%, and a further 7 indicated 20% (Figure 30). Current scientific research and anecdotal evidence indicates that some species commonly peck grapes, some remove grapes, while others do both. This information would allow recognition of what bird species are causing damage to your grapes without reliance on seeing them. However, the behaviour of each bird species is unclear and we are trying to establish more of these foraging trends. Where possible, we recommend being observant of these foraging strategies.

For example, in a block of Merlot it may be observed that both Starlings and Silvereyes are causing crop damage. If we then have knowledge that Starlings only remove berries and Silvereyes only peck berries, and the majority of damage is a result of pecking, more effort may be allocated to controlling the Silvereyes. The obvious difficulty at present appears to be attempting to identify the peckers from the removers, and which control techniques are bird species specific. It is generally understood that most honeyeater species (feathery tongues) are peckers and others species, such as Starlings, Pied currawongs and Black faced cuckoo shrikes are berry removers.

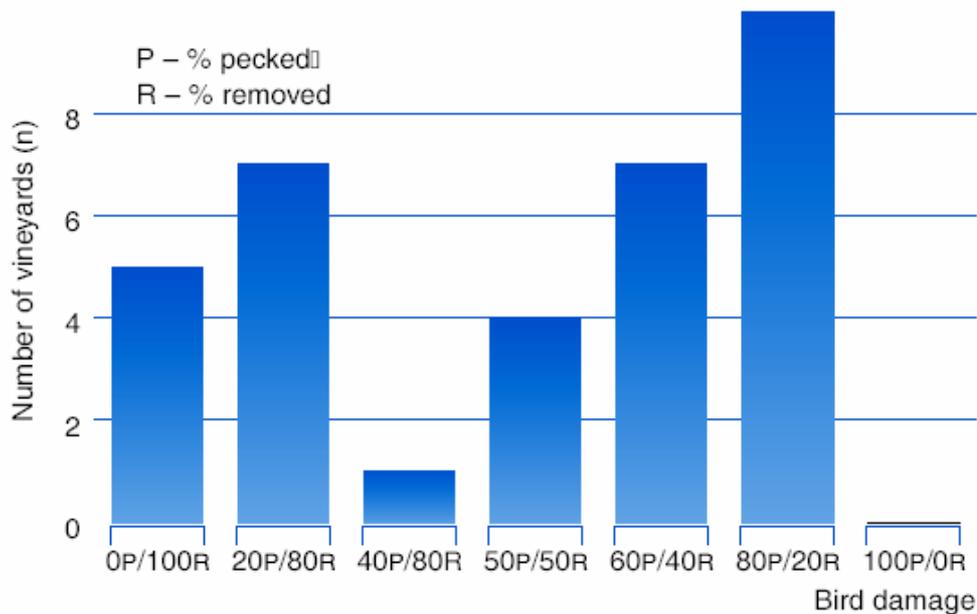


Figure 30. Number of grapes pecked as opposed to number of grapes removed. Ten vineyards indicated that 80 percent of their total bird damage was attributed to grapes that had been pecked, as opposed to 20% which were removed.

2.5 Relationship between grape variety and bird damage

The data indicate that 62 percent of vineyards producing Sauvignon Blanc perceive this variety as the their most damaged grape, and 7 percent estimate that Sauv Blanc is the least damaged variety. In contrast, of those producing Shiraz, 30 percent estimated that it was damaged most and 25 percent estimated that it was damaged least. Sauvignon Blanc is clearly the most damaged grape variety, and Shiraz is the least damaged grape variety in the Orange region (Figure 31).

It is unclear exactly which birds prefer which grape varieties, but it seems birds show some preference for particular grape varieties. These data would suggest that Sauvignon Blanc is preferred by birds, but this may require closer examination.

This relationship may imply that individual grape varieties should be managed as a single entity, rather than managing multiple grape varieties under the one plan of control. Further, for producers expanding their vineyards, or those starting new vineyards, it may be worth recognising these data, although all varieties experienced some damage.

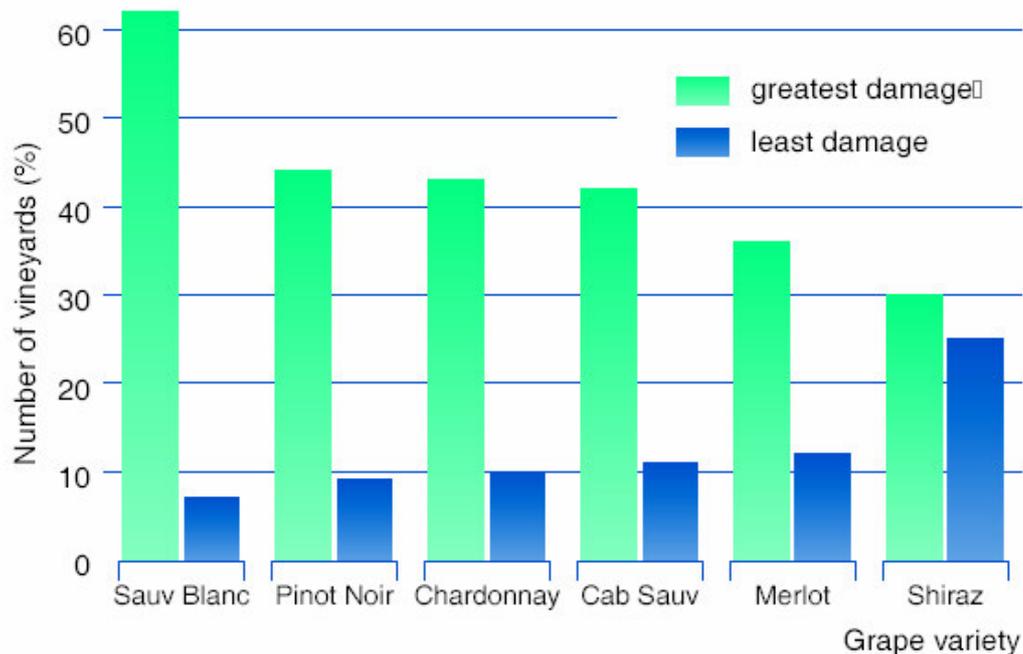


Figure 31. Relationship between grape variety and bird damage. Sixty-two percent of vineyards that produce Sauvignon Blanc regarded this variety as receiving the greatest amount of bird damage during 2000. Shiraz was regarded by vineyards as that variety which received the least amount of bird damage.

2.6 Relationship between habitat features and degree of bird damage

A ‘prolonged ripening period’ and ‘adjacent trees and vegetation’ were deemed as those features that increased bird damage. Dams, roads and water courses were thought to have no affect on overall grape damage (Figure 32). However, while some vigneronns felt that human activity, overhead powerlines and the presence of neighbouring vineyards and had no effect on grape damage, others perceived these features as increasing damage.

Various landscape features have been previously suggested to influence the amounts of damage. In some circumstances, birds will find the nearest most suitable perching spot from which to start their assent on vineyards. As birds are very mobile, these sites can be quite long distances from vineyards. We are further investigating the influence of habitat features, and distances to features, and how they may influence damage to vineyards. There perching opportunities are limiting, birds may utilise other available features. This implies that reducing perching opportunities for birds may do little to reduce overall crop damage. Concurrent research into the influence of habitat features on grape damage may reveal more conclusive results.

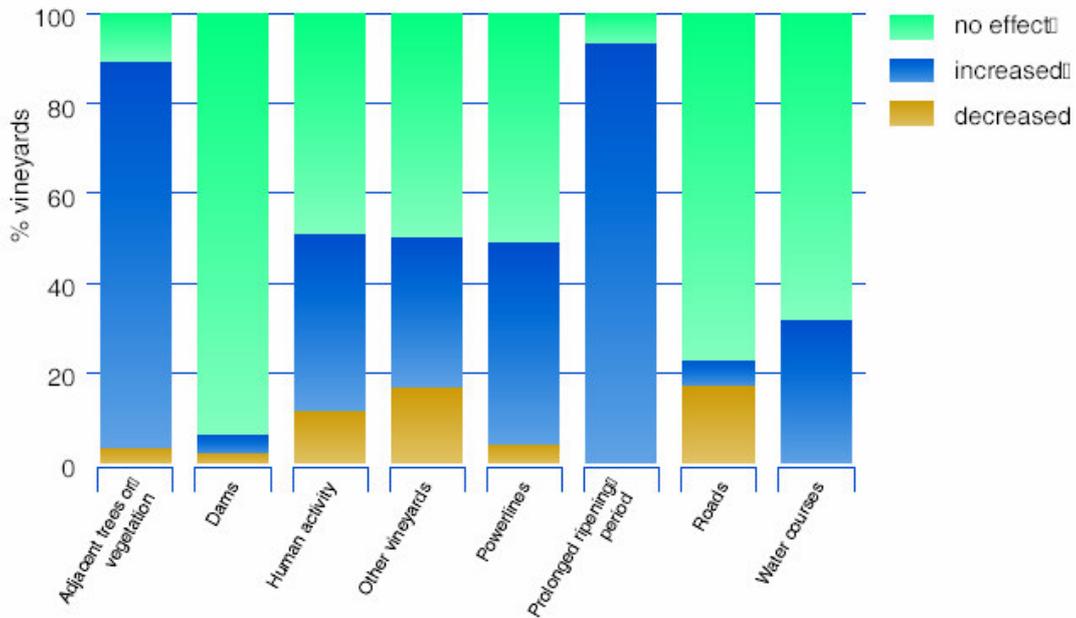


Figure 32. Effect of habitat features on the degree of bird damage. ‘Adjacent trees or vegetation’ and ‘a prolonged ripening period’ were seen to increase the amount of bird damage in vineyards during 2000.

2.7 Most commonly used control technique(s)

Shooting is the most commonly used control technique (Figure 33). Results indicate that shooting is generally used in combination with other control techniques, and alone is thought to be ineffective against pest birds. A combination of control techniques may be the key to effectively reducing bird damage, and reliance on any single control technique does not appear to be as effective.

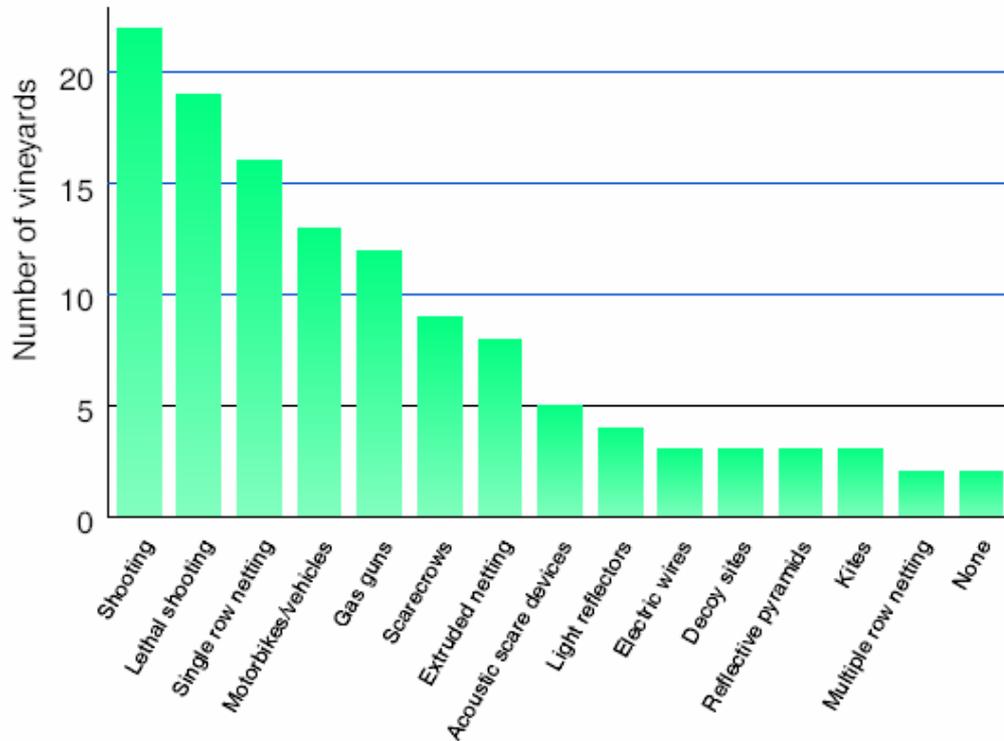


Figure 33. Most commonly used control technique(s). Shooting and lethal shooting were the most commonly used control techniques. Twenty-six out of 41 (22+19) vineyards carried out both shooting and lethal shooting activities.

2.8 Total area of vineyard managed by control technique(s)

Shooting to scare and lethal shooting (birds permanently removed) are the most widespread forms of control (Figure 34). Although model aeroplanes cover some 250 ha, it should be noted that this particular technique was only used within one vineyard, (n=1). Gas guns (n=12) are more commonly used. Their use is widespread and they are thought to be substantially more effective than lethal shooting and several other control techniques in reducing overall damage.

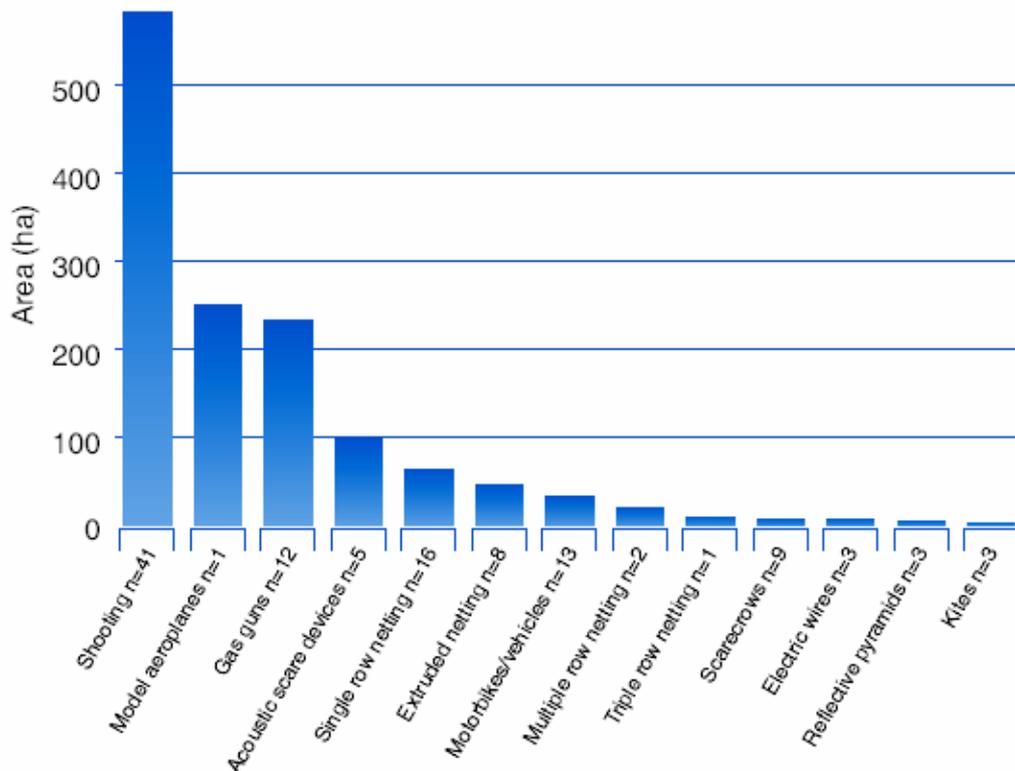


Figure 34. Total area of vineyard managed by control technique(s). Shooting (includes lethal shooting) is used across the majority of vineyards, being used in 586 ha of the 595 ha covered in this survey. Model Aeroplanes were used in 250 ha, and Gas guns in 233 ha. In contrast, many of the most commonly used control techniques (Figure 7) are providing coverage of small areas of vineyards. For example, Scare crows are commonly used, but are perceived to offer protection to only a small amount of vineyards.

2.9 Most effective control technique for the control of crop damaging birds

Netting, in general, was regarded as the most effective control technique for the season of 2000. Interestingly, shooting and lethal shooting were the most commonly used control techniques (Figure 33), implemented to control the largest area of producing vineyard (Figure 34), yet they are thought to be only 24% and 0% effective, respectively (Figure 35). Other than netting, results may suggest that not all control techniques should be used on their own.

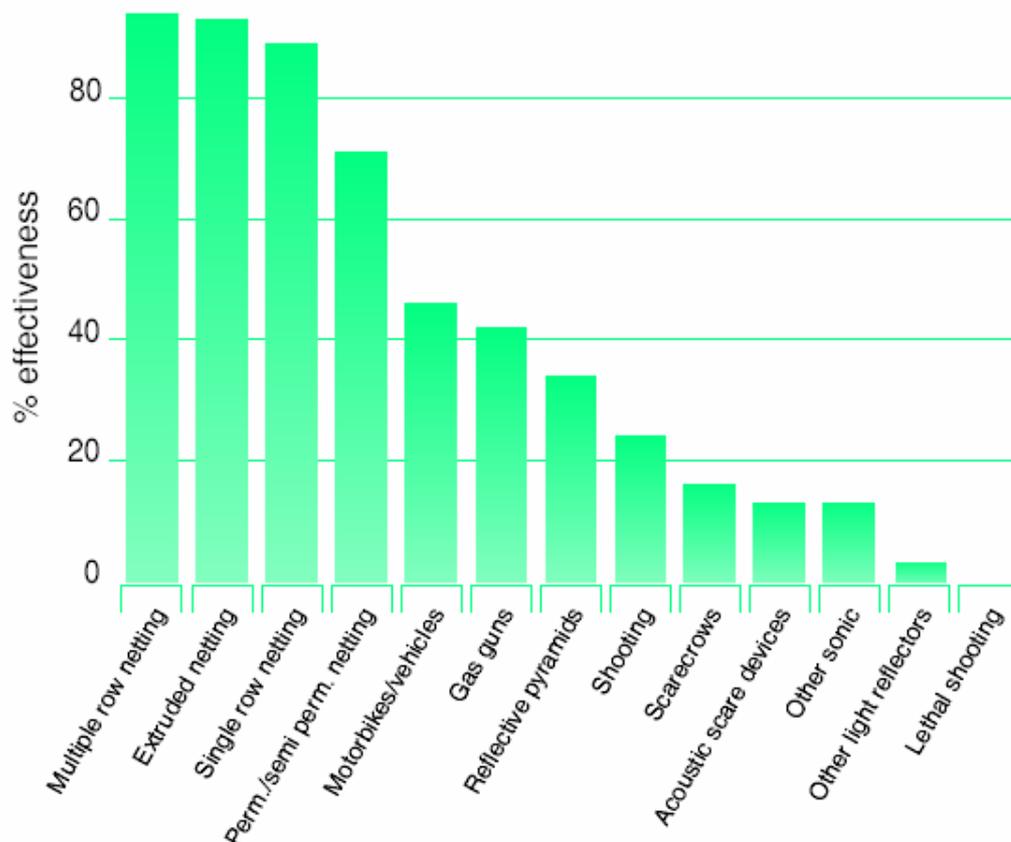


Figure 35. Most effective technique for the control of crop damaging birds. The most effective control technique is multiple row netting (94% effective), extruded netting (93% effective) and single row netting (89% effective) respectively.

3. SUMMARY

In summary, this questionnaire has revealed major trends that may otherwise have remained unrecognised. Some include:

- The abundance and diversity of bird species vary greatly across vineyards, and will change as local and regional conditions change. Many birds are also migratory, and respond to available resources as they travel between destinations.
- ‘Learned behaviour’ in birds is also thought to make control difficult. For example, birds become aware that scare-guns are of no real threat if not followed with periodic shooting. Similarly, scarecrows offer little long term relief from damage once birds recognise that they are stationary.

3.1 Ways to improve your ability to manage birds and reduce the impacts they cause

- Keep a bird list and make a concerted effort to identify bird species during your next grape ripening period. Having current knowledge of your pest birds may help to deliver a more species specific control effort.
- Make general observations of where damage is occurring in your vineyard, and note any habitat features which may be influencing this damage eg. powerlines. This may

help focus your control effort and allow more precise placement of your chosen control technique(s).

- Take note of the arrival and departure patterns of bird species during your next grape ripening period. Predicting seasonal and opportunistic movements of your pest birds, from previous seasons, may help to identify the amount, type and likely areas where damage will occur, and further help in the appropriate timing and delivery of effective control.
- Measure and record the proportion of your grapes that are pecked or removed during your next grape ripening period. This information will help identify the type (peckers or removers) of crop damaging birds that cause damage in your vineyard. This may aid in choosing a more appropriate type of control.
- Communicate with other vignerons in your local area to discuss the effectiveness of different control techniques. This information may be very helpful, although it will only have particular relevance providing damage occurs from similar bird species on similar grape varieties.
- Make notes of where previous control devices/techniques were set up and evaluate whether these positions were appropriate. Evaluation may be achieved by monitoring the amount of bird damage and observing the number of birds surrounding positioned control devices/techniques during the next grape ripening period.
- Adopt a planned approach to trial different ideas or control techniques, anything is possible, you may have a more effective solution. For example, trial a combination of control techniques rather than a one off control. A preventative management approach may be far more effective than one that is reactive (responding after damage occurs).

PART D: REVIEW OF STARLINGS AND WINE GRAPES

1. BIOLOGY AND BEHAVIOUR

1.1 General Description

Common starlings (*Sturnus vulgaris*) are small to medium sized birds. Adults of both sexes are glossy black with a red and purple sheen. Juveniles are grey-brown with black beaks. At post-breeding moult, starlings gain fresh plumage with characteristic white spots, which they gradually lose as their plumage wears. Adults have long, sharp bills which are yellow in the breeding season and black with differently-coloured lower mandibles following annual moult. Lower mandibles are blue-grey on males and pink on females. Adult starlings are 200-220mm long and weigh between 75 and 90 grams. They have short square tails.

1.2 Classification and Evolution

Common Starlings belong to the Sturnidae family which include 106 species worldwide. Australia has only three species; the common starling (*Sturnus vulgaris*), the metallic starling (*Aplonis metallica*) and the common myna (*Acridotheres tristis*). Although traditionally linked to Corvidae, recent study on DNA hybridisation (Sibley and Ahlquist 1990) has identified starlings as having a more discrete evolutionary history. Sibley and Ahlquist (1990) suggest the closest relatives of the starlings may be the mocking birds of America (Tribe Mimini). Traditionally starlings have been classified according to their skins (Amadon 1943, 1956), their bone and muscle structure (Beecher 1978) and their biology and behaviour (Feare 1984).

Sturnus is one of the more successful and evolutionary advanced genera of this family. They have evolved from arboreal, fruit eaters towards terrestrial, more omnivorous feeding and have developed long toes and powerful legs (Feare 1984). Beecher's (1978) study of bones and muscles identified *Sturnus* as having more highly developed protractor muscles (used to raise the upper mandible) and a narrower skull. This is thought to be a significant advance for this genus, enabling them to persist longer in drier environments by feeding on insects in the ground by 'prying' the soil and locating their prey without needing to tilt their heads (Beecher 1978).

1.3 Reproduction

Sexual activity and nest building peaks in early spring (August-September). Starlings form pairs and nest in tree hollows, holes in the ground and gaps or crevices in cliffs, shrubs, buildings, tree stumps and fence posts (see section 1.3.1). Males build a small cup-shaped nest within a bulkier mass of sticks, leaves, feathers and grass.

Males will establish territories and defend up to three nest holes but as breeding approaches are restricted to one by competing males. Territories are as small as 0.5m from the nest hole (Kessel 1957), but during breeding may expand up to 10m (Feare 1984) to prevent other males from mating with the female. Males attract females by decorating nests with fresh leaves and flowers and performing a variety of singing displays.

Starlings have up to three broods a year. Synchronized breeding occurs in the first brood, with females of a roosting flock laying within a few days of each other. Females start laying eggs on consecutive mornings, producing 4-6 blue unspotted eggs. The number of eggs in the clutch and not the size of the eggs will vary depending on physiological condition and food availability (Lack 1968). If this first clutch is unsuccessful, females may lay a replacement clutch between nine and ten days later (Feare 1984). An intermediate or second clutch is often laid in December. Intermediate and replacement or delayed clutches often have a much lower breeding success (Merkel 1978; Feare 1984).

Typical of most bird species, not all female starlings are able to successfully compete for mates and nest locations. These younger and smaller 'floating' females continue to be reproductively active and may mate with males while nesting females are absent and lay eggs in nests established by other females (Kessel 1957; Yom-Tov *et al.* 1974; Numerov 1978; Sandell and Diemer 1999). These females are also known to remove the original eggs from the nest (Feare 1984).

Similarly, males often seek other females, but will remain with the first mate to guard her and assist in feeding of the young. A female starling's aggression towards other females will decrease male polygamy (Sandell and Diemer 1997, 1999, Sandell 1998) and will potentially improve breeding success. Both successful and unsuccessful pairs may split, breed with other starlings and raise chicks in other nests for the second brood (Feare and Burnham 1978; Verheyen 1980).

The initial laying period of the first brood occurs in mid Spring (late October), however the precise timing is dependent on temperature. Females will delay egg-laying until temperature starts rising (Evans 1980; Meijer *et al.* 1999). This is thought to be an adaptive response, timing egg-laying and chick rearing to periods of high food availability (Dunnet 1955; Feare 1984; Meijer *et al.* 1999).

The timing of the first brood will dictate the laying dates of the second brood. If egg-laying is delayed this will decrease their chances of raising a second brood (Feare 1984; Anderson 1961; Verheyen 1980; Kessel 1953a). Another clutch is laid in early January.

Incubation of the eggs requires females to spend 80 percent of their time on the nest for 12 days. Males also assist in incubation for occasional short periods through the day, but have little effect on heating of the eggs (Feare 1984). Once hatched, the featherless chicks rapidly increase in weight from 6 to 25 grams in just 12 days, then a further 9 days elapse before the chicks fledge.

During these early stages chicks are fed a high protein diet comprising mainly soil invertebrates (e.g. Gromadzka and Luniak 1978). Parents with larger broods increase visit rates, travel shorter distances and switch type of prey in an attempt to improve fledging success (Tinbergen 1981; Westerterp *et al.* 1982; Wright and Cuthill 1989, 1990a,b; Wright *et al.* 1998)

Fledged young rapidly learn to fend for themselves and locate food by following adults to feeding sites. Food quality is now less critical and fruit becomes a larger proportion of their diet (Brown 1974; Tahon 1978; Feare 1980).

1.3.1 Nest sites

Most hollow nesting birds have specialised nesting requirements and select hollows with particular characteristics. Factors that contribute to site selection include; the depth and diameter of the hollow, the size of the entry hole, the height of the entrance, the orientation of the entrance, and site location (Rendell and Robertson, 1994; Feare 1984; Verheyen 1980; Moeed and Dawson, 1979; Pinkowski 1976; Thomas, 1957).

Starlings have been found to select holes that are higher (Verheyen 1969), perhaps to reduce access to predators (Feare 1984). Smaller entrance hole diameters can provide protection from larger predators or competing species (eg, Moeed and Dawson, 1979) and reduce heat loss (Westerterp 1973).

Orientation of the entrance hole has found to be important in hollow selection. Starlings (Verheyen, 1980; cf Rendell and Robertson 1994), common flickers (Lawrence, 1967), downy woodpeckers (Dennis, 1969) and eastern bluebirds (Pinkowski, 1976) have displayed preferences for cavities orientated toward the south east, which is the direction of the morning sun in the northern hemisphere. This orientation would allow energy or warmth to be derived from the heat of the early morning sun (Feare, 1984).

Starlings are opportunistic in their selection of nest sites. They are known to nest in hollows of a range of tree species, cliffs, fence posts, on the ground; and in wall cavities and under roofing of urban structures including sheds, houses, factories, aircraft hangers, aircraft, and electricity cable pylons (Thomas 1957; Feare, 1984). Open cup shaped nests are also found in trees and shrubs with dense foliage (Thomas 1957), or unusually in the wool of a live sheep (Anonymous 1910).

1.4 Diet and Feeding Behaviour

Starlings are highly adaptable feeders and vary food types according to their nutritional demands, food availability and the nutrient content of the food source. Their adaptability is reflected in the large differences in species composition found in dietary studies (e.g. Wood 1973; Potvin and Bergeron 1976; Coleman 1977; Gromadzka and Gromadzki 1978; Moeed 1980).

Starlings require animal protein to live (Berthold 1976) and breed (Al-Joborae 1979), and invertebrates provide a staple diet for starlings throughout the year. The most commonly eaten food items are members of Coleoptera (beetles) and Lepidoptera (moths and butterflies). These are usually eaten in larval form and found just beneath the soil surface. When available; seeds, cereals, fruits, vegetables and household wastes are also consumed as an easily obtained energy source.

Starlings have different nutritional requirements, and hence vary feeding sites and food types, between seasons. For example, females during the breeding season will select high protein and calcium-rich foods for egg production and raising of chicks (Ward 1977). Juveniles, present in early summer and mid autumn, will forage more often in arboreal habitats and consume more fruit than adult birds (Brown 1974; Tahon 1978; Feare 1984). Juveniles are less proficient at locating invertebrates beneath the soil and remain arboreal even if fruits are not available (Feare 1984; Stevens 1985).

Starlings spend over half the day feeding, with the highest proportion of time spent in permanent open grasslands (e.g. Whitehead *et al.* 1995). Other feeding sites vary seasonally (e.g. Dunnet 1956; Williamson and Gray 1975) and include orchards, vineyards, gardens, feedlots and rubbish sites.

Regardless of season, once a feeding pattern is established starlings will utilise the same foraging sites for extended periods (Bray *et al.* 1975; Feare 1980, 1989; Morrison and Caccamise 1985; Whitehead *et al.* 1995;). Larger movements recorded between feeding sites (e.g. Summers and Cross 1987) are probably due to lower food availability in these areas. Following successful bouts of feeding, starlings are known to return to the exact same position to within a metre (Tinbergen 1981).

Bouts of feeding are usually ended by disturbance from various sources, including other starlings (Feare 1984). However, unlike other pest birds of agriculture, starlings have no crop and cannot consume and store large quantities of food. Length of feeding is therefore also restricted to the capacity of the gut and their ability to digest food.

European studies have that shown starlings prefer feeding in areas that are further away from 'hedges' (Whitehead *et al.* 1995). This is thought to increase their chances of seeing approaching predators. In Australia, although quantitative data is lacking, stands of vegetation are more open and feeding sites with adjacent strips or rows of vegetation are likely to be preferred by starlings. Rows of large trees may allow birds improved access to feeding areas and provide vantage points for sentinel birds, while still allowing views of the surrounding area.

Height of pasture is also important in the selection of foraging sites. Grasslands with shorter grass (Brownsmith 1977; Williamson and Gray 1975; Whitehead *et al.* 1995) or freshly cut grass (Tinbergen 1981) are preferred to areas with long grass. This is consistent with starlings foraging behaviour in grasslands, providing improved access for detecting arthropod larvae beneath the soil.

Starlings feed in large flocks which improves their feeding efficiency and decreases losses from predators. As the breeding season approaches feeding flocks become progressively smaller as more time is spent at feeding sites which are closer to the nest (Wright and Cotton 1994).

1.5 Roosting

Starling's roosting behaviour plays an important role in their social interaction, daily activities and foraging patterns. Starlings are widely recognised for roosting in extremely large numbers, often in association with other species. Night roosts of starlings and other blackbirds have been reported to contain up to 20 million birds (Meanley and Webb 1965). National surveys conducted in the United States (Meanley and Royall 1976) found 137 of 723 blackbird roosts contained a million birds or more.

There has been little study done in Australia but night roosts are currently much smaller. The largest number of starlings recorded roosting in Australia was on a Hobart bird of 25000 birds (Wall 1973). In other areas starlings are often found roosting with other species. For example,

in Wollongong New South Wales, Wood (1995) found starlings roosting with common mynas (*Acridotheres tristis*) in small isolated groups of between 60 and 130 and larger groups of between 355 and 935.

Night roosting occurs throughout the year but roosts are larger in winter and autumn (Davis 1970; Williamson and Gray 1975). During this time there is a higher prevalence of first year birds (Wynne-Edwards 1929; Marples 1934). During spring and summer starling roosts are generally smaller as they are raising chicks and do not travel far from nesting and feeding sites.

Communal night roosting in starlings is thought to enhance foraging opportunities and offer improved protection from predators and climatic conditions. However, the importance of temperature and humidity and protection from predators has been largely discounted (Yom-Tov 1976; Kelty and Lustick 1977, Pulliam and Millikan 1982; Caccamise *et al.* 1983). Although starlings roosting together may have an energy-saving advantage (Brenner 1965; Swingland 1977) the energy spent flying to feeding sites, which is commonly less than 2km, would not be compensated (Yom-Tov *et al.* 1977). This may suggest that there are more important social reasons for communal roosts.

Consistent throughout the literature is that wind appears to be zero or close to zero within roost locations (Yom-Tov 1976; Kelty and Lustick 1977). Starlings have also been observed changing positions as a result of changing wind direction (Kelty and Lustick 1977) and by thinning tree canopy and increasing wind velocity starlings may leave the roosting sites altogether (Good and Johnson 1976). Night roosts are nearly always found in areas protected from the wind, such as trees with dense foliage including conifers and palm trees (e.g. Bevan 1962; Gochfield 1978; Wood 1995).

Starlings appear to show fidelity to both feeding sites and roosting sites depending upon season, availability of food and age (Morrison and Caccamise 1985; Caccamise 1990; Feare 1989). It was traditionally recognised that communal roosting was an efficient method for birds to locate feeding sites, whereby birds learn the location of new feeding sites by following other successful foragers from the roost (Ward and Zahavi 1973; Loman and Tamm 1980; Tinbergen and Drent 1980; Kiis and Moller 1986; Mock *et al.* 1988). However, studies on starlings have indicated that the roost does not act as an 'information centre' as previously suggested and that roosting behaviour is more closely related to the location of feeding sites than a loyalty to roosting sites (Caccamise 1990). Even when starlings remain loyal to roosting sites, juveniles are found not to follow adults to feeding sites when food supply is relatively stable (Summers and Feare 1995). However, for migrants exploring new areas and when food is unpredictable, roosting may play a more important role for information gathering (Summers and Feare 1995).

Longer term observation of starling roosts indicates roosting locations are used year to year (Marples 1934; Delvingt 1961). Marples (1934) found 20 percent of roosting locations had been in use for over 10 years and a few for over 100 years. Roosting sites that are used over such long periods can only occur in habitats that cannot be destroyed or spoiled, or that can regenerate annually e.g cliffs or reed beds (Marples 1934). Spoiling of large tree roosts by starlings often deprive future generations and native birds of roosting and nesting opportunities.

Starlings also roost in smaller groups during the day, where they preen, sing and rest in-between feeding. These daytime roosts occur in both sheltered and open areas (Feare 1984) and at different sites to the larger communal night roosts. During the day, starlings are often observed roosting in prominent open areas, such as power lines and large dead trees. The location these open roosting sites are thought to be an important factor contributing to the distribution and severity of damage on agricultural crops (Boudreau 1972; Stevenson and Virgo 1971).

White (1980) found positive correlations between changes in average weekly population estimates and weekly temperature changes in roosts. Dominant, usually adult birds depart the roost first and locate best feeding sites and juveniles fly over, gauge competition and may stop or fly on (Summers and Feare 1995). Starlings do not usually return to the same geographical area in successive winters (Spaans 1977). There is also a preponderance of first year birds in the roost in winter

1.6 Movements, Migration and Dispersal

There is very little information about starling movements in Australia, but movements of starlings of Europe and North America have been extensively studied and reviewed by various authors (e.g Long 1981; Feare 1984; Feare and Craig 1999). The daily movements and migratory and dispersal patterns of starlings described in this section are based mainly from studies undertaken in these countries.

1.6.1 Daily Movements

After sunrise, starlings depart highly aggregated groups at roosting sites and disperse in smaller groups to a variety of feeding areas. They depart roosts over a prolonged period of 50 minutes (Wynne-Edwards 1929; Eastwood *et al.* 1960, 1962) with groups leaving in 3 minutes intervals (Eastwood *et al.* 1962). Adult birds leave before juveniles, presumably to secure higher quality feeding sites (Summers and Feare 1995). Adults remain faithful to feeding areas for extended periods, whereas juveniles will visit a variety of feeding sites in a day and many more over the season (Summers and Cross 1987).

Starlings usually feed within 2 km from the roosting site, but can travel up to 50 km (Boyd 1932; Bray *et al.* 1975), or even 80 km (Hamilton and Gilbert 1969) from the roost. During autumn and winter, starlings leave the roost earlier (Marples 1934), travel greater distances and have a lower fidelity to particular feeding sites (Summers and Cross 1987; Caccamise 1990). Food availability, age of the birds (Feare 1989) and location of nesting sites (Stewart 1978) may be other factors which influence distance travelled from the roost.

As mentioned in the previous section, some studies indicate short-term movements of starlings centre more around core feeding areas rather than a proximity to roosting sites (Morrison and Caccamise 1985; Caccamise 1990). These studies suggest when starlings travel to distant feeding sites, away from their usual activity centre, they will select alternative roosting sites to minimise necessary travel time.

Before returning to the roost at dusk, starlings will regularly gather in large groups nearby to roosts. These flocks are termed pre-roost assemblies in Europe or staging and supplementary feeding areas in North America. Before sunset, large flocks are often found gathering to feed

on grain crops and vineyards. They also form non-feeding groups in trees, shrubs, buildings, powerlines and antenna, where they preen and sing. Observations of roosting starlings in Tasmania suggest that some starlings will gather in groups on powerlines and pylons prior to roosting and others will fly directly to the roost (Wall 1973).

1.6.2 Migration and Dispersal

Larger movements of starlings can be explained by migration and dispersal. Starling migrations involve two-way movements which are usually correlated with changing seasons. Dispersal of starlings occurs in one direction and are mainly juveniles dispersing from their birth place.

Starling populations are found to be both migratory and sedentary. Starlings of northern Europe will consistently migrate south or south-west during winter to take advantage of increased food availability. Millions of birds are known to regularly travel across the North Sea into Britain each year. Conversely, many populations of southern Europe are sedentary and persist there throughout the year (e.g Potts 1967). These resident starlings will defend nest sites and visit familiar feeding sites year round (Feare 1984). Some populations in the south also comprise resident and migratory starlings who occupy the same breeding areas (Feare 1984).

The rapid colonisation of North America from introduced populations in New York was initially by non-breeding winter migrants (Wing 1943; Mills 1943; Quaintance 1951; Long 1981). They now breed over most of their North American range, and migrant seasonally both in a easterly and westerly direction. There are also thought to be both migratory and sedentary populations in North America.

In some areas, starlings exhibit distinct migratory patterns, often travelling the same routes in successive years (Goodacre 1959; Rydzweski 1960; Gromadski and Kania 1976). However, in Holland, Spaans (1977) found starlings did not return to the winter locations of the previous year. He suggested this may have been due to a poorer wintering habitat. Despite an often lack of fidelity between seasons, starlings will still consistently feed in the same areas during the same season (See Diet and Feeding behaviour; Bray *et al.* 1975; Whitehead *et al.* 1995; Feare 1980, 1989; Morrison and Caccamise 1985).

The other major movements of starlings occur in summer when juveniles of the first brood disperse from their natal colonies. Juveniles may disperse within a few weeks of leaving the nest (Feare 1984). These summer dispersals may also involve adults, but are mainly juveniles (Tahon 1980, Nankinov 1978, Feare 1984).

Dispersing starlings may travel large distances seeking new feeding and breeding sites. These movements have been shown also in Australia by the recovery of a bird in Brisbane banded a month before in Tasmania, a distance travelled of 2000 kilometres (Green 1965). Dispersing birds travel to areas with existing populations, as well as to areas not yet established by starlings. An isolated island in the Fijian group was colonised by starlings which are thought to have travelled over 1200km from islands to the south (Hill 1952). In North America, the first starlings to disperse into other areas were migrants for the winter periods. In contrast the starlings dispersing into Western Australia have been mainly birds seeking breeding sites (Long 1972, 1981).

1.7 Mortality and Survivorship

Starlings are highly successful breeders and populations can rapidly increase under favourable conditions. Starlings, like other hole nesting birds have a high percentage of nests producing young. In studies in Europe and North America commonly 70-95 percent of first brood nests produce fledged young (Collins and de Vos 1966; Dehaven and Guarino 1970; Kessel 1957; Feare 1984). The same studies show that second broods are not as successful with 40 to 80 percent of nests producing fledglings.

Infertility and embryos dying is the main cause of eggs not hatching (Dunnet 1955; Tenovuo and Lemmetyinen 1970). Loss by predators and nest parasitism by other starlings also occur but these have little effect on hatching success. Once hatched, most deaths occur in the first few days following hatching (Korpimaki 1978). Chicks that are laid later cannot successfully compete for food and have a higher mortality (Lack 1968; Feare 1984).

Despite variation in mortality rate between studies, juveniles consistently suffer higher mortality than adult birds. A review of 11 studies revealed on average, 65 percent (n=8, s.d 6.2, range 56-73) of first year birds and 55 percent (n=11, s.d 9.4, range 50-68) of adults die each year (from Feare 1984). However, starling mortality fluctuates annually and is thought to be gradually decreasing to around 35-40 percent (Clobert 1982; Clobert and Leruth 1983; Feare 1984).

Significantly more females than males will die in the first year (Davis 1959; Coulson 1960; Summers *et al.* 1987). This differential mortality causes a significant bias in sex ratio, with most populations comprising 2 males to every female. Unlike males, females will breed in the first year, which is thought to contribute to their higher mortality (Coulson 1960). In subsequent years females and males tend to die at similar rates, although female mortality may be slightly higher (Coulson 1960; Frankhauser 1971, Suthers 1978).

The average life-span of a starling is about 12 to 18 months (Feare 1984). Many juveniles will die before reaching this age, and others live considerably longer. The maximum recorded age of a starling in Britain is 16 years 10 months, in USA is 17 years 8 months and in Germany is 21 years and 4 months (Feare 1984).

The major cause of adult and nestling mortality is probably starvation (Feare 1984; Keymer 1980), although this is difficult to quantify. Other mortality factors, including predation and disease, are unlikely to significantly affect population levels. Predators of starlings in Australia include most birds of prey, cats, dogs and rodents. A list of Australian birds and mammals that are known to kill starlings are in Table 10.

Table 10. Australian birds and mammals known to prey upon starlings (*Sturnus vulgaris*)

Predator	Source
Pied Currawong	Personal observation
Peregrine Falcon	
Nankeen Kestrel	Fleming, personal communication ⁺
Swamp Harrier	Falla <i>et al.</i> 1979
Collared Sparrowhawk	Johnson 1991
Barn Owl	
Australian Raven	Lepshi 1994
Domestic dog	Personal observation, Feare 1984
Domestic cat	Coulson 1960
Brown rat* ⁺	

*moribund birds. ⁺ Atypical observation not normal associated as a significant predator of starlings.

1.8 Habitat

Starlings are one of the most common species in lowland suburban and cleared agricultural areas of the south east of Australia but also occur in open woodlands, irrigated pasture, feedlots, mulga, mallee, reed-beds around wetlands, coastal plains, and occasionally alpine areas. They avoid dense dry sclerophyll woodlands, wet eucalypt woodlands and forest, rainforest and arid regions. Populations are more marginal in the north and western parts of their range, where climate may partially limit their establishment. Their failure to colonise the apparently suitable habitat of south-west is probably due to concerted efforts to control emerging populations and the barrier offered by the Nullarbor plains. Water availability appears important hence high rainfall regions, irrigated areas, temporary surface water, and flooded drainage swamps attract high densities.

Preferred night roosts are introduced plant species with dense foliage including Africa boxthorn (*Lycium ferocissimum*), firethorn (*Pyracantha*), hawthorn (*Crataegus momgyna*), plane tress (*Platanus*), palms, willows, cypress, pines, cedars, oak, and reed beds (e.g. *Typha* or cumbungi), or concealed cavities in human structures or cliffs. In comparison prominent areas such as powerlines, dead trees, building roofs, and aerials are often used throughout the day for perching and preening.

2. STARLING DAMAGE TO WINE GRAPES

Bird damage in agriculture is consistently found to be unevenly distributed across and within agricultural crops (e.g. Dyer 1967; DeHaven 1974). Flocks of starlings will concentrate their feeding and habitually visit particular areas and ignore others (e.g. Bray *et al.* 1975; Whitehead *et al.* 1995). This has been demonstrated for birds damaging grain crops, where fewer than 5 percent of the fields in a region may bear 95 percent of the overall damage (Dyer 1967). As a result, while particular farmers suffer devastating losses, the impacts of bird damage measured over large areas are often small in relation to the overall loss to production.

A highly skewed distribution of damage is also likely in Australian wine grapes, although little information on damage severity and distribution is available. However, some estimates

from questionnaire surveys report damage as high as 63 percent in some vineyards while overall damage is generally lower (Bomford 1992). In South Australia, Graham *et al.* (1996) found that 35 percent of grape growers suffered damage equal to or in excess of 10 percent.

More comprehensive damage assessments to grapes have been carried out in North America (Stevenson and Virgo 1971; Dehaven 1974). Results from the 1974 study indicated that mainly house finches (*Carpodacus mexicanus*) and starlings caused an overall mean loss of 1.99% (± 1.08), but some individual farmers suffered up to 82.5 % loss (Dehaven 1974). In Ontario Canada, Stevenson and Virgo (1971) found that while robins and starlings damaged less than 0.5% of the total value to 128 vineyards, only 14 individual growers suffered moderate to severe losses.

Unequal distribution of damage is important when interpreting economic losses over large areas. If damage is widespread but the majority of growers experience insignificant losses, as is commonly suggested, damage control may not be economically justified for these growers but will be of great importance for the fewer individual growers experiencing devastating losses.

2.1 Factors Contributing to Damage

Characteristics of the cultivar and the vineyard will contribute to varying degrees of bird damage. Age, maturity, sugar content, berry size, pulpiness, colour, height of the grapes on the vine, vigor and foliage thickness are characteristics of the cultivar that may affect bird damage levels. Vineyard characteristics such as proximity of adjacent roosting and perching sites, and size of the vineyard may also influence damage.

Earlier ripening cultivars of cherries (Tobin and Dolbeer 1987; Tobin *et al.* 1989a; Tobin *et al.* 1991), apples (Mitterling 1965; Baker 1980; Tobin *et al.* 1989b) corn (Bridgeland and Caslick 1983; Bollinger and Caslick 1985) and sunflowers (Samanci and Hanzel 1983; Cummings *et al.* 1989) suffer significantly greater bird damage than later maturing varieties. However, this trend has not been shown for grapes. Bird damage to early and late maturing varieties of grapes has been found not to be significantly different (DeHaven 1974). Birds will first start damaging grapes as early as a month before harvest (Stevenson and Virgo 1971), when grapes begin to 'colour' or 'raisin'. This corresponds to a sugar content of around 11-13 °Brix (Tobin 1984). After this level of maturity is reached bird damage does not necessarily increase with increasing maturity (Stevenson and Virgo 1971; Tobin 1984).

Sugar content and types of sugar, which will vary according to grape maturity, also do not show significant correlation with bird damage levels to grapes (Stevenson and Virgo 1971; Tobin 1984). However, bird's preferences have been linked to sugar concentration (Levey 1987, Schuler 1983) and type of sugar (Schuler 1983; Martinez del Rio *et al.* 1988) for other fruits. Fat content (Borowicz 1988) and other nutrients (Johnson *et al.* 1985; Brugger *et al.* 1993; but see Piper 1986) also may be important in a bird's selection of fruit and seeds.

Size of fruit is important in a bird's selection of fruits (McPherson 1988; Sallabanks 1993; Avery *et al.* 1995; Jordano 1995). A related but independent factor, fruit pulpiness or the amount of pulp per fruit may also influence a bird's choice (Sallabank 1993; Piper 1986). Piper (1986) found the amount of pulp per fruit to be more important than other factors including diameter, pulp to seed ratio, size of seeds, percent lipid, protein or minerals.

Colour is a cue that birds use to identify ripe and nutritious fruit (Turcek 1963; Snow 1971; Willson and Thompson 1982; Willson *et al.* 1990). Dark varieties of grapes (DeHaven 1974) and cherries (Stevens and DeBont 1980) are found to suffer greater starling damage than lighter coloured varieties. Other studies have found no significant differences in damage between different coloured varieties of grapes (Tobin *et al.* 1991). This contrariety may be partially explained by different colour fruits being preferred by particular bird species. For example, a New Zealand study found blackbirds preferred red grapes and song thrushes preferred white grapes (Watkins, personal communication).

Bunches at different heights on the vine will attract variable levels of damage (DeHaven 1974). Upper branches with sparse vegetation often attract heaviest damage (Boudreau 1972; DeHaven 1974). This is particularly true of un-trellised grapes where the lower vegetation will be significantly thicker. However, the behaviour of different bird species complicates this relationship. Starlings (DeHaven 1974) and silvereyes may continue to feed in the denser lower branches, while other species attack the upper bunches.

Other than bird abundance, the characteristics of the vineyard and the surrounding area are perhaps the most important factors affecting the levels of bird damage. Vineyards with adjacent suitable roosting habitat are much more likely to suffer greater damage (Boudreau 1972; Stevenson and Virgo 1971). This is also widely accepted as an important factor for other bird-crop conflicts (e.g. sunflowers: de la Motte 1977; 1990; corn: Cardinell and Hayne 1945; Mitchell and Linehan 1967; Martin 1977; Bollinger and Caslick 1985).

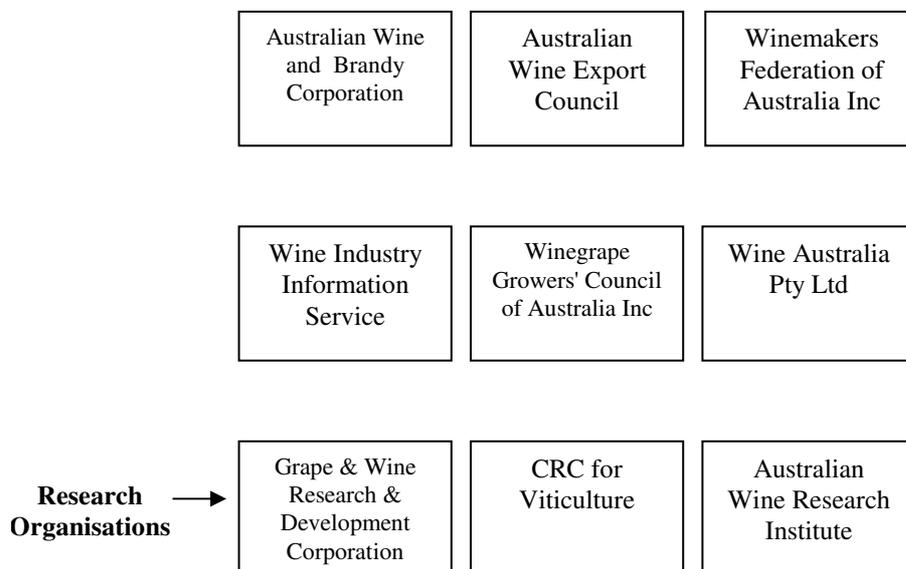
Smaller vineyards are often more susceptible to bird damage than large fields. This is probably caused by a preference for the outer edges of the vineyard and the high edge to area ratio of smaller fields.

Other factors that increase the number of birds in crops and subsequently increase bird damage levels include; the abundance of insects (Woronecki and Dolbeer 1980; Woronecki *et al.* 1981, but see Mott and Stone 1973 and Bollinger and Caslick 1985) and rainfall (Tobin 1984; Morton 1967). During and immediately after rainfall the number of birds feeding in a vineyard was significantly higher (Tobin 1984).

2.2 Overview of Australian Wine Industry Organisations

The following information provides an outline of the organisations and funding bodies involved in wine industry research, contact details are listed in Appendix 2.

2.2.1 National Organisations



Grape and Wine R and D Corporation (GWRDC): Allocate funds to projects and programs according to their Annual Operation Plan and Five Year R andD Plan. 1996/7 \$1.8M in Grape RandD and \$2.9M in Wine RandD. The plans and priorities for research are set by the Viticultural Priorities Reference Group (VPRG), who consult with national and state grower and winemaker bodies. Department of Primary Industries and Energy (Levies Management Unit) collects statutory levies on tonnage from grape growers and wine makers (matched \$ for \$ by the commonwealth). These funds are distributed to GWRDC.

Viticultural Priorities Reference Group (VPRG): Temporary GWRDC selected panel of 'experts' in viticulture who develop national lists of research priorities for GWRDC (through consultation with national and state grower and winemaker bodies). They consult national and state organisations including; Winegrape Growers Council of Australia Incorporated.; Winemakers Federation of Australia Incorporated, NSW Wine Industry Association; South Australian Wine and Brandy Industry Association Incorporated; Wine Industry Association of Western Australia Incorporated.

CRC for Viticulture : 'Partner' of GWRDC. Key vehicle for the coordination of research activities between key provider and research organisations.

Australian Wine Research Institute: Major wine research organisation. Received 90% of GWRDC's funding for Wine RandD (1996/97).

2.2.2 State Organisations

The major state wine industry bodies are:

NSW Wine Industry Association	SA Wine & Brandy Association	Wine Industry Association of WA Inc
Phylloxera and Grape Industry Board of SA	Queensland Winemakers Association	Vineyards Association of Tasmania

The NSW Wine Industry Association sends surveys to local associations to rank their research priorities, these are then collated and sent to GWRDC via the VPRG. Wine Industry Associations in other states consult the local associations to establish research priorities but direct surveys are not carried out.

3. TECHNIQUES TO MEASURE AND CONTROL DAMAGE AND ABUNDANCE

3.1 Measuring Damage

Appropriate damage assessment is a critical step in the effective management of bird pests and allows for improved planning and evaluation. The methods used for measuring damage to wine grapes include; questionnaire surveys, direct measures and simulation modeling.

3.1.1 Questionnaires

Questionnaire surveys are useful in setting research priorities and assessing damage over large areas. Face-to-face interviews (Bennett 1984), phone interviews (O'Donnell and Vandruff 1983) and mail surveys (Atwood 1956; Dawson and Bull 1970; Crase and Dehaven 1973; Stickley *et al.* 1979; Wakeley and Mitchell 1981; Bomford 1990; Graham *et al.* 1996; Johnston and Marks 1997) can all be used to gather damage information. There is a trade-off between obtaining specific, more accurate information and time and cost. Face-to-face interviews are more useful when more complex information from specific groups is required (Orlich 1979), but are more time-consuming and costly. Mailed surveys can be used over larger areas and have the lowest cost per response.

All questionnaire surveys have potential biases associated with them. Non-random errors as opposed to random sampling errors, are consistent under different conditions and can be estimated and accounted for. These biases can occur when a proportion of the targeted sample do not respond (e.g. Dawson and Bull 1970), the survey is conducted after too much time has lapsed (Sen 1972) or when respondents overestimate or underestimate damage depending

upon what is perceived to be socially acceptable (Macdonald and Dillman 1968, Crabb *et al.* 1987).

These errors can be reduced by careful wording of questions to avoid leading particular responses. Correct and objective phrasing of questions has been reviewed by a number of authors (Kahn and Cannell 1967; Orlich 1979; Filion 1981; Chadwick *et al.* 1984; Crabb *et al.* 1987).

Non-random biases associated with questionnaires can be estimated and taken into account in analyses and conclusions (MacDonald and Dillman 1968; Sen 1972). For example, fruit growers with more damage are often more likely to respond to a questionnaire about severity of damage (Dawson and Bull 1970). By re-sampling a proportion of the candidates that did not reply, this 'non-response' bias can be estimated and accounted for. To be applicable in most situations estimates or rankings of damage should be correlated with actual damage which can be determined using direct measures.

3.1.2 Direct Measures

Estimating bird damage without counting all the grapes in the vineyard requires taking a representative sample and predicting total damage. Standard random sampling procedures (e.g. Cochran 1977; Caughley and Sinclair 1994; Granett *et al.* 1974) are used to achieve accurate and precise measures. The desired degree of accuracy or precision will dictate how much time and cost is required for damage estimates. For example, on a producer level general assessments can be made without spending a great deal of time or money.

Direct measures of damage include weighing, counting, and visual estimation. Counting and weighing are considerably time consuming, but can be used to calibrate visual methods. Due to the time involved there have been few studies on grape damage by counting and weighing, however, these techniques have been used for cereal crops (e.g. Dawson 1970; Khan and Ahmed 1990) and apples, pears and stone fruits in orchards (Long 1985).

Calculating damage by weighing involves cutting and weighing a representative sample of bunches. A theoretical undamaged weight for the whole sample is calculated from the mean weight of the undamaged bunches. An estimate of the damage in each plot is then calculated from the difference between this weight and the actual weight of the whole sample (from Khan and Ahmed 1990). Cutting and weighing grapes is used for determining grape quality, maturity and the correct harvest time (Roessler and Amerine 1958), but there are no known studies of estimating bird damage to vineyards using this technique.

Estimates can also be calculated by counting the number of damaged, missing and undamaged grapes on each sample. While counting of grapes has been used to estimate total damage (Burton 1990), the most common use of this method is to calibrate visual estimation methods (Stevenson and Virgo 1971; DeHaven and Hothem 1979).

Visual estimation is a rapid and the most widely used method to obtain measures of damage to wine-grapes (Stevenson and Virgo 1971; DeHaven 1974; DeHaven and Hothem 1979). This involves estimating damage visually, using a ranking scale and experienced observers. Biases can reduce the accuracy of damage assessment and where possible should be estimated

and corrected for. Compensatory growth of grapes and over- and under-estimation of damage from pecked grapes are examples of non-random errors.

Different bird species cause different types of damage. For example, starlings generally pluck whole grapes, whereas silvereyes generally peck grapes. Although pecked grapes may not be completely lost to the grower, they may cause secondary losses through mold and insect attack. This may have implications when this is the major type of damage occurring, for example in California, DeHaven (1974), found 76.6 percent of the 1806 bunches damaged had more pecked grapes than missing grapes.

Visual estimates of damage can be simplified by correlating the number of grapes damaged with the number of bunches (Hayne 1946; DeHaven and Hothem 1981; Burton and Byrne 1992). This allows the recording of damaged and undamaged bunches rather than applying a ranking scale and estimating the damage to each bunch. The difficulty is producing a relationship that is applicable to different bird species and to vineyards where bird damage is not randomly distributed.

Where damage is non-random, stratification will increase precision. For example, sampling the areas around the edges of a crop separately, where bird damage is often, will often improve repeatability of estimates. When sampling over larger areas, stratification according to the age of the vines, the geographic areas, different varieties and early or late maturing date can also improve precision (DeHaven 1974).

3.1.3 Simulation Modelling

Models can be used to predict and simulate bird damage without directly measuring it. Bioenergetics models were first developed by Wiens and Innis (1974) and have since been used to predict damage to corn and grain crops from starlings and blackbirds (Iceridae) (Wiens and Dyer 1975; Weatherhead *et al.* 1982; White *et al.* 1985). These models predict damage by translating bird density and energy demands (Kendeigh 1970), into the amount of the resource removed.

To provide accurate estimates many parameters are required which are often difficult to obtain and may not be available (Otis 1989). The models are also deterministic and do not take into account the natural variation in damage (Otis 1989; Hone 1994). Despite difficulties, comparison against an enclosure study revealed similar damage estimates (Weatherhead *et al.* 1982).

This model is probably most useful when estimating damage over broad agricultural areas, when density and feeding habits are already known, easily obtained or being determined for other reasons. When applying this model to starlings and wine grapes, factors such as uneven distribution of damage, opportunistic feeding habits and diets, and damage caused by different age classes (juveniles) and other species would need to be considered.

3.2 Trapping

In most situations and for most bird species trapping is unlikely to reduce populations below the economic damage threshold. However, there are a large variety of different trapping methods that have been used successfully in research applications. Mist nets, cannon nets,

walk-in cage traps, clap and sprung traps, modified Australian crow (MAC) traps and capture at nest sites are briefly discussed below.

Mist nets are one of the most commonly used techniques for researchers. Australian bird-banders manual recommends 1¼ inch mesh for passerines (Lowe, 1989). These nets comprise netting attached to poles, and are commonly used for small to medium-sized birds. Birds fly into the net and remain caught until released. The nets are generally used each morning and late afternoon for a period of two hours, and left closed overnight and during the middle of the day to avoid capturing non-targets and to minimise stress during the heat of the day (Lowe, 1989). Nets should not be used in excessively windy or hot periods or during rain, and they have to be continuously monitored and checked during trapping periods (Lowe, 1989). Frequently checking the nets minimises the stress on birds and minimises the threat of predators attacking the trapped birds. The threat from predators is the main disadvantage of mist netting because even with frequent checks smaller birds especially may be lost to larger birds or other predators. The stress of being tangled in and being removed from the net is minimised by regular checks and training in the correct removal procedure, birds that are badly tangle are cut out of the net to avoid injury.

A technique requiring considerable skill is the use of cannon nets. These employ explosively propelled devices to throw a net over an area where birds have congregated (Lowe, 1989). In the past, waterfowl, parrots, eagles and other species have been captured using these devices but in Australia it is virtually restricted to the capture of waders (Lowe, 1989). Rocket-nets are similar devices (Rowley and Chapman, 1981). This method has the potential to be successful for capturing starlings, because starlings congregate in large numbers to feed and roost (Bray et al., 1975). An additional licence to use explosives is also required from state or territory government and a great deal of training is required to ensure competence (Lowe 1989).

Walk in cage traps operate by attracting birds into a cage with a lure including food or other birds. A trap door is then activated closing the bird inside the cage. The use of lure-birds is applicable for flocking birds such as starlings. Simple designs can capture a single bird at a time, more elaborate designs can capture multiple birds and include holding catches for lure birds. Traps must be checked regularly to prevent attacks from predators (Lowe, 1989).

Clap and sprung traps have a spring-activated net which is to throw a net over an area or to close a door on a cage. Some traps can be triggered by a bird, while others rely on a person to trigger the spring. Sprung traps are known to be successful for robins and raptors (Reilly, 1968; Cam, 1985) and according to Parry (1968) claptraps are successful in catching kookaburras. These traps are normally operated singularly or in pairs because captured birds have to be quickly removed from the traps (Lowe, 1989).

The use of the Modified Australian Crow Trap is described by Gadd (1996). These entrances of this trap can be adjusted for difference species (Gadd 1996). This trap was first used to control crow numbers (Woodbury, 1961), and more relevantly is used on the Western Australian boarder to capture and control starlings (Pryde, R. 2002, personal communication). The trap can capture and hold a large number of birds and providing that there is adequate shade, food and water.

Catching by hand or with hand-held nets at nest sites is an opportunistic method which is unlikely to result in large numbers of birds being captured, but maybe useful for research applications. The adults of a few species of birds, such as land nesting sea birds including mutton birds, may be captured by hand during daylight (Lowe, 1989). A major disadvantage of catching breeding adults is the possible effects of their activities on the eggs and young (Lowe, 1989). Catching birds nesting in man-made nest boxes is a successfully used technique for both research and control (e.g. Knittle and Guarino 1976; DeHaven and Guarino 1970). Dehaven and Guarino (1969) used a spring-loaded trap door that closed over the entrance of the nest box when triggered by a treadle inside the box. It has been found that birds were more likely to return to the nest after capture if they were captured leaving the nest rather than captured inside the nest box (Coleman, 2000, personal communication).

3.3 Legalities of Bird Control in New South Wales

In many situations lethal means of bird control have little effect on reducing damage. Alternative methods such as netting or providing decoy food sources are often more likely to provide greater long-term benefits. However, some lethal control such as shooting can be useful for reinforcing scaring programs. Permits are not required for introduced species. However, harming of any native bird requires a permit from NSW National Parks and Wildlife Service (3.3.2.1). This excludes those declared 'locally unprotected' (3.3.2.2) ie. Corvids (crows and ravens), sulphur-crested cockatoos and galahs. If you are an owner, manager or occupier you will require a section 121 (Occupier's licence, 3.3.2.4). Other workers or employees require a section 120 (General licence, 3.3.2.5). Both licences can be obtained using the section 121 application form, without charge. National Park staff will usually conduct a site inspection to verify damage has taken place and issue tags and a permit for a specified number of birds. Tags need not be attached to each bird.

Any control of bird pests must also be implemented in accordance with other acts. For example, they must be carried out in a humane way (Prevention of Cruelty to Animals Act 1979), when there are no non-target risks (NPWS Act 1974), and they are not owned by anyone, on another person's property (trespass), or in a national park or reserve (NPWS Act 1974).

National Parks and Wildlife in NSW have also issued several restricted permits to allow trapping of various species of Cacatuidae (Table 11).

Table 11. Contacts details of individuals licensed by National Parks and Wildlife to trap Cacatuidae as at 1 July 2003

Species	Surname	First Name	Area	Phone
Sulphur crested Cockatoos, Galahs, Little Corellas	Ackerod	Ray	Bringelli (Camden Sydney)	02 47748471
Sulphur crested Cockatoos, Galahs, Short and Long-billed Corellas	Dickson-Flint	Leslie		02 69635391
Sulphur crested Cockatoos, Galahs, Little Corellas	Freeman	John	Maitland	02 49336715

3.3.1 Poison

There are currently no chemicals registered for poisoning birds in an agricultural setting, and any use is strictly illegal. There are however, two poisons registered in NSW for application only in or around buildings; Alphachloralose and Scatterbird (Amino pyridine). These are restricted for use by pest control operators, must exclusively target introduced species and also requires a site specific permit from NSW NPWS (Contact Jeff Hardy 02 95856481). Restricted access is attainable in exotic disease emergencies (refer to Appendix 3. for an example).

3.3.2 Relevant sections of NSW legislation

3.3.2.1 Harming protected fauna (NPW Act 1974-Section 98)

Harming protected fauna, other than threatened species, populations or ecological communities

(1) In this section, "protected fauna" does not include threatened interstate fauna, threatened species, populations or ecological communities, or locally unprotected fauna under section 96.

(2) A person shall not:

harm any protected fauna, or

(a1) harm for sporting or recreational purposes game birds that are locally unprotected fauna, or

(b) use any substance, animal, firearm, explosive, net, trap, hunting device or instrument or means whatever for the purpose of harming any protected fauna.

[Penalty: Maximum penalty: (a) 100 penalty units and, in a case where protected fauna is harmed, an additional 10 penalty units in respect of each animal that is harmed, or (b) imprisonment for 6 months, or both.]

(3) A person shall not be convicted of an offence arising under subsection (2) if the person proves that the act constituting the offence was done:

(a) under and in accordance with or by virtue of the authority conferred by a general licence under section 120, an occupier's licence under section 121, a game licence under section 122, a trapper's licence under section 123 or an emu licence under section 125A or a licence under Part 6 of the [Threatened Species Conservation Act 1995](#) , or

(b) in pursuance of a duty imposed on the person by or under any Act.

(5) Subsection (2) does not apply in relation to things which are essential for the carrying out of:

(a) development in accordance with a development consent within the meaning of the [Environmental Planning and Assessment Act 1979](#) , or

(b) an activity, whether by a determining authority or pursuant to an approval of a determining authority, within the meaning of Part 5 of that Act if the determining authority has complied with that Part.

3.3.2.2 Locally unprotected fauna (NPWAct1974 Section 96)

(1) The Governor may, by order published in the Gazette, declare any protected fauna within a locality specified or described in the order, being fauna of a species named in the order, to be fauna to which this section applies. [Note: For orders under this subsection, see Gazettes No 61 of 7.5.1976, p 2013; No 147 of 19.10.1984, p 5146 and No 159 of 21.10.1988, p 5499]

- (2) An order under subsection (1) does not apply, and shall be expressed so as not to apply, with respect to any lands within a national park, historic site or nature reserve.
- (3) Any protected fauna declared to be fauna to which this section applies are, for the purposes of sections 70 (5) and (6) and 98, locally unprotected fauna.
- (4) An order under subsection (1) does not apply to, and must not be expressed to apply to, any threatened species, population or ecological community.
- (5) Without affecting subsections (2) and (4), an order under subsection (1) may be subject to such conditions and restrictions as may be specified in the order.

3.3.2.3 Relevant orders published in the Government Gazette

NPWAct 1974 Order published in the Government Gazette of New South Wales No.147
Friday 19 October 1984:

J. A. ROWLAND, Governor.

I, Air Marshal Sir JAMES ANTHONY ROWLAND, Governor of the State of New South Wales, with the advice of the Executive Council, and in pursuance of section 96 (1) of the National Parks and Wildlife Act, 1974, do, by this my Order declare protected fauna of the following species within the Central and Western Divisions of the State (as defined by the Crown Lands Consolidation Act, 1913). except within areas reserved or dedicated under the National Parks and Wildlife Act, 1974. to be fauna to which section 96 of that Act applies (locally unprotected fauna):

Cacatua galerita Sulphur-crested Cockatoo

Cacatua roseicapilla Galah

Signed and sealed at Sydney this 19th day of September, 1984.

By His Excellency's Command, TERRY SHEAHAN. Minister for Planning and Environment. (8275)

NPWAct 1974 Order published in the Government Gazette of New South Wales No.159
Friday 21 October 1988:

J.A. ROWLAND. Governor.

I, Air Marshal Sir JAMES ANTHONY ROWLAND, Governor of the State of New South Wales, with the advice of the Executive Council and in pursuance of section 96 (1) of the National Parks and Wildlife Act 1974, do, by this my Order, declare protected fauna of the following species within New South Wales, except within the Counties of Camden, Cumberland and Northumberland, and within areas reserved or dedicated under the National Park and Wildlife Act 1974 to be fauna to which section 96 of that Act applies (locally unprotected fauna):

Corvus coronoides Australian Raven

Corvus tasmanicus Forest Raven

Corvus mellori Little Raven

Corvus orru Australian Crow

Corvus bennetti Little Crow

Signed and sealed at Sydney this seventh day of September 1988 by His Excellency's Command TIM MOORE. Minister for Environment. (6808)

3.3.2.4 Occupiers Licence (NPW Act 1974 Section 121)

(1) An authorised officer may issue a licence (in this Act referred to as an "occupier's licence"), authorising an owner or occupier of specified lands:

- (a) to harm, or
- (b) to permit a person, holding a general licence issued to the person under section 120 or a trapper's licence issued to the person under section 123, to harm,
 - (1) a specified number of fauna of a specified class found on those lands and the licence may authorise the disposal, whether by sale or otherwise, of fauna harmed under the authority of the licence.
 - (2) If an occupier's licence is proposed to be subject to a condition requiring labels, tags, slips or other objects to be affixed or attached to the skin or carcase of fauna harmed under the authority of the licence, the licence must not be issued unless the licensee has been supplied by the Service with sufficient labels, tags, slips or other objects to enable the licensee to comply with the relevant condition.
 - (3) An occupier's licence shall not be issued with respect to threatened species, populations or ecological communities or to authorise game birds to be harmed for sporting or recreational purposes. However, a licence can authorise a sporting or recreational shooter to harm game birds for any other specified lawful purpose.

3.3.2.5 General Licence (NPW Act 1974 Section 120)

- (1) An authorised officer may issue a licence (in this Act referred to as a "general licence"), authorising a person to do any or all of the following:
 - (a) to harm or obtain any protected fauna:
 - (i) for the purpose of providing specimens of natural history for any scientific institution or museum,
 - (ii) for the purpose of carrying on any scientific investigation,
 - (iii) for the purpose of exhibiting the fauna, or
 - (iv) for any other specified purpose,
 - (a1) to hold or to keep in possession or under control any protected fauna for any purpose mentioned in subparagraphs (i)–(iv) of paragraph (a),
 - (b) to exhibit protected fauna,
 - (c) to dispose of, whether by sale or otherwise, any fauna harmed, obtained, held, kept or exhibited under the authority of the licence,
 - (d) to sell any fauna in the person's lawful possession, otherwise than as a fauna dealer or skin dealer,
 - (e) to harm any protected fauna (other than a threatened species, population or ecological community) in the course of carrying out specified development or specified activities.
- (2) A general licence does not, except in so far as the terms of the licence otherwise expressly provide, authorise the harming of fauna in a national park, historic site, state recreation area, regional park, nature reserve, state game reserve, karst conservation reserve, wildlife district, wildlife refuge, wildlife management area, conservation area, wilderness area or area subject to a wilderness protection agreement.
- (2A) A general licence does not authorise the harming of game birds for sporting or recreational purposes. However, a licence can authorise a sporting or recreational shooter to harm game birds for any other specified lawful purpose.
- (3) A general licence may be issued without conditions or limitations or may be issued subject to specified conditions or limitations.
- (4) Without affecting the generality of subsection (3):
 - (a) a general licence may but need not specify the species of protected fauna that may be harmed under its authority, and
 - (b) a general licence may but need not be limited to specified areas.

(5) A general licence may authorise any specified persons in addition to the person to whom the licence is issued to do the things authorised by the licence. In any such case, the specified persons are taken to be holders of the licence for the purposes of this Act.

(6) To avoid doubt, the Director-General is not a determining authority for the purposes of Part 5 of the [Environmental Planning and Assessment Act 1979](#) when issuing a general licence.

3.4 List of Management Techniques

Deterrents:

Scarecrows	Electric wires (eg. Vineyard Crop Saver [®])
Balloons	Filament wires
Kites (eg. birds of prey)	Humming wires
Peaceful pyramids [®]	Extruded (rigid) netting
Other light reflectors (eg. mirrors or CDs)	Drape-over knitted netting- single row
Model Aeroplanes	Drape-over knitted netting- multiple rows
Shooting	Drape-over knitted “Triple” netting
Gas guns	Permanent/ semi-permanent netting
Ultrasonic acoustic deterrent	Other roosting deterrents (eg. spikes, coils/ wire)
Bird Deter (radar deterrent system)	DTER (chemical)
Phoenix Wailer (acoustic)	SCAT (chemical)
Bird Gard /Flower Fruit (acoustic)	Rudducks (chemical)
Sonic combining distress calls	Cyndan polybutene (chemical)
Other Sonic	Garrards (Polybutene) (chemical)
Motorbikes or vehicles	Garlic spray

Lethal control:

Lethal Shooting
Trapping

Integrated:

Screening crops
Decoy sites
Sacrificial vines
Habitat modification

PART E: CONTRIBUTION TO NATIONAL GUIDELINES FOR MANAGING BIRD PESTS IN HORTICULTURE

The following draft sections (1-4) will form part of a Natural Heritage Trust initiative to publish national guidelines for the management of bird pests in horticulture.

1. MEASURING DAMAGE

Appropriate damage assessment is a critical step in the effective management of bird pests and allows for improved planning and evaluation. The methods used for measuring bird damage in horticulture include questionnaires, direct and indirect measures.

1.1 Questionnaires

Questionnaires are useful in setting research and management priorities over large areas. Face-to-face interviews (Bennett 1984), phone interviews (O'Donnell and Vandruff 1983) and mail surveys (Atwood 1956; Dawson and Bull 1970; Crase and Dehaven 1973; Stickley et al. 1979; Wakeley and Mitchell 1981; Bomford 1990; Graham et al. 1996; Johnston and Marks 1997) can all be used to gather damage information. There is a trade-off between obtaining specific, more accurate information and time and cost (see Table 12). Face-to-face interviews are more useful when more complex information from specific groups is required (Orlich 1979), but are more time-consuming and costly. Mailed surveys can be used over larger areas and have the lowest cost per response.

Table 12. Comparison between face-to-face interviews, telephone surveys and mailed questionnaires based on rankings

Factor	Face-to-face interview	Telephone survey	Mailed questionnaire
Large sample size	-	0	+
Large geographical area	-	0	+
Question complexity	+	0	-
Highest percent return	+	0	-
Lowest per unit cost	-	0	+
Ease of information gathering	-	0	+
Time required	-	+	0
Completeness of answers	+	0	-

From Miller 1983 and Crabb *et al.* 1987

+ most favourable ranking

0 intermediate ranking

- least favourable ranking

All questionnaires have potential biases. These biases can occur when a proportion of the targeted sample do not respond (Dawson and Bull 1970), the survey is conducted after too much time has lapsed (Sen 1972) or when respondents overestimate or underestimate damage depending upon what is perceived to be socially acceptable (Macdonald and Dillman 1968).

Errors can be reduced by careful wording of questions to avoid leading particular responses. Correct and objective phrasing of questions has been reviewed by a number of authors (Kahn and Cannell 1967; Orlich 1979; Filion 1981; Chadwick *et al.* 1984; Crabb *et al.* 1987).

In some cases, biases associated with questionnaires can be corrected to improve accuracy (MacDonald and Dillman 1968; Sen 1972). For example, fruit growers with more damage may be more likely to respond to a questionnaire about severity of damage (Dawson and Bull 1970). By re-sampling a proportion of the candidates that did not reply, this 'non-response' bias can be estimated. To be applicable in most situations estimates or rankings of damage should be correlated with actual damage, which can be determined using direct measures. Considerable thought needs to be given to asking only questions for which data can be analysed.

1.2 Direct Measures

Estimating bird damage without counting and evaluating all crops on a property requires taking a representative sample and predicting total damage. Standard random sampling procedures (e.g. Cochran 1977; Caughley and Sinclair 1994; Granett *et al.* 1974) are used to achieve accurate and precise measures. The desired degree of accuracy or precision will dictate how much time and cost is required for damage estimates. For example, on a producer level, general assessments can be made without spending a great deal of time or money.

Direct measures of damage include weighing, counting, and visual estimation. Counting and weighing are considerably time consuming, but can be used to calibrate visual methods. These techniques have been used for cereal crops (e.g. Dawson 1970; Khan and Ahmed 1990) and apples, pears and stone fruits in orchards (Long 1985).

Calculating damage by weighing involves cutting and weighing a representative sample of fruit. A theoretical undamaged weight for the whole sample is calculated from the mean weight of the undamaged samples. An estimate of the damage in each plot is then calculated from the difference between this weight and the actual weight of the whole sample (from Khan and Ahmed 1990). Weighing to obtain estimates of damage is often more difficult in horticulture than grain crops (such as corn and sunflowers), due to variable weights of individual fruits and difficulties measuring damage to pecked fruit.

Estimates can also be calculated by counting the number of damaged and undamaged samples within a crop. While counting has been used to estimate total damage (Long 1985; Burton 1990), a common use of this method is to calibrate visual estimation methods (Stevenson and Virgo 1971; DeHaven and Hothem 1979).

Visual estimation is a rapid and the most widely used method to obtain measures of bird damage to agricultural crops (Dolbeer 1975; Stevenson and Virgo 1971; DeHaven 1974; DeHaven and Hothem 1979). This involves estimating damage visually, with or without a ranking scale and experienced observers. To improve accuracy, these may be calibrated by counting or weighing samples which have been visually assessed.

The decision to use weighing, counting or visual estimates will depend on the type crop as well as available resources. For example, when measuring damage to grapes it is often not practical to count all the individual berries on each bunch so a visual estimate may be

preferred. However, for larger horticultural crops such as vegetables, stone fruits and apples counting may be just as efficient.

Where damage is patchy within a block, stratification will increase precision and decrease sampling effort. For example, sampling the areas around the edges of a crop separately, where bird damage is often higher, will often improve sampling efficiency. When sampling over larger areas, stratification according to the age of the crop, geographic areas, different varieties and early or late maturing date can also improve efficiency (DeHaven 1974).

1.3 Indirect Measures

Models can be used to predict bird damage without directly measuring it. Bioenergetics models were first developed by Wiens and Innis (1974) and have since been used to predict damage to corn and grain crops from starlings and blackbirds (Icteridae) (Wiens and Dyer 1975; Weatherhead *et al.* 1982; White *et al.* 1985). These models predict damage by translating bird density and energy demands (Kendeigh 1970), into the amount of the resource removed.

To provide accurate estimates many parameters are required which are often difficult to obtain and may not be available (Otis 1989). The models also do not take into account the natural variation in damage (Otis 1989; Hone 1994). Despite difficulties, comparison against an enclosure study revealed similar damage estimates (Weatherhead *et al.* 1982).

These types of models are probably most useful when estimating damage over broad agricultural areas, when density and feeding habits are already known, easily obtained or being determined for other reasons. When applying these models to estimate damage, factors such as uneven distribution of damage, opportunistic feeding habits and diets, and damage caused by different age classes would need to be considered. These factors are particularly important in horticulture where fruit is often only a small proportion of a pest bird's diet.

Any prediction of damage from bird density relies on assumptions about density-damage relationships. Does bird damage increase directly with increased densities of pests? There is no known published information about these effects in horticultural crops. In practice, estimates of bird density can be more difficult to obtain than estimates of damage.

1.4 Measuring Secondary Damage

In addition to direct tonnage loss by birds there are secondary losses, which are not easily measured in terms of cost. As discussed (Part A section 2.1), secondary spoilage comprises moulds, yeasts, bacteria and insect damage. Costs associated with this type of damage may include; downgrading of crops by purchasers, extra staff costs in removing bird damaged fruit and/or increased cost of fungicide application. In some crops there also may be compensatory responses with increased growth from remaining fruit. Timing of bird damage may also be a factor, for example if wine grapes are pecked immediately prior to harvest this may have a lesser effect on wine quality.

In most cases estimates of direct percent loss will be sufficient to base management decisions. However, it should be recognised that these estimates are therefore likely to be conservative, when there's a high percentage of pecked or partially damaged fruit.

1.5 When to Measure

The most appropriate time to measure damage will vary for different crops and situations. Taking measurements as close as practical before harvest is most suitable when:

- the majority of damage occurs late in the season, and
- all damage is easily identified at this time.

However the situation is more complex when damage is occurring at different stages of growth such as buds, flowers or plants prior to ripening, and when damage early in the season is no longer detectable before harvest. In these circumstances damage must be measured in separate stages and collated to obtain overall estimates of damage.

1.6 Early Forecasting of Damage

The techniques discussed so far have focused on estimating damage after it has occurred. However, this often prevents adequate management preparation for the same ripening season. Although bird damage can be variable, early predictions are useful for management planning. When forecasting damage, consider the following:

- What was the damage to my crop last year? Assessing damage this season helps management decisions for next season.
- What is the severity of damage other growers are experiencing in my area? Discuss bird damage with local industry associations, Department of Agriculture representatives and other growers in the district. Government and Industry contact details are found in Appendix 2.
- Which bird species are likely to cause greatest damage in my area? For further information consult field guides for bird distribution maps of the major species. Note that some species, particularly honeyeaters are highly migratory and maybe problem species when natural food sources are limited.

1.7 Case Study 1: Measuring rosella damage to cherries in the Mt Lofty Ranges, South Australia

The Adelaide Hills in the Mt Lofty Ranges of South Australia are well suited to cherry growing, providing an ideal cool climate and well-drained soils. A major pest to cherry orchards in the area is the Adelaide Rosella (*Playcercus elegans adelaidae*) which can cause severe damage to buds, flowers and ripening fruit. The following example illustrates a technique used in a 3 hectare orchard for assessing rosella damage to four varieties of cherry (*Prunus avium*): William's Favourite, Black Douglas, Lustre and Makings (from Fisher 1991).

1. Select eight trees for each variety.

Using paired random numbers identify five cherry trees for each variety. A simple technique for achieving this is to allocate letters for rows and numbers for trees, e.g. Row B Tree 7. The number of trees required will depend on the number in the orchard and the severity of damage in each variety. Normally when damage is low fewer trees and branches are required. Selecting an equal number of samples in each variety is a form of stratification and enables

better comparison between varieties. In this case William's Favourite was the most heavily damaged therefore extra samples could be taken in these blocks.

2. Select eight branches on each tree.

Divide each tree into a low section, (up to 2.65m- able to be reached when standing on the ground) and a high section (from 2.75-5.9m- able to be reached using a picker's ladder). Select a branch on the north, south, east and west sides of each tree at each of these two levels. This overcomes any bias associated with rosellas targeting a particular direction or height. For example, in this study fruit on higher branches were damaged earlier than those lower down, so if only lower branches are sampled bird damage would've been underestimated.

3. Count the number of damaged and intact buds on each branch.

Damaged buds can be easily identified as the base of the husk is left on the tree while the rest of the bud is removed. The number of damaged buds can then be expressed as a percentage of the total number of buds. Cherries do not continue to initiate buds after summer, so an estimate just prior to flowering should provide accurate estimates of bud damage. Bud damage however, is only one component of overall damage which includes damage to flowers and fruit. Compensatory growth of remaining buds and cherries may also occur. For example some bud damage may in effect be similar to the normal horticultural practice of thinning and even result in economic benefits (Sinclair and Bird 1987). The initial study by Fisher (1991) focused on bud damage but the same sampling procedure could be extended to include an estimate of damage to fruit.

4. Assess damage to fruit just prior to harvest.

Just prior to harvest repeat the selection procedure (Step1-2) but randomly select 5 clusters of cherries on each of the eight selected branches on each tree. Count the number of missing and intact cherries on each cluster. An overall percentage of damaged cherries can then be estimated.

1.8 Case Study 2: Measuring bird damage to wine grapes in the Orange Region, New South Wales

Orange cool climate wines are grown in high altitude vineyards surrounding Mount Canobolas at 990m above sea level. The majority of vineyards are less than 10 hectares and are interspersed with a diversity of vegetation types, including scattered eucalypts (*Eucalyptus macrorhyncha*, *E. seeana*, *E. tereticornis*, *E. viminalis*), pine (*Pinus radiata*) plantations, mixed farming, apple and stone-fruit orchards and sheep and cattle grazing country. Bird species which damage fruit are equally diverse. The main pests include starlings, silvereyes, pied currawongs, crimson and eastern rosellas, noisy friarbirds, red wattlebirds, yellow-faced honeyeaters and a variety of other honeyeaters. The following example illustrates a technique used in a 5 hectare vineyard with four wine grape varieties, Cabernet Sauvignon, Merlot, Chardonnay and Sauvignon Blanc.

1. Systematically select 10 vines from each outside edge from each block.

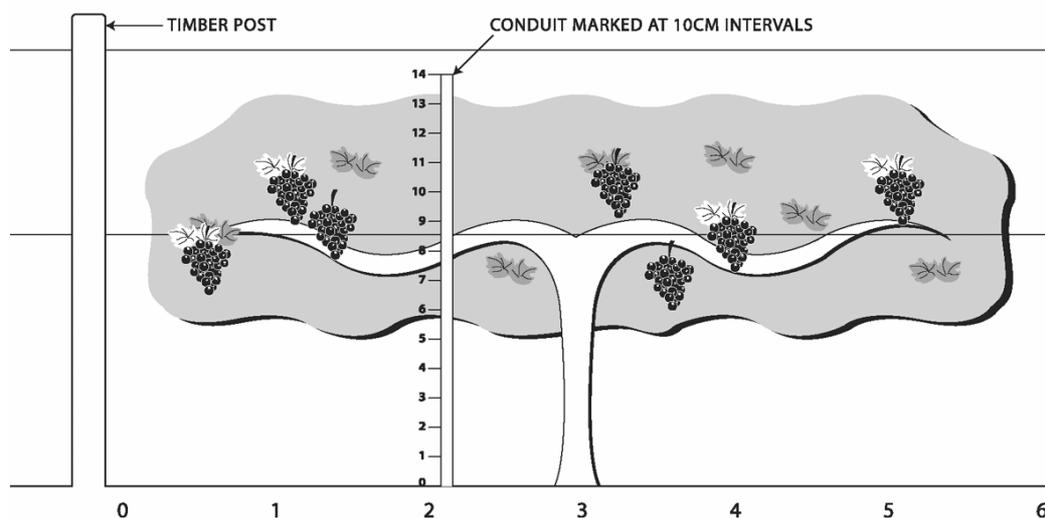
The outside edge here refers to the first and last two rows of the block and the first and last two vines in each row. Systematic sampling is where the first vine is selected at random then subsequent vines on that edge are selected at regular intervals. For example with a random start vine of 6 and an interval of 10, subsequent vines sampled would include 16, 26, 36, 46, etc. This can be carried out in a smooth action working around the block. Study in the Orange region indicates bird damage to wine grapes is always greater on at least one of the four outside edges than in the interior of the block except when damage is less than 5% (Tracey *et al.* In press).

2. Randomly select 1 bunch from each of the 10 vines.

Vines should be randomly selected to avoid over-sampling more visible bunches. One technique to overcome this bias is described below.

At each vine place a pole marked at 10 cm intervals at an arbitrary horizontal distance of 0-6. Using a pair of random numbers, one for the horizontal distance and one for the vertical distance locate the nearest bunch to that location. Random numbers can be selected between 7 and 12 (10 cm intervals) for the vertical axis and 0 and 6 for the horizontal axis. The vertical numbers corresponds to all harvestible bunches occurring between a vertical distance of 70 and 120 cm. Depending upon trellis height and structure this height may vary. For example if the fruiting area is lower you might need to select numbers between 5 and 10. A horizontal number of 3 requires placement of the pole at the vine stem; 0 at the left hand edge; 6 at the right hand edge; 1 at a third of the distance from the edge; 2 at two thirds and so on (see Figure 1).

Figure 1: Technique for selecting random bunches



3. Visually estimate damage to selected bunches

Study the selected bunch and estimate the bird damage to the nearest 5%. Calculate the average bunch damage for each edge. Visual estimates of bird damage in a variety of crops have been considered accurate for most purposes (e.g. Dolbeer 1975; DeHaven and Hothem

1979; Martin and Crabb 1979; Stevenson and Virgo 1971). Practice and calibration by estimating damage to bunches with known damage will improve accuracy.

4. Re-sample if damage is greater than 10%

If damage is less than 10% in each outside edge no more sampling is necessary, you can be confident that your estimate is a good indication of damage in your entire block. Regardless of block size a sample of 10 vines within a edge has been calculated as sufficient to estimate a damage level of 10% or less (with a standard error of 0.05) (Tracey *et al.* In press). If damage is greater than 10%, more samples are then required. The level of damage will dictate the number of samples needed in each edge (see Table 13). The same number of samples must then also be taken from the interior of the block.

Table 13. Sample sizes needed to estimate percent damage with 5% standard error

Percent damage	5	10	20	30	40	50	60	70	80	90	95
Sample Size	4	10	24	37	46	49	46	37	24	10	4

5. Calculate overall damage.

Mean damage for each block is calculated from estimates of damage within each edge and, if sampled the interior. For overall estimates you need to take into account the number of vines in each sampled section. This can be achieved simply by multiplying the percent damage in each section by the number vines in it, and dividing the sum of these for each section by the total number of vines in the block. The overall percentage loss can then be converted to cost using production Figures.

In this study the sampling technique allowed more blocks to be assessed with decreased effort. In this case grapes losses were found up to 95% and averaged 14% over 167 vineyard blocks. Using average losses across vineyard blocks, although patchy, would therefore equate to approximately \$182/tonne.

1.9 Case Study 3: Measuring parrot damage to apples and stone fruits in south-west Western Australia

The majority of Western Australia’s commercial fruit-growing areas occur in the lower south-west region. Suitable climate and reliable annual rainfall supports apple, pear, nectarine, peach, plum, apricot and wine industries. Many orchardists grow a variety of fruits and are located adjacent to stands of jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*), forestry plantations and livestock grazing country. Four main parrot species, the red-capped parrot (*Purpureicephalus spurius*), western rosella (*Platycercus icterotis*), Australian ringneck (*Barnardius zonarius*) and short-billed black cockatoo (*Calyptorhynchus latirostris*) are reported to damage fruit. This example describes an intensive, but simple method for measuring damage involving counting numbers of damaged fruit in and under every tree in six apple and stone fruit orchards over three seasons (from Long 1985).

1. Count the number of damaged fruits *beneath* each tree.

This study conducted monthly counts from December to June. This was necessary to ensure early damage to fruit was taken into account. Fruit was judged to be as either 'old' (brown and wrinkled) or 'new' (fresh-looking) and only new fruit was recorded in each successive count.

2. Count the number of damaged fruits *in* each tree.

Standing underneath each tree count the number of fruits damaged. This is also conducted monthly simultaneously to Step 1. Extra effort is required to ensure that every damaged fruit is counted, particularly on very tall trees.

3. Estimate total damage

Following harvest and packing determine the total number of fruit grown for each variety. The number of damaged fruit over the total grown will provide an overall estimate of bird damage. If loss of fruit occurs for other reasons (e.g. sunburn, insect damage, wind, hail, or undersize) then these should be included in the total number grown. Cost of bird damage can then be estimated from numbers damaged in each variety.

This technique is very time consuming and could be made more efficient by reducing the sample size, particularly in varieties suffering low damage. An example would be to randomly or systematically select every fifth tree and follow the same procedure. In the third year Long (1985) reduced sampling in this way for the green varieties of apple and simply multiplied the total damaged by five. Estimates were similar to counting every tree and significantly reduced sampling time.

On this occasion bird damage was found to be insignificant with a maximum percentage loss over the six orchards of only 1.75%. The value of damage to fruit did therefore not exceed \$100 in any orchard.

1.10 Case Study 4: Measuring cockatoo damage to peanuts in Lakeland Downs, Cape York Peninsula Queensland

Situated in the Laura River Valley of tropical North Queensland, Lakeland Downs has recently experienced regional development and expansion into various horticultural industries. Historically a cereal grain cropping and dairy farming area, Lakeland Downs, with high rainfall and well-drained ferrosol soils, now also successfully produces large quantities of peanuts, coffee, bananas and sugar. From the mid-1990s peanut crops have received high levels of damage from red-tailed black-cockatoos (*Calyptorhynchus banksii*) and sulphur-crested cockatoos (*Cacatua galerita*). These species pull the peanut shrub out of the ground by the stems, and shell and retrieve the nuts. Further damage is caused by these birds to irrigation systems. This example illustrates a technique to assess direct and indirect damage to irrigated peanut crops. (From Garnett 1998)

1. Estimate the area of crop damaged

In this situation cockatoo damage occurs intensively in certain sections of the crop and at negligible levels in most other areas. Damage is particularly severe within 200m of adjacent roosting habitat (Garnett 1999). Damage is therefore more easily measured by calculating the

area over which it occurs rather than attempting to count individual plants. Area can be estimated using odometers and measuring the distances around damaged peanut shrubs, or from aerial photography.

2. Convert area to cost

Area can be converted into tonnage loss using an estimate of production and price received per tonne. In this study an average of 0.607 tonnes of peanuts were produced per hectare (1.5t/acre), and an average price of \$650 per tonne received.

3. Record the costs of repairing irrigation systems damaged by cockatoos

In this study cockatoos caused regular damage to pivotal irrigators by chewing through 20mm poly-pipe casing and internal electrical wiring. The costs of repair should also include all labour involved. Costs of the damage to plants as a result of poor irrigation maybe more difficult to quantify but could be added by estimating the area or number of plants affected.

4. Calculate total costs

Overall costs of cockatoo damage can be estimated by simply summing the above costs.

In 1998, losses to profits averaged 7.3% across 7 blocks (range 0 - 31.8%) and totaled \$28,167 for one district. Further indirect costs to irrigators and crops from poor irrigation were estimated at \$7500 for this district. In 1999, an integrated strategy of scaring, reinforcement and sacrificial crops and concerted efforts by peanut growers, QNPWS and the Peanut Company of Australia contributed to reductions in damage.

2. REVIEW OF BIRD PESTS TO HORTICULTURE

The following section reviews the identification, habitat, movements, foods and feeding behaviour, breeding, protection status and damage caused to agriculture, in urban areas and the environment for the top twenty bird pests of horticulture. This list was collated after consultation with experts in bird pest research and management in each state and is arranged alphabetically by family then species. A summary table for other horticultural bird pests is attached in Appendix 4. The publications below are general texts which were used and/or are recommended for further reading but are not referred to after each species:

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2.1 Sulphur-crested Cockatoo (*Cacatua galerita*)

Other names: White Cockatoo, Greater Sulphur-crested Cockatoo.

Field Identification

A large (48-55 cm) white bird with a prominent yellow crest which curves forward. Sexes similar, differing slightly in size and iris colour. Distinctive uneven flight pattern with a series of wing beats followed by a glide. Often seen in large flocks and communal roosts, but also occur in pairs and small groups particularly in the tropics and during the breeding season. Associate with galahs (*Eolophus roseicapillus*) and corellas (long-billed, *C. tenuirostris*; western, *C. pastinator*; and little, *C. sanguinea*) while feeding. Corellas can be distinguished by a smaller and leaner stature and shallow wing beats during flight. Voice: A single distinctive screech as a contact call; an occasional high pitched call while roosting or feeding and a series of harsh screeches when alarmed.

Habitat

Sulphur crested cockatoos are common in a variety of habitats in eastern and northern Australian including sclerophyll, vine and rainforests, eucalypt and casuarina woodland, cultivated areas, parklands and open savannas. Open pasture and croplands are preferred where vegetation persists along watercourses. Hence this species has benefited from clearing, cropping and improved access to water. They often roost in tall, dense stands of eucalypts where water is close-by, but the distance to feeding sites vary.

Movements

Considered mainly sedentary seldom moving large distances between seasons, although may occasionally relocate for breeding, food or to escape adverse climatic conditions. Local movements usually occur along watercourses but flocks can transverse large open areas for food. Despite daily movements of up to 6 km they maintain fidelity to roosting sites. They form larger flocks and travel further in Autumn, when not breeding. During this period flocks are often more likely to travel into cleared areas. Similarly during the breeding season birds are more dispersed and tend to be resident. Highest densities occur just after breeding.

Foods and Feeding Behaviour

Sulphur-crested cockatoos have a varied diet of grass and plant seed, nuts, fruits, green leaves and stems, flowers, bark, roots, rhizomes, and insect larvae. Where available, seeds, grain and onion grass comprise the majority of their diet. Hence birds are mainly observed feeding in open areas. Fruiting, seeding and flowering trees initiate arboreal feeding which is also more common in northern parts Australia.

Larger flocks form whilst feeding, rather than roosting or flying, where groups can consist of a few birds to several hundred. Feeding flocks also tend to be larger in more open habitats. The majority of feeding usually occurs in the morning 1 hour after sunrise and afternoon 2-3 hours before sunset, with larger flocks during the afternoon session. Feeding forays usually last 1-2 hours, but this varies with season and region. For example, in some regions feeding is

more common in the middle of the day, especially during the cooler months; and conversely rare in summer when temperatures are highest.

Breeding

Breeding normally occurs from July to December. Hollow entrances and linings are chewed in branches or trunks of mature trees. Most common nest hollows occur between 5-20m in eucalypt trees in close proximity to water. Nesting also occasionally occurs in cliff faces and in mature *Melaleuca* and *Angophora*. A single pair of cockatoos will nest in each tree despite the regular occurrence of multiple hollows. They have however, been recorded sharing trees with other species including, galahs, kookaburras, barn owls and starlings.

Males and females usually visit hollows throughout the year. Both sexes prepare the nest, incubate eggs, which takes about 30 days and feed the young. Two to three white eggs are laid on a bed of wood chips 2-10cm deep. However pairs average less than one fledgling, due to infertile eggs, lace monitors, possums, bees, carpet pythons and trapping for aviculture. Fledging occurs at around 10 weeks but juveniles are fed by their parents for a further 6 weeks after leaving the nest. From banding studies cockatoos are known to live beyond 8 years in the wild but are many are likely to be older, as captive birds have lived over 100 years.

Damage

Damage to horticulture is caused mainly to buds, shoots and growing stems rather than fruit. However sulphur-crested cockatoos are known to remove large chunks or split pome and stone fruit for seeds. Seeds of citrus fruits are also consumed. The size of the pieces removed can be used to distinguish damage by smaller species. Damage to fruit occurs by consuming fruit on the branch, knocking others to the ground or removing whole fruits and flying to an adjacent roosting tree. They also damage nuts (e.g. hazelnuts, almonds, walnuts, pecans, chestnuts, pistachios) by cracking the shells; chew buds and young shoots, including those of cherries, grape vines and peanut shrubs; and chew and strip bark and foliage from orchard trees. Mature grape bunches are often snapped directly from the vines. A range of vegetable crops are also susceptible.

Protection Status Protected, Locally unprotected (NSW).

Sources and Further Reading:

Noske, S. (1980). Aspects of the behaviour and ecology of the White Cockatoo (*Cacatua galerita*) and Galah (*C.roseicapilla*) in croplands in north-east New South Wales. *Masters of Science Thesis, University of New England, Armidale.*

Temby, I. (1998). Reducing cockatoo damage in Victoria. *Eclectus*, 20-26.

2.2 Little Corella (*Cacatua sanguinea*)

Other names: Bare-eyed, Blue-eyed, Dampier's, Short-billed, Blood-stained corella or cockatoo.

Field Identification

White cockatoo (36-39 cm) found only in Australia and New Guinea, with bare bluish eye skin, small erectile crest and a small whitish bill. Underwing and undertail are sulphur yellow, seen during flight. A pink patch between the eye and bill is variously prominent between races; deepest pink in the *westralensis* race, unnoticeable in the nominate *sanguinea* race and intermediate traces in the other two races (*gymnopsis* and *normantoni*). Distinguish from the long-billed corella by bill length and the absence of a prominent crimson or salmon throat bar, although the *westralensis* race may have small traces of colour on the throat. Wing beats are shallower than Galah (*Eolophus roseicapilla*) but deeper than the Sulphur-crested cockatoo (*Cacatua galerita*). Usually seen in large noisy flocks. Voice: very raucous calls during flight and while roosting. Calls are similar but distinguishable from sulphur-crested cockatoos but almost identical, only slightly deeper than the calls of the long-billed corellas (*Cacatua tenuirostris*).

Habitat

Little corellas occupy a variety of timbered habitats including lightly wooded grassland, acacia shrubland, swamp sclerophyll forests, open sclerophyll, monsoon and riparian woodland and adjacent croplands, ploughed paddocks and grazing areas. Large flocks are also prominent in rural townships, around homesteads and grain silos, gardens, sporting fields and recreational areas. They are prevalent in the arid and semi-arid rangelands and considered a dry-land species, but are uncommon in areas without permanent water. In drier parts of Australia are replaced by Major Mitchell's Cockatoo (*Cacatua leadbeateri*). In southern South Australia they are distributed along the Murray River and tributaries in association with river red gum (*Eucalyptus camaldulensis*). These eucalypts and associated watercourses are also targeted in other areas including south west Victoria and the Pilbara region of Western Australia. They also occupy other woodland areas with tall grasses and in close proximity to water including open mallee, coolibah (*Eucalyptus microtheca*), *Callitris-Casuarina*, *Eucalyptus-Allocasuarina* and *Andansonia-Eucalypt* woodland. Local populations will venture into more marginal habitats, such as *Eucalypt-Acacia* shrublands, saltbush (*Atriplex*), dry mallee and arid *Callitris* during food storages. On Australia's mainland the distribution and abundance of little corellas has increased since European settlement, particularly in South Australia and the wheat belt of Western Australia, due to increased access to water, clearing of native shrublands and improved pastures. In comparison, long-billed corellas (*Cacatua tenuirostris*) are declining in some areas as a result of replacing preferred native pastures, particularly the native yam or Murnong (*Microseris lanceolata*) for agriculture.

Movements

Mainly a sedentary species which displays larger movements in response to extremes in climatic conditions. However, are more nomadic than sulphur-crested cockatoos and perhaps galahs. Typically there are no large-scale seasonal movements but some populations exhibit regular local movements with seasonal patterns. Pairs will separate from flocks and travel to

riverine habitat during the breeding season. Immatures and non-breeding adults are more mobile and can disperse up to 250 km, particularly after the breeding season (May - October). Erratic movements often occur with available water and food. For example, during drought large flocks depart from arid regions of western Queensland and NSW and seek refuge around billabongs, dams and waterholes of semi arid and tableland regions. Conversely large influxes of little corellas have appeared in other areas during floods where prolific breeding can occur (e.g. Melbourne during the 1974 floods). Despite little evidence of movement across the Bass Strait populations have established in Tasmania where they are now widespread in central farmland areas. However, aviary escapees are a likely contributing factor, being also implicated in establishing populations in Perth and Adelaide.

Little corellas form large communal roosts of thousands, but leave in small groups (1-20) during the dawn period to travel to feeding sites and return before sunset. During the middle of the day they normally loaf and shelter in tall trees, often beside water or feeding sites.

Foods and Feeding Behaviour

Grass seed comprises the majority of their diet with varying amounts of seed from other sources, as well as nuts, fruit, berries, buds, shoots, flowers, roots, corms and occasionally insect larvae. Hence most foraging occurs on or close to ground level. They become arboreal in some areas particularly in urban and horticultural regions where open pasture is limited and exotic or cultivated fruit or nut trees are plentiful. In native and other agricultural environments they prefer woodlands with established perennial grasses over shrublands or shrubby woodlands with sparse grass cover. Preference for seeding grasses, herbs, shrubs and trees varies considerably with season and location; oats, sorghum, wheat, acacia, *Eucalyptus camaldulensis*, spinifex (*Triodia*) and rice grass (*Xerochloa*) are commonly consumed when available. Particular weed species are also targeted especially double gee (*Emex australis*), tick weed (*Cleome viscosa*) and hogweed (*Boerhavia*). Wood boring insects of young eucalypts are also sought after, where individuals will split bark and crack limbs to retrieve the insects. Similar to other large parrots little corellas have a habit of chewing various objects, ranging from man-made structures and cables to roost trees. Although they will consume leaves, bark, buds and other vegetative matter, chewing behaviour is more likely a result of their innate curiosity, hence they often target novel items in their environment or for beak maintenance.

Little corellas regularly form large noisy flocks in the hundreds or thousands, especially whilst feeding and roosting. Flocks of up to 70 000 birds have been reported in the Kimberly, Western Australia. They also recurrently co-occur with other species such as long-billed and western corellas, galahs and sulphur-crested cockatoos. Single birds and small flocks, in particular, will join flocks of other species. In the breeding season (May- October) flocks tend to be smaller as pairs remain closer to their nest hollows. Peak feeding occurs in the early mornings and late afternoons, where they can spend a great deal of time digging for buried seeds and roots, including freshly sown seed.

Breeding

Most commonly breed in hollows in riverine eucalypts, but hollows of bottle-trees, mangroves, crevices in cliffs and termite mounds are used occasionally. Little corellas can usurp galahs from nests and have been known to raise their young. They usually re-nest in the

same hollows of the previous season, with several pairs often occupying hollows in the same tree. Breeding season (usually May-October) and clutch size varies with climatic conditions with multiple broods possible in good seasons and little or no breeding during drought. Two to three, occasionally four eggs (35 x 26 cm) are laid in unlined hollows, but often only one young is raised per nest due to eggs not hatching. Both sexes incubate eggs; males during the day and females at night.

Damage

Little corellas cause similar damage to Sulphur-crested cockatoos, although their more nomadic habits can result in larger numbers arriving unexpectedly. Fruit damage typically occurs as a result of birds seeking seeds rather than the fruits themselves. Citrus, apples and stone fruits are commonly damaged as a result. However young apples and pears and other pome fruits are also consumed directly. In some cases more fruit or nuts are knocked to the ground than actually eaten. They seldom eat grapes but are known to prune vine foliage, clip and pull out young vines and snip off entire bunches. Similar pruning, and foliage destruction, including ringbarking can cause significant economic losses to nut orchards including chestnuts, hazelnuts, pistachios and almonds. Vegetable crops and peanuts are often dug up or pulled out of the ground. A variety of commercial cereal crops, particularly oats, wheat, sorghum, rice, maize, canola, sunflower, safflower also suffer losses where little corellas target the grains, sever plants or seed heads and exhume freshly sown seed from the ground. When foraging in crops little corellas can hold seeds under their tongue for later de-husking and eating. Grain storage areas, silos, co-axial cables, and household wiring are also at risk.

Their chewing habits can result in considerable damage to existing native vegetation and habitat restoration projects. For example large roosting colonies along watercourses of the Flinders Ranges, often exceeding 10000 individuals are known to cause significant damage to many mature eucalypts, particularly river red gum (*E.camaldulensis*), but also native pine (*Callitris columellaris*), peppermint box (*E. odorata*), and long-leaved box (*E. goniocalyx*). Rows of planted native plants for revegetation projects appear more susceptible than naturally occurring plants of a similar age possibly as they represent something novel.

Protection Status Protected in NSW, Not protected in SA, Victoria and certain shires of WA where they are causing agricultural damage.

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2.3 Galah (*Elophus [Cacatua] roseicapilla*)

Other names: Rose, Rose-breasted, Willock Cockatoo

Field Identification

Easily recognised small (35-38 cm) pink and grey cockatoo. Erratic flight pattern. Noisy and conspicuous. Voice: loud high pitched 'chill chill' during flight; shrill screech in alarm and softer hum while roosting or feeding. Generic name derived from Greek, 'dawn' and crest' referring to the rose-pink crest like the rising dawn. Specific name from Latin '*roseus*' rose; '*capillus*' capped.

Habitat

Highly varied habitat requirements occurring throughout Australia in open savannahs, agricultural areas, open forests, woodlands, shrublands, mangroves, arid and semi arid regions, sand-plains and urban areas. They seldom occur in dense wet sclerophyll or rainforests and avoid extreme desert regions. Although in open country they prefer riverine or roadside habitat with remnant eucalypt or casuarina woodlands. They are common to farming districts and urban parks, gardens, and sporting fields. Their abundance and distribution has expanded dramatically and continues to expand due to clearing and thinning of dense forests, cereal cropping and improved access to water since European colonisation. In particular the availability of cereals from crops, storage facilities and stock feed has provided food during winter periods when it was naturally scarce. Galahs are now the most widely dispersed and probably the most abundant cockatoo in Australia. Highest densities occur in the Murray Darling river system of the south-east, and the wheat belt of the south-west.

Movements

Generally sedentary with nomadic tendencies in juvenile and non-breeding sub populations and in certain habitats. Sedentary birds will concentrate their movements around their nest sites and return to hollows to roost, travelling less than 10 km for food. Nomadic sub-populations may traverse larger areas (>1000km²) and will roost near food sources. Galahs rarely display large scale seasonal movements with the exception of some populations of the far north which are thought to move to the north coast in the dry season and away from it during the wet. Extreme climatic conditions and habitats with variable food and water availability can also result in large regional movements.

Foods and Feeding Behaviour

Seeds of grasses and herbs, especially cereal grains comprise about three-quarters of their diet throughout the year. The remainder includes small quantities of nuts, fruits, berries, shoots, buds, flowers, tubers and insects. Galahs are ground foragers who search by sight, rarely digging except when seeds or rhizomes are close to the surface. Cultivated seed crops, particularly wheat, oats and barley, provide a stable food source in many areas. Availability of grain is providing by germinating crops, stubble, spillages around storage areas or along roadsides, and as stock feed or in livestock dung.

Seeds of native and improved pastures such as *Erodium*, clover seed (*Trifolium*), *Danthonia*, western button grass (*Dactyloctenium radulans*), Flinders grass (*Iseilema membranaceum*) and Mitchell grass (*Astrebla lappacea*) are commonly consumed outside cropping areas and seasons. Winter and autumn crops such as sunflower and sorghum are also often exploited, in some cases offering year round access to commercial crops. Seed heads from introduced thistles; scotch (*Cirsium vulgare*), saffron (*Carthamus lanatus*), white stemless (*Onopordon acule*) and rhizomes of onion grass (*Romulea*) are also frequently eaten.

Feeding flocks of 500-1000 galahs is common in cropping areas and groups are larger when food sources are more concentrated. Largest flocks form during feeding rather than roosting or flying and whilst feeding on grain rather than in pasture or orchards. For nomadic groups flocks will roost within 2 km of feeding sites and visit them repeatedly while the food source remains. They will often forage with sulphur-crested cockatoos (*Cacatua galerita*), long-billed (*Cacatua tenuirostris*) and little (*Cacatua sanguinea*) corellas, Major Mitchell's cockatoos (*Cacatua leadbeaterii*), red-tailed black-cockatoos (*Calyptorhynchus banksii*) and mallee ringnecks (*Barnardius zonarius barnardi*) and respond to alarm calls, but flocks usually remain partially segregated. Feeding forays usually last between one to four hours and begin within an hour after dawn and within 5 hours of dusk. Shorter periods (<30mins) can occur during the day especially when temperatures are lower, food is scarce and whilst feeding young.

Breeding

Galahs can breed throughout the year and vary according to rainfall and food resources with peaks February to May and August to November. Pairs form permanent bonds and remain loyal to nest sites which they'll both visit throughout the year. Hollows in eucalypts near water are selected in preference to other sites, although they can nest in cliff crevices, logs and fence-posts. Unlike other cockatoos, galahs will line nests with eucalypt leaves. Two to six eggs (35 x 26 mm) are incubated by both sexes for around 23 days. Feeding the young is also shared equally. Fledging occurs at around 50 days and young remain partially dependent until 100 days. About 47% of eggs laid reach fledging and about 19% of fledged young died before independence. Adverse weather conditions, competition for other hole nesting species, and predators contribute to nesting failure.

Damage

Damage to germinating cereal crops by galahs is more severe than in other industries due to their dependence on seeds. Despite collecting excess grain from other sources, significant damage can still occur to commercial crops of wheat, sorghum, barley, oats, maize, sunflower, canola and safflower. Although they occasionally eat fruit, damage to orchards, vineyards and nut plantations is usually caused by pruning leaves, buds and flowers, clipping and pulling out young plants, stripping bark, and splitting fruit for seeds. Citrus, apples, stone fruits, wine grapes, walnuts, chestnuts, hazelnuts, pistachios, almonds, are susceptible to this type of damage. Young eucalypts, particularly in re-vegetation programs and other native plant species including saltbush (*Atriplex vesicaria*) and bluebush (*Maireana sedifolia*) can also suffer similar damage. Impacts in urban areas to timber trellising, rubber insulators, cables etc. also occur and are typical of large parrot species with a curious and intelligent nature. Temporary covers of grain storage and haystacks are often torn, exposing the contents

to weather and spoilage. Rhizomes, bulbs and clover seed often attract galahs to sports ovals, bowling greens and golf courses, where large groups can cultivate these areas.

Protection Status Protected. Locally unprotected in central and western divisions of NSW.
Unprotected in Victoria

Sources and Further Reading

Noske, S. (1980). Aspects of the behaviour and ecology of the White Cockatoo (*Cacatua galerita*) and Galah (*C.roseicapilla*) in croplands in north-east New South Wales. *Masters of Science Thesis, University of New England, Armidale.*,

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2.4 Crows and Ravens (*Family Corvidae*)

Other names: Corvo

Field Identification

Common large (48-54 cm) black birds. Native Australian crows and ravens are the only members of the *Corvus* genus with white eyes. Five native species are recognised, all with similar size and appearance and difficult to distinguish; Little Crow (*Corvus bennetti*); Torresian Crow (*C. orru*); Australian Raven (*C. coronoides*), Forest Raven (*C. tasmanicus*) and Little Raven (*C. mellori*). An introduced species the House or Columbo Crow (*C. splendens*) has also been observed in Fremantle, Western Australia and near the Melbourne Zoo in Victoria, but individuals have not established due to efforts to remove them. This species is smaller (42-44 cm), has brown eyes and grey-brown around the neck and breast. Native species can be separated by slight variations in plumage, habits and calls. The two crows have hidden white down at the base of their feathers, which is grey in the raven species'. Ravens also have more prominent throat hackles, which are especially long and pointed in the Australian raven. Other differences particularly calls, flight pattern and flock size can be used to distinguish species, consult field guides for further details.

Habitat

Occupy most types of habitat, particularly farmlands, dry open eucalypt woodlands and forests, open savannah, coastal and urban areas. Alpine areas and arid regions particular along watercourses are also frequented. The little crow (*C. bennetti*) is better adapted to drier habitats including mallee, mulga and spinifex. All species avoid dense closed forests, with the exception of the forest raven (*C. tasmanicus*). This species is the only corvid found in Tasmania and is uncommon on the mainland with only a few isolated populations residing on the north-east coast of New South Wales, coastal regions of southern Victoria and South Australia. Expanding agricultural development, particular stock grazing has facilitated increases in corvid distribution and abundance in many areas.

Movements

Sedentary. No regular large-scale movements are evident. However the little raven and little crow display more nomadic traits. These species often perform larger movements in response to water and food availability, and often become sedentary for only three months during breeding. For example in the Murray Darling region large numbers of little ravens travel south-east in summer to higher rainfall areas, returning in autumn. Individual movements are also greater for the little raven (up to 352km) and little crow (up to 691 km), in comparison to other species. Non-breeding birds travel further and comprise the main component of corvid populations. Breeding birds typically return to the same sites for breeding and establish territories, which vary in size considerably between species and habitats, from 0.4 to over 130 hectares.

Foods and Feeding Behaviour

Omnivorous scavengers and predators, corvids consume many types of insects, carrion and vegetable matter. Large insects usually comprise the majority of the diet, followed by carrion,

and plant material, such as fruit, vegetables, seeds and foliage. Availability and hence quantities of different foods vary between habitats and season. Nestlings, eggs, small lizards and birds are also frequent prey items. Food is usually first located by aerial searches after sunrise followed by long bouts of ground foraging. Will also occasionally consume fruit and beetles, bugs and flying insects from trees and shrubs. Feeding around carcasses is most common, and often includes caching surplus meat. These sites can be vigorously defended during food shortages and provide a range of insects including dung and carrion beetles. Spiders, grasshoppers, locusts, weevils, ants and caterpillar larvae are also common prey items. Peak feeding occurs during early morning and late afternoon, with flocks returning to roost in the middle of the day. Crows and ravens regularly visit watering sites throughout the day, more frequently in arid areas. Mixed feeding flocks often congregate around food sources where distributions overlap, in some cases all three raven species have been observed feeding at one site.

Breeding

Large bulky stick nests occasionally bound with mud and lined with grass, bark strips and wool. Usually constructed by both sexes in an upright fork of the uppermost canopy, but lower in arid areas. The little raven nests are typically much lower (<10m), occasionally even on the ground in cleared areas. A single brood of three to six are raised in a season (July-October). Eggs size varies between species, little crows laying noticeably smaller eggs (39 x 26 mm) than other species (44-45 x 30-41 mm). The little crow also has a more variable breeding season and clutch size, more likely to nest in response to rainfall. Females incubate for around 20 days, and both sexes feed young which fledge at about 40 days.

Damage

Known to consume various quantities of grapes, cherries, olives, plums, berries, pineapples, passionfruit, potatoes, almonds, peanuts and grains. Corvids directly consume fruit or foliage and sever seedlings. In vineyards crows and ravens remove fruit using their bills from trellis posts and have been observed pushing young vines to the ground to feed from them. They can also perch on and forage directly from foliage, evident also in grain crops. Commercial grains and storage areas are often susceptible. Oats, wheat, sorghum, maize and rice are commonly consumed, often as stock feed and during sowing, but also in stubble paddocks following harvest. Crows and ravens are also frequently implicated causing stock losses, and known to prey upon lambs and injure sheep. However, losses are rarely significant as injury is most prevalent to already sick, dying or mismothered lambs. Some studies suggest only the largest species (*C. coronoides* and *C. tasmanicus*) are capable of inflicting damage and unlike raptors these have difficulty penetrating mammal skin, hence why soft parts are targeted (mouth, eyes, anus, umbilicus).

Protection Status: Locally unprotected (check status in your region).

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2.5 Pied currawong (*Strepera graculina*)

Field Identification

Large (41-51 cm) mainly black bird with white patches on the wing, and base and tip of the tail. The wing patch is crescent-shaped and prominent during flight but also visible whilst perching. Their intense yellow eye is distinctive and can be used to distinguish from other large black and white birds. Similar species of the same genus; black currawong (*Strepera fuliginosa*) of Tasmania and the grey currawong (*Strepera fuliginosa*) of southern and western Australia are also known to damage horticultural crops. They occupy similar habitats and have comparable movement, feeding and breeding behaviour. However, several differences have been identified below. Voice: distinctive ringing; deep guttural 'currawong'.

Habitat

Occupy a wide range of habitats including open eucalypt woodland and forest, wet sclerophyll, rainforest, shrubland, coastal woodland, parks and gardens, orchards, vineyards, and agricultural areas with scattered eucalypts. Rare or absent from open savannahs, arid and semi-arid regions. Most abundant along coastal areas of New South Wales and Queensland.

Movements

Nomadic. No large-scale seasonal movements are evident but many populations travel to lower altitudes during winter. These relatively short movements (<80km) are also associated with populations moving to urban areas, particularly in the south-east. Increases in abundance in the Murray-Darling catchment indicate there are also many winter visitors to that region. Altitudinal movement as well as a small northward shift is apparent in south-east Queensland where large influxes occur to nearby low-lying areas during autumn and winter. Movements are confined during breeding (September to November) where pairs aggressively defend small territories. In Canberra and Sydney there are increasing numbers of pied currawongs which breed in urban areas, and remain there throughout the year. The black and grey currawongs are more sedentary throughout their range.

Foods and Feeding Behaviour

Omnivores, pied currawongs consume a variety of insects, small birds and reptiles, fruits and vegetable matter. Proportions vary with availability, habitat and season. Insects and small invertebrates comprise the major diet component during breeding. In some cases swarms of insects, particular stick insects cause large influxes to local areas. Fruit from orchards and vineyards are increasingly consumed in agricultural regions during summer and autumn. While populations in urban areas during this period and also in winter often scavenge a variety of foods, including vegetable scraps, pet food and garden fruit. Predation on nestlings, eggs, adult birds and lizards is also common. Feeding flocks are conspicuous and range in size from solitary birds to large flocks. Large congregations are typical around food sources and during roosting. Up to 200 have been observed foraging on a single vineyard and in suburban gardens. Grey currawongs (*Strepera fuliginosa*) are more elusive and occur only in small flocks on the mainland, usually solitary or pairs and rarely in groups greater than five.

Although the Tasmanian subspecies (*Strepera fuliginosa arguta*) forms larger flocks (up to 40).

Breeding

A large, but often shallow bowl of sticks lined with grass, bark and rootlets is assembled in an upright fork of the upper-most canopy. Tallest trees, often eucalypts are selected in preference if they occur within small clumps. Isolated trees are rarely used. Permanent pairs return to nests of the previous season, establish territories and commence nest building, usually in August. Populations in northern Queensland often breed earlier than southern populations, but most breeding occurs between September and November. Two to four light brown eggs (41 x 30 mm) with darker spots are laid and incubated for 21 days. One brood is raised per year. Males assist by feeding females during nesting, then both sexes feed young for around 9 weeks after fledging. Breeding occurs throughout their distribution more often in forested habitats, but increasingly in urban areas (see Movements).

Damage

Large flocks of pied currawongs frequently raid vineyards, orchards and market gardens for fruit, nuts and vegetables. Significant losses can occur to grapes, cherries, persimmons, olives, and nuts as well as other crops. Small plantations near favoured roosting habitat are particularly susceptible, in some cases resulting in total losses. Persistent and intelligent feeders, they have been observed consuming fruit through nets by landing and swinging on them. The majority of smaller fruits are removed completely and swallowed whole. They are also responsible for carrying the seeds of weed species such as camphor laurel, cotoneaster and privet, and have a potential role in their dispersal. Pied currawongs are known to prey on large numbers of native birds including fairy-wrens, thornbills and honeyeaters. However, the decline of native birds is linked to many other factors, and introduced species, starlings and sparrows are also common prey. Hence the implications of predation for native species may need further investigation.

Protection Status Protected

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2.6 Red Wattlebird (*Anthochaera carunculata*)

Other names: Wattled honeyeater, Barkingbird, Gillbird, What's o'clock, Chock

Field Identification

Large (32-36 cm) honeyeater with grey-brown plumage which is streaked white. Wing primaries and tail feathers have white edges, obvious in flight. Silver-white cheek patch, red wattle and eye, and yellow underbelly. Juveniles are similar but without wattle or yellow belly and have a red-brown iris. Separate races in south-east (*carunculata*) and western (*woodwardi*) Australia; and an isolated population on Kangaroo Island (*clelandi*). Voice: Noisy harsh calls, 'tobacco box' or 'what's o'clock', grating 'chock'.

Habitat

Occupy a range of habitats, including open sclerophyll woodlands, mallee, coastal heath and shrublands. Common also in farmlands, parks, gardens, vineyards and orchards particularly with stands of remnant woodland or native regrowth. Occasionally inhabit the edges of denser forests, including rainforest. Widespread and prominent in lowland open eucalypt woodland in the temperature zone, especially those with diverse shrubby understorey consisting of banksias, callistemons, and acacia.

Movements

Movements have not been well studied but most populations are probably sedentary. Nomadic movements also occur, often as a result of prolific flowering shrubs and trees. Visiting migrants can also increase resident populations in various seasons. Regular altitudinal and latitudinal movements have been recorded in some areas, particularly southern NSW and the ACT where some flocks are believed to migrate up the coast for winter with large numbers of yellow-faced (*Lichenostomus chrysops*) and white-naped (*Melithreptus lunatus*) honeyeaters. Small east-west migrations also occur in Western Australia during some seasons.

Foods and Feeding Behaviour

Mainly nectivorous prefer eucalypts, banksias, angophoras, eromophila, xanthorrhoea mistletoe, grevilleas, hakeas and other native flowering plants with high nectar loads. Exotic trees and shrubs are also a common source of nectar, particularly in urban areas. A variety of insects are consumed regularly, quantities varying according to the availability of nectar and other food sources. In some cases insects comprise the majority of their diet. Sugary shelters and excretions of psyllids and coccids such as lerps, manna or honeydew are also frequently gleaned from plants, particularly eucalypts. Fruit comprises a small proportion of their diet, increasingly during shortages of other food types.

Usually solitary or in small groups when feeding, although sometimes large flocks (>100) will concentrate around favoured food sources. Their long brush tipped tongues and bills are well suited for probing tubular flowers, although inflorescences from other species are often selected in preference. Arboreal and active feeders, they are most commonly observed

accessing blossoms in the outer canopy, but also forage among foliage, bark and occasionally on the ground. They habitually establish feeding territories of up to 100m, which they aggressively defend from many insectivorous and nectar-feeding species including other wattlebirds. Peak feeding occurs in early mornings and late afternoons, with less time spent foraging during periods of abundant nectar.

Breeding

Considerable effort is given to building nests which can take several weeks. A small cup of fine grass, bark and twigs, lined with fur, hair or wool is shaped within a larger nest of carefully intertwined long thin sticks and grass. Nests are usually well concealed within foliage of a tall shrub or tree, often eucalypts, mistletoe or acacia. Two or three oval speckled pink eggs are laid 2-5 days after completing the nest. Two, but occasionally three broods are raised in a season (July-February). Females, with occasional assistance by males, will incubate for 17 days, after which both sexes feed the young which continues until 2-3 weeks after fledging. In recorded studies, as few as 26% of young reach fledging resulting in an average of 0.51 per nest. Mortality mainly due to adverse weather conditions and predation by goshawks, currawongs, butcherbirds, ravens, possums, cats and snakes. Oldest recorded from banding records 12 years 11 months.

Damage

Often observed in vineyards and orchards and known to cause damage to grapes, peaches, plums, figs, cherries, olives, loquat, apples, apricots, pears, and berries. Their sharp bills cause large angular punctures from which juice and flesh exuded. Occasionally smaller fruits (<10mm x 10mm) are swallowed whole. Damage is more significant during shortages of nectar or insects. In some cases fruit consumption is only evident on overripe fruit left on trees (Araluen NSW).

Protection Status Protected

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2.7 Noisy Miner (*Manorina melanophrys*)

Other names: Micky miner; Southern black-backed miner; Cherry eater; Snakebird; Squeaker, Solider bird.

Field Identification

Pale grey medium sized (24-28cm) honeyeater with a black crown, face and ear, bare yellow patch behind eye and yellow bill. Darker grey wing with an olive to yellow streak.

Distinguish from yellow-throated and black-eared miners by head plumage. Voice: distinctive, high-pitched and noisy 'tee, tee, tee, tee' in alarm, variety of other calls.

Habitat

Prefers open woodlands and forests, particularly edges and isolated patches without a distinct shrub layer, including dry eucalypt woodlands, grassy forests, mixed dry sclerophyll with *Callitris*, and lightly timbered farmlands, parklands, gardens and pasture, orchards, vineyards and road reserves. Densities are known to increase with decreasing area of woodland, hence are generally absent from large forest remnants (>500 hectares) but are most abundant in small fragments (1-2 hectares). Also occasionally found in remnant or planted fragments of wet sclerophyll, coastal heath, melaleuca, acacia, brigalow and mulga. Avoids dense forests and woodlands. Hence this species has benefited from grazing, clearing and fragmentation of native vegetation.

Movements

Sedentary throughout range. Most individuals remain within small well defined territories, with home ranges of less than 200m in diameter. Female home ranges are even smaller commonly less than 100m. Occasionally larger movements of up to 18km have been recorded, perhaps a result juvenile dispersals or in some cases translocated birds returning to their previous territories. Very sociable and seldom observed singly or in pairs. Small groups of 6 to 30 birds aggressively defend core areas within a larger home range. Communal roosts are often at new sites each evening, usually in outer branches of feeding trees and shrubs.

Foods and Feeding Behaviour

Omnivorous feeders they consume a variety of insects, nectar, fruit, seeds, vegetables and occasionally frogs and reptiles. Commonly forage in and defend high nectar bearing trees and shrubs including eucalypts, banksia, grevillea, and camellias. Arthropods are regularly consumed especially spiders, beetles, weevils, bark beetles, bugs, and wasps. Psyllids, lerps and manna are also occasionally gleaned from leaves and bark, although noisy miners exclude many other bird species which are thought to maintain these at lower levels. Fruits from trees and shrubs such as native tamarind (*Diploglottis australis*), Moreton Bay Figs (*Ficus macrophylla*), saltbush (*Rhagodia*), orchards; and seeds of *Poaceae*, goosefoot (*Chenopodium*) and peppercorn (*Schinus areira*) are also consumed opportunistically.

Active, aggressive and gregarious, they forage within colonies in sub-flocks (or coterries) of 6-30 but hundreds can congregate in clumps of flowering plants. Feed in tree canopy, along branches, trunks, and on the ground, but mainly in foliage. Mixed feeding groups rarely occur

due to their defensive behaviour, but may feed alongside other species in more structured vegetation.

Breeding

Two to six eggs (mean 2.9) are laid in a fragile bowl of sticks, bark and leaves lined with softer material such as hair or fur, held in a tree or shrub fork. Breed communally with up to 22 males and one female attending a single nest during a season; and year round, but most commonly between June and September. Twice as many nests have been observed during these months, than warmer months of October to January, despite fewer insects, possibly a strategy for limiting predation. Four broods can be raised in a year with building of a new nest commencing directly after young are independent, ~16 days after fledging. About 34% of eggs reach fledging, an average of 0.89 fledged young per nest. Mortality mainly due to starvation, abandonment, failure to hatch, predators and adverse weather conditions.

Damage

Noisy Miners are known to damage horticultural crops, particularly soft fruit such as grapes, plums, apricots, cherries, peaches, nectarines, pears, apples and berries. They collect flesh and juice from sharp angular punctures in fruit using their brush tipped tongues. Smaller fruit such as berries and grapes are often swallowed whole. They are known to swallow the seeds of weed species such as peppercorn (*Schinus areira*) and blackberry (*Rubus fruticosus*), but their potential to spread environmental weeds is probably limited by their sedentary habits.

Although noisy miners occasionally remove insect pests they are also associated with increased eucalypt dieback which has been attributed to aggressively excluding insectivorous birds. Removal of noisy miners in one area caused a significant increase in the abundance and diversity of other insectivorous birds, and hence potentially decreasing the impacts of defoliating insects. Most bird species entering territories of noisy miners are mobbed and chased, and in some cases killed.

Protection Status Protected

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2.8 Noisy Friarbird (*Philemon argenticeps*)

Other names: Leatherhead; Knobnose; Four-o'clock; Monk

Field Identification

A large(30-35cm) brown-grey honeyeater with an obvious bald black head. Distinctive knob on bill, smaller on immatures and absent from juveniles. Silver-grey crown, nape and throat and white underbelly and tail tip. Voice: conspicuous raucous 'four o'clock'.

Habitat

Inhabit open dry sclerophyll forests and woodlands, swampy woodland and heath including coast heath; mallee, brigalow, gidgee, parks and gardens. Riverine habitats with river red gum (*E. camaldulensis*) and black box or coolibah (*E. microtheca*) associations are also commonly occupied, included those which extend into arid areas. Avoid rainforest, dense wet sclerophyll, sedgeland, open savannah, and pure stands of *Callitris* or introduced pine (*Pinus*).

Movements

Migratory. Most populations also display nomadic movements following good quality nectar flows of flowering trees and shrubs. Southern populations have more pronounced migratory habits and large numbers regularly move to lower altitudes and north during winter, returning for spring and summer. The longest recorded movement was a bird which moved from Mudgee south to Mitta Mitta in north east Victoria, a distance of 510 km. In comparison fewer movements are apparent in the north extremities of their range where many individuals are sedentary.

Foods and Feeding Behaviour

Mainly nectar but also fruits, flowers, pollen, seeds, insects, lerps, manna, honeydew and occasionally bird eggs and nestlings. Flowering trees and shrubs with abundant nectar are sought after and aggressively defended. Preferences for plant species fluctuates with flowering seasons, favoured species include, swamp mahogany, red ironbark, yellow gum (*E. leucoxydon*), white box (*E. albens*), Blakely's red gum (*E. blakelyi*), red bloodwood (*Corymbia gummifera*), *Angophora*, paperbarks (*Melaleuca*), banksias and grevilleas. They are mainly arboreal, foraging in the high canopy on flowers and foliage, though also forage in the shrub layer and occasionally on the ground. Often hawk insects and during spring and summer can consume large quantities. Cicadas are a preferred food source when available and are thought to influence breeding success in some areas. Feed in mixed flocks with lorikeets, red wattlebirds and other honeyeaters, until competition intensifies due to food shortages. Usually feed in noisy small flocks of less than 20 but larger congregations can occur around food sources.

Breeding

Noisy Friarbirds build basket-shaped nests from strips of bark, dry grass and long thin twigs carefully interwoven and bound together by spider webs. The nest cup has softer material

including soft bark fibres, leaves, hair and wool. Nests are suspended by the rim amongst leafy branches of eucalypts, kurrajongs or other species, usually well concealed but more conspicuous than red wattlebird nests. Breeding adults will often return to the same nesting sites in consecutive seasons despite migratory habits. However young are eventually forced from their natal areas if they don't disperse and seldom return. Two to 4 blotched pale pink to pink-brown eggs are laid up to 4 times a year, but more commonly 3. Females incubate for around 16 days but both feed the young and defend the nest. Young continue to be fed by both sexes until 2-3 weeks after fledging. Predators, abandonment during dry seasons, and parasitism by the common koel and other cuckoos are the main causes of nesting failure. When successful, nests produce an average of around 2.3 fledglings. Adults are known to live over 9 years.

Damage

Often a pest of orchards and vineyards, especially during nectar shortages in Autumn. Significant losses can occur to grapes, cherries, stone fruit, plums, pears, tropical fruit, blueberries, mulberries, bilberries, blackberries and figs. In some situations overripe or damaged fruit is targeted in preference to viable fruit. For example a greater number of birds have been recorded in freshly machine harvested wine grapes than adjacent unharvested blocks. The nature of the damage is similar to red wattlebirds, with large pecks and hollowed out flesh.

Protection Status Protected

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2.9 Common Blackbird (*Turdus merula*)

Other names: Eurasian, European, Fennoscandian blackbird; Ousel.

Field Identification

Uniformly black medium sized (25cm) bird with a yellow-orange bill and eye-ring. Bill becomes almost red-orange in forested habitats. Long rounded tail, obvious in flight. Females are dark brown with faint streaks on the chest, also have a duller yellow-brown bill. Juveniles are similar to females but have a tinge of rufous on the chest plumage. Native of Europe, North Africa and southern Asia the common blackbird is a member of the Muscicapidae family (True Thrushes) and shares a genus with the song thrush (*Turdus philomelos*) also introduced to Australia in the late 1850s. Voice: musical fluting song; a high, harsh 'tsee tsee' in alarm.

Habitat

Common in most habitats of south-eastern Australia, displaying a preference for urban bushland, parks, gardens and horticultural areas.. Unlike the song thrush which is restricted to the urban areas of Melbourne the common blackbird has colonised many types of natural habitat including riverine vegetation, rainforest, wet sclerophyll, dry eucalypt woodlands, coastal heath and even mallee. Their distribution continues to expand particularly along the Murray-Darling river systems to the north. Vegetated river systems in other areas are also thought to aid dispersal. Local densities are generally stable although slight decreases are evident in suburban Canberra. Often prefer areas with a combination of open or cleared pasture and a dense shrub layer.

Movements

Sedentary in Australia, with few movements recorded over 10 kilometres. They are known to be partial migrants in Europe particularly in the northern extremes of their range. In Australia large movements of up to 500 kilometres can occur but are likely juveniles dispersing after the breeding season. Solitary or in pairs, small territories are defended year round, but particularly during the breeding season. They roost in the thick foliage of shrubs and trees, forage in open areas, shrubs and leaf litter during the day and return to roost in the late afternoon.

Foods and Feeding Behaviour

Predominantly rely on arthropods including ground invertebrates, flying insects, earthworms, snails and spiders, but also consume variable amounts of fruit, small reptiles and vegetable matter. Mainly forage on the ground, raking at leaf litter and probing open pasture and lawns in urban areas. Occasionally arboreal and consume native (e.g. *Pittosporum undulatum*, *Exocarpus cupressiformis*) and cultivated (e.g. olives, blackberry, grapes, figs) fruits. Some of which they are implicated spreading into new areas. Vigorously defend territories and are aggressive towards other bird species.

Breeding

Three to five pale blue-green eggs with reddish brown spots (34mm x 23mm) are laid in a large deep bowl of dry grass, bark strips and leaves bound by mud. Nests are usually well concealed and suspended from <1m to 12 metres in the top of a stump, log or in an upright fork amongst bracken fern or other dense tree or shrub foliage. Eggs are incubated by the female for 12-14 days. They will continue raise broods in ideal conditions, mostly from August to February. Nesting failure is often caused by predators, particularly the pied currawong. Replacement clutches are usually laid, in one case 5 unsuccessful attempts were recorded during a season.

Damage

If available will consume fruit throughout the year. Grapes, cherries, peaches, nectarines, figs, olives, berries are particularly susceptible. Damage to vineyards and orchards is often associated with adjacent shrubs and dense garden plants, hence damage is concentrated around these features. Small fruit, including grapes, cherries, olives and figs are usually taken whole and consumed in nearby vegetation. Although sedentary have been implicated in the spread of weed species including blackberries (*Rubus* spp) and olives. Also have potential to compete with native species including closely related Whites Thrush (*Zoothera lunulata*).

Protection Status Unprotected, Introduced

Sources and Further Reading

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2.10 Black-faced Cuckoo-shrike (*Coracina novaehollandiae*)

Other names: Blue jay; Messenger bird; Shufflewing

Field Identification

Soft grey medium-sized (33cm) bird with white belly, tail tip and black face extending behind eye and to the breast. Black breast and cheek absent on immatures. Distinctive undulating flight pattern, and wing shuffle on landing. Unrelated to cuckoos or shrikes but have comparable plumage to cuckoos and a similar bill shape to shrikes. Surprisingly linked as close relatives to corvids using DNA despite morphological and behavioural differences. Voice: 'plee-urk' and a descending gentle 'quarieer quarieer quarieer'

Habitat

One of Australia's commonest birds, distributed throughout the country in most habitats. Particularly abundant in open sclerophyll woodland and forest, farmlands, roadside vegetation and tree-lined watercourses. Common also in suburban areas, parks and gardens and extend to arid regions along watercourses. Also occur in rainforests and tall wet sclerophyll forest but at lower densities and often for only short periods during migration.

Movements

Migratory. Large scale movements regularly occur with seasons. Northward movements commence mid Autumn and include many individuals who travel to New Guinea for winter. A number of individuals remain throughout the year in most populations, hence were often considered sedentary. However complete departures occur in some areas particularly southern high altitude ranges including sections of Wollombi, Canberra and Jamieson. Altitudinal movements are evident in these areas where populations take advantage of the milder climate and greater food availability of lowland areas during winter. Occasional nomadic movements outside seasons are also thought to occur in response to available food. Seasonal movements create regular increases in density in the north during winter and corresponding decreases in the south and the opposite trend during summer. In the eastern states, migratory movements have recently been identified as predominantly north-west rather than directly northward. Hence populations from the south-east regions travel in a direction perpendicular to the coast of New South Wales. Migration patterns are less obvious in the west.

Foods and Feeding Behaviour

Predominantly insect diet supplemented with seeds, fruit and vegetable matter. Caterpillars, beetles, grasshoppers and many flying insects are commonly consumed. Individuals, pairs or small groups often perch on exposed branches in the upper canopy, or forage amongst the outer foliage for a variety of insects. Rarely feed continuously on the ground but will dive from perches, often landing, to take insects and other food. Large flocks can occur especially during migration in Spring and Autumn. For example flocks of up to 45 have been observed in vineyards of central New South Wales during April, assumed to be migrating north for the winter.

Breeding

A small flat nest is carefully shaped from fine dry grass, twigs and bark, bound with spider webs and positioned in a horizontal fork of a tall tree often *Casuarina*. Habitually build nests 10 to 20 metres up in the canopy, although sometimes lower, and well concealed. Occasionally utilise disused nests of other species, including mud nests of the magpie lark. The unusually flat nest often results in eggs or chicks falling out, for example during high winds. Three or sometimes two green eggs with brownish blotches (34 x 24 mm) are laid once a year typically between August and January. They will breed throughout their distribution, often following rain in arid areas.

Damage

Black-faced cuckoo shrikes are known to consume large quantities of orchard and vineyard fruit, including such as grapes, stone fruits, berries, pears and other soft fruits. Damage is perhaps more severe by migrating flocks which occur in larger groups and take advantage of easily accessible energy sources. Damage to fruit usually occurs by squashing and tearing fruit, and swallowing pip, seeds and skin. However, they have a clear preference for insects and are likely to be beneficial in orchards and vineyards in many situations and during most of the year. For example, potentially detrimental insect pests such as vine moth caterpillars (e.g. *Hippotion celerio*) are known prey items.

Protection Status Protected

Sources and Further Reading

2.11 House Sparrow (*Passer domesticus*)

Other names: English, Eurasian Sparrow.

Field Identification

Sexually dimorphic. Males have a grey crown, chestnut back, neck and wings with black tips, white cheeks, and a grey rump and tail. Their black bib is increasing prominent with status, particularly during breeding, dominant males displaying the largest bibs. Females are a uniform pale grey with dark streaks on the wings. Voice: continual jangly 'cheerup' and chirps when feeding or perching; a high pitched 'treeee' in alarm.

Habitat

Commensal with humans and inhabit most continents throughout the world. Introduced to Australia in the 1860s by acclimatisation societies are now abundant in cities, towns, rural areas, around farm buildings, particularly in the south-east. Are closely associated with humans and populations are known to decline in towns which have been deserted. They avoid unsettled areas and forested habitats. Their failure to colonise western states may be due to the barrier of the desert and lack of continuous human habitation. In rural areas, densities are greatest when properties are small and hence human activity more concentrated. House sparrows roost in trees with dense foliage often of introduced species including palm trees, reed beds, roof spaces, or ivy which surrounds buildings or trees. In urban areas are more common in the centres of towns and cities rather than the suburban garden areas.

Movements

Sedentary. No seasonal movement patterns are evident throughout their range. However, they can disperse rapidly, initially colonising parts of Australia at a rate of over 100 km per year. Conversely, dispersal is limited and gradual in unsettled areas particularly drier regions where colonisation can occur at a rate of less than 7 km/year. Highly sociable and gregarious they usually form small colonies but can also congregate in large flocks of several thousand, particularly following the breeding season.

Foods and Feeding Behaviour

Predominately feed on seeds and scavenge food wastes but will also consume flowers, buds, fruits and insects. Vegetable matter, bread, grain, grass seed including weed species are regularly consumed. Small groups, usually less than 20 forage on the ground along walkways, near rubbish sites and open areas. Often aggressively defend feeding locations from smaller species, but can co-occur with starlings and blackbirds. Occasionally forage in the tree foliage where they catch flying insects and remove and peck fruit.

Breeding

House sparrows build untidy grass and stick dome nests lined with feathers, mainly in gaps of buildings, often under eaves, and between and beneath roofing material. Occasionally nest also in tree hollows including eucalypts. Two to six white to pale grey eggs, with dark grey and dark brown spots are incubated for 10-14 days. Young fledge after 14-17 days. Have a

long breeding season which can extend from July to April, with peak breeding between September and February. Two to three broods are commonly raised during this season. Males often switch partners between broods but remain loyal to nest sites, which are aggressively defended from other males and smaller native species.

Damage

House sparrows are considered the most significant pest of crops in New Zealand and commonly cause damage to fruit, vegetable, grain and oilseed crops in Australia. Significant losses have been recorded to pear, apple, berry, cherry, grape, nectarine, apricot, plum peach and loquat orchards. Vegetables and cereals such as tomatoes, lettuce, lucerne, peas, wheat, maize, corn, sunflower, soya bean, and rice are often damaged, including the removal of germinating shoots and seedlings. Pecked damage to fruit often also results in secondary losses such as insects and fungal diseases. Considerable amounts of grain can also be lost to feedlots, piggeries and poultry farms. Aesthetic problems arise as a result of faeces from roosting and nesting areas and blocking drains and gutters with nesting material. They are also susceptible to range of potential diseases, including salmonella, tuberculosis, Giardia, and cryptosporidium although prevalence and their importance as vector for transmission is largely unknown. They are known to usurp native species from nest hollows, although normally will prefer to nest in buildings.

Protection Status Introduced, unprotected

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2.12 Australian Ringneck (*Barnardius zonarius*)

Other names: Port Lincoln ringneck, Twenty- eight parrot

Field Identification

Small to medium sized (28-44 cm) parrot with mostly green plumage and a prominent yellow 'ringneck' half-collar. Hence the specific name is derived from the Latin *zona*, girdle or belt. The four distinguished races differ in appearance, vocalisations and distribution '**Port Lincoln**' (*Barnardius zonarius zonarius*), '**Twenty-eight**' (*Barnardius zonarius semitorquatus*), '**Mallee Ringneck**' (*Barnardius zonarius barnardi*), and the '**Cloncurry Ringneck**' (*Barnardius zonarius macgillivrayi*). The green headed races (Mallee and Cloncurry Ringnecks) are rarely implicated in damage to agriculture hence this section focuses on the dark hooded races. The 'Port Lincoln' and 'Twenty-eight' parrots both have black heads, dark blue cheeks, and blue leading edges to otherwise green wings. The 'Twenty-eight' race has a unique red frontal band above the beak and the 'Port Lincoln' a yellow belly and flank.

Voice: repeated melodious whistling as a contact call or a trisyllable 'twent-ti-eight' for the 'Twenty eight' race and a series of clamorous calls when alarmed, usually in flight.

Habitat

Although races of Australian ringnecks occur in a diverse array of vegetation communities, their habitat requirements are generally similar. They prefer open woodlands, shrublands and grasslands and often reside in remnant vegetation along watercourses, particularly in arid areas. The Port Lincoln is a very successful race, the commonest parrot in Western Australia's wheat belt, it utilises all types of timbered habitats and occurs in abundance in any arid areas with river red gum. There are few stands of mallee in eastern Australia without populations of Mallee ringneck although some populations are thought to have contracted as a result of clearing and settlement. Similarly populations of Cloncurry ringnecks appear to have retreated to remnants following expansion of farmlands. In contrast the dark-hooded races are increasingly observed in orchards, croplands, gardens and towns and cities including Perth. The twenty eight occurs in denser vegetation of the south west including tall stands of jarrah, karri, marri and wandoo, and is displaced by the Port Lincoln race where this vegetation has been cleared. Habitat clearing is highlighted as a major factor resulting in increasing range and abundance of the Port Lincoln race.

Movements

A mainly sedentary species. However, population influxes are known to take place in wetter areas during drought and regular movements occur in arid areas in response to rainfall. Hence ringnecks are often more nomadic in drier areas, irregularly visiting desert regions. They frequently occur in mixed flocks with other species such as crimson, western and pale headed rosellas, red-capped and red-rumped parrots and blue bonnets, particularly at water or feeding sites. They leave the roost at sunrise, perch in trees during the heat of the day and return to roost before sunset. In drier areas are observed at watering points before feeding and roosting, although this is uncommon in the wetter areas of the south-west.

Foods and Feeding Behaviour

Ringnecks prefer feeding on seeds of grasses, herbs and low shrubs, but often consume bulbs, corms of onion grass, berries, flowers, beetles, lerp, insect galls and larvae, and cereal from crops, spills or storage areas. Some populations are more arboreal regularly feeding in the outer branches of orchards and eucalypts during flowering and fruiting seasons. The fruits of eucalypts, Angophora, mistletoe (e.g. *Amyema quandang*) and cultivated crops are often consumed when available. They will also chew tree and shrub foliage for food and beak maintenance, including Xanthorrhoea and a range of eucalypt species. In suitable trees they will consume sap, which often has a similar sugar content to nectar, by stripping bark and scraping the exposed cambium and phloem with their beaks. Unlike red-capped parrots and other species which split fruit for their seeds, ringnecks usually avoid unripe fruits. Hence this species tends to cause greater damage to orchards closer to picking. When feeding in orchards birds enter soon after first light, reach peak numbers after an hour and disperse within 3 hours of sunrise. Undisturbed birds will often remain in orchards or nearby roosting habitat throughout the day, feeding occasionally. Feeding frequency is higher again before sunset. Certain populations are quite timid when appropriate refuge habitat is absent, characteristic of the green headed races. Pairs or small groups of up to 12 are usually observed feeding but much larger groups occur at water sources and favoured feeding sites. They often feed in association with other parrot species.

Breeding

Females prepare hollows of tree branches, trunks or logs, often showing preference for eucalypts within dense copses. In the drier parts of their range they retreat to remnant eucalypts along watercourses to breed, particularly river red gum. The breeding season varies noticeably between races, distribution and with rainfall in more arid regions, but generally occurs between September and December or March and May. The same hollows are often occupied in consecutive years. Ringnecks reach sexual maturity at 2 years and lay four to six (average 4.6) white eggs directly on the wood inside hollows or in a small bed of bark shavings, grass or leaves. Incubating females are fed by the male who remain close to the nest. Eggs hatch after ~20 days when hatchlings are fed by both parents. During suitable conditions broods have high fledging success (>65%), however the number of nests and the brood size declines dramatically during drought. Nesting success is also influenced by starlings, goannas, honeybees and occasionally galahs.

Damage

The majority of damage by ringnecks in horticulture is attributed to the Port Lincoln and to a lesser extent the Twenty-eight parrot. The other races are generally declining in range and abundance and rarely occur in large enough populations to cause economic impact. These blue-headed races however, can cause significant damage to apples, pears, plums, peach, nectarines, cherries, grapes, blueberries, blackberries, citrus, olives, almonds, vegetables and cultivated flowers. Preference towards red-skinned apple varieties and pears, plums and nectarines is evident in some regions. Fruit damage occurs when ringnecks tear chunks of fruit and remove and discard the skin, but they will also consume fallen fruit. Secondary losses also occur with fungal and other infections as well as ensuing damage by Western rosellas, which more often consume fruit already attacked by ringnecks or red-capped parrots. Ringnecks are also known to damage cereal crops, garden plants and forestry plantations.

Damage to plantations of York gum (*Eucalyptus loxophleba*), Tasmanian blue gum (*E. globulus*), and wandoo (*E. wandoo*) is common, where damage to trunks, foliage and young shoots can cause deformities. Greatest economic damage occurs when trees are young and the base sawlog is vulnerable. Young plants in revegetation programs and native plants and shrubs such as Xanthorrhoea or farm trees are also at risk. Damage is particularly severe during seasons of poor eucalypt flowering.

Protection Status Protected

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2.13 Musk Lorikeet (*Glossopsitta concinna*)

Other names: Red-eared lorikeet, Red-crowned lorikeet, Green keet, Green leek,

Field Identification

A green lorikeet with bright red cheeks and forehead. Blue to turquoise crown, olive/ brown on lower back of the neck and yellow patches on the side of the breast. Bill is black with a red-orange tip. Large flocks are often seen racing through the high canopy or among dense foliage in the tops of eucalypt trees hence are often confused with purple-crowned or little lorikeets especially as they frequently occur together. However, size can be used to distinguish species as Musk lorikeets are noticeably larger (22cm vs 16cm) than the other two species. Females are similar but usually duller and slightly smaller. Voice: a shrill metallic screech during flight, varied but continual noisy chattering while feeding.

Habitat

Musk lorikeets prefer sclerophyll woodlands, dry open forests, tall mallee shrubland, and open parks and gardens with scattered eucalypts. They are also common in semi-cleared agricultural areas including orchards where remnant riparian or roadside woodland persists. They usually avoid wet sclerophyll woodlands and rainforest. Their preferences for particular vegetation types vary with flowering seasons but some regional patterns have emerged. White box (*E. albens*) and Red Ironbark (*E. sideroxylon*) communities are frequented to the north and west of the great dividing range; Red Bloodwood (*E. gummifera*) in East Gippsland, Victoria; River Red gum (*E. camldulensis*) near Melbourne; but avoidance of Brown Stringybark (*E. baxteri*) in surrounding areas of Adelaide. Other vegetation types are occasionally utilised in good flowering seasons such as *Angophora*, coastal woodlands and open heathlands.

They avoid logged forests and gradual declines in abundance have been attributed to clearing eucalypts for agriculture. However, planting native trees in suburbia or increased eucalypt plantations in rural areas have increased local populations in some areas.

Movements

Classic nomadic species whose movements are closely associated with flowering eucalypts. Their erratic movements are likely to be a result of variable nectar availability, although movements can be more predictable than many other lorikeets. They are common in sclerophyll forest of south-eastern Australia, particularly Victoria but increasingly rare in Queensland. Tasmania also has considerable populations which commonly move large distances but exhibit little movement to the mainland. A small feral population has also established in Perth. Suburban populations are thought to have altered their movement behaviour due to an ongoing supply of flowering and plants, hence have become more sedentary. Influxes to suburban areas have also been attributed to surrounding bushfires or adverse weather conditions including drought.

Foods and Feeding Behaviour

Unlike other parrots, lorikeets have no ventriculus to store grit and grind and digest food, but instead use a brush tipped tongue for collecting nectar. Musk lorikeets are strongly arboreal

and favour nectar from flowering plants, particularly eucalypts. Certain native plant species are preferred including river red gum (*E. camuldulensis*), swamp mahogany (*E. robusta*), red ironbark (*E. sideroxylon*), *Angophora*, *Callistemon* (bottlebrush), *Banksia*, *Grevillea* and *Melaleuca* (paperbark). Plantations of sugar gum (*E. cladocalyx*) and South Australian blue gum (*E. leucoxylon*) are also regularly visited for nectar. Pollen, fruit, flower buds, seeds and insects are consumed as supplements in various quantities, including the fruits of a variety of cultivated crops.

A very gregarious species, they can form flocks of several hundred at feeding sites. Feeding activity is often chaotic and noisy, with birds excitedly flying backward and forwards among foliage. Peak feeding time occurs in early mornings but continuous feeding throughout the day is not uncommon. They will also frequently feed in association with other lorikeets (rainbow, scaly breasted, little and purple crowned) and swift parrots. Pairs will often remain together within flocks during feeding and roosting. Roosting sites occur in tall trees away from feeding areas.

Breeding

Musk lorikeets build basic nests in eucalypt cavities, often with very small entrances (4cm diameter) which parents push their way into. Two white rounded eggs (25mm x 20mm) are laid on a small amount of chewed wood inside the cavity. The female incubates, but both sexes roost inside hollow and then assist in feeding and raising young. They have a 24 day incubation period, fledge at ~60 days and reach maturity at 13-14 months, but often don't breed until they are 2 years old. Breeding usually occurs between September and November but is thought to be dependent on flowering.

Damage

Musk lorikeets will invade orchards and vineyards for ripening apples, pears, Nashi fruit, cherries, loquat, apricots, plums, peaches, nectarines, vegetables, and wine and table grapes. Damage is particularly prevalent in South Australia and Victoria, and perhaps more severe in stone fruits than other horticultural industries. Due to their preference for flowering eucalypts damage is most serious during poor flowering seasons, when large incursions to horticultural areas can occur. Damage to nuts such as almonds and hazelnuts arise during bud development. Partially ripe grain crops such as sorghum, corn and wheat are also consumed although significant damage to these crops is rare. Large feeding flocks in orchards can cause significant damage within short periods, often in localised areas. Hence damage occurs to many fruits on a single tree rather than evenly over the crop. Musk lorikeets are persistent feeders, for example in the Mt Lofty Ranges large flocks visited a pear orchard every day for 3 weeks until the crop was eliminated. Lorikeet damage is distinguished from other species by horseshoe-shaped marks made by the lower beak and triangular marks made by the upper beak. Fruit and skin fragments under damaged crops trees fruit are similar or smaller than those left by rosellas (i.e <1 x 1cm).

[Historical notes Open seasons were declared in the 1920s in Qld and NSW as a result of their damage to orchards. In 1908 > 1000 killed in a single orchard with strychnine. 1890s thousands were captured with snare poles with some in Sydney catching 120 per day. Sometimes also killed with sticks while feeding in trees others caught by hand]

Damage reduction strategies

Become engrossed in feeding and often ignore approaching danger and reluctant to leave feeding areas even when shot. Often shot but not deterred by shooting. For example 56 were shot out of a single tree without the rest of the flock taking alarm (North). Hence shooting to scare or scaring unlikely to be effective.

Protection Status Protected,

SA protection permit under section 53 NPWSA however need for a permit is waived for the period between 14 Dec 2000 and 30 June 2001 in specified regions of the state

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2.14 Crimson and Adelaide Rosella (*Platycerus elegans*)

Other names: Blue cheeked, Murray, Yellow Rosella, Mountain Lowry, Murray Smoker, Murrumbidgee Parrot

This species now includes three rosella types which are quite distinct in geographic distribution and plumage colour. Hence were known previously as different species and locally by different common names; **Crimson rosella** (*Platycerus elegans elegans*, and *P. elegans nigrescens* of north-east coast of Queensland), **Yellow rosella** (*P. elegans flaveolus*) and **Adelaide rosella** (*P. elegans adelaidae*).

Field Identification

All types are medium sized (35-38 cm), with prominent blue cheek patches and broad tails. The blue cheek complex is unique to this species with the exception of the green rosella (*Platycerus caledonicus*) found only in Tasmania and some islands of Bass Strait. Sexes are similar within all subspecies, with females with slightly smaller heads and bills. The crimson rosella (A) is a brilliant deep red with bright blue shoulder patches and tail. Juvenile plumage is olive green with patches of crimson on forehead, breast, rump. *P. elegans nigrescens* plumage is alike but darker. Yellow replaces crimson in the Yellow Rosella (subspecies *flaveolus*) (B) except for a red frontal band. The Adelaide Rosella (subspecies *adelaidae*) (C) has plumage of varying amounts of orange which replaces the crimson or yellow of the other forms.

Voice: A loud 'kweek kweek' during flight, a smooth piping whistle ('psita-a-see') when perched.

Habitat

The crimson rosella tends to prefer wetter forests and woodlands, commonly found in most types of rainforest and wet sclerophyll forest. Their occurrence in open habitats, farmlands, orchards, vineyards, urban parks and gardens and semi-cleared landscapes is usually associated with adjacent blocks of wet or dry eucalypt woodland, riparian vegetation or attributed to the movements of immature post breeding flocks. Adelaide rosellas are dispersed through a variety of forested and cultivated habitats in the Mt Lofty ranges including black (*E. largiflorens*) and grey (*E. macrocarpa*) box and mallee (e.g. *E. diversifolia*, *E. rugosa*) habitats and orchard landscapes, but are more restricted to river red gum (*Eucalyptus camaldulensis*) communities further east around the Flinders Ranges. The Yellow rosella distribution is even more closely associated with the occurrence of river red gum. This subspecies is restricted to riparian vegetation of the Murray- Murrumbidgee river systems and occurs away from watercourses only where river red gum subsists.

Movements

All species are sedentary with only occasional nomadic movements at the fringes of their range, during winter, or by immature flocks. Local movements in winter may occur from Eucalypt woodland to more open areas. Likewise regional movements towards denser vegetation communities often takes place before the onset of breeding.

Foods and Feeding Behaviour

The three rosella types predominantly feed on plant material including foliage, seeds, buds, flowers, fruit and nectar. However insects and their larvae, including Christmas beetles, aphids and psyllids often supplement their diet. Unlike many other parrot species foraging most commonly occurs in tree and shrub canopies. Pairs and small groups forage in the foliage and branches of eucalypt, casuarina, callitris, acacia, grevillea, pine, fruit and nut crops, and introduced weed species such as wild olives, blackberry, lantana, sweet briar and tobacco. The yellow rosella is often observed foraging high in the branches of flowering and seeding river red gum. Ground feeding increases in frequency during the summer months and in open areas, where small flocks feed on pasture weeds, thistles, dock, clover seed, onion grass, and spilt grain. Peak feeding time occurs in the early morning and late afternoon during winter, but is more constant in autumn. Mixed feeding flocks also occur with eastern rosellas (*Platyercus eximius*), superb parrots (*Polytelis swainsonii*) and Australian ringnecks (*Barnardius zonarius*).

Breeding

Primarily breed in tree hollows of eucalypts in dense woodland from September to January. Rosellas chew and strip existing bark, sticks, wood chips and linings rather than bring in new material. Females select sites nearby to those occupied in the previous season, sometimes also used and lined by other species. Females incubate 4-8 white oval eggs for 21 days, leaving the nest for short periods in the mornings and afternoons to be fed by the male. Young fledge after 35 days and remain with parents for a further 4 weeks. Nests produce an average of 0.4 to 3 fledged young per clutch, and are usually larger in nests used in previous seasons. Nest failure is often caused by destruction of eggs by mammals or birds including other crimson rosellas or desertion.

Damage

Various levels of damage occurs to a wide variety of horticultural crops including apples, cherries, stone fruits, almonds, grapes, pears, plums, guava and quinces. Adelaide rosellas in particular can cause severe losses to cherry crops in the Mt Lofty Ranges by damaging buds, flowers and fruit. Bud damage can be considerable in some areas with total losses resulting in some varieties. Crimson races will also occasionally cause damage where they occur near orchards and vineyards. Vegetables and young wheat crops are also damaged in some areas. In contrast to the other subspecies the yellow rosella is not implicated in causing significant horticultural impact. This is likely due to their more specialised habitat requirements, and little overlap with horticultural regions.

Protection Status Protected

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2.15 Eastern Rosella (*Platycerus eximius*)

Other names: Red-headed, white-cheeked, or golden mantled Rosella; Rosehill parrot, .

Field Identification

Medium sized, broad tailed colourful parrot. Head, upper breast and tail coverts bright red, white cheeks, yellow belly and lower breast, blue shoulders and green to turquoise rump. Females and immatures are a little duller and have a slight patchy green on rear of crown. Voice: calls similar but higher pitched than crimson rosellas; rapid high pitched 'pink pink' during flight, an ascending whistle or slow piping 'kwink kwink; when perched.

Habitat

Eastern rosellas replace and coexist with crimson rosellas in more open habitats but rarely inhabit rainforest or wet sclerophyll forest. They are common throughout their range in open woodlands, farmlands, orchards, cultivated croplands, and suburban parks and gardens. However, in drier parts they reside in close proximity to creeklines or floodplains. Their occurrence in open forests is associated with grassy understorey or adjacent grasslands, hence this species has benefited from clearing of dense forest or replanting of grassy landscapes. They are also often observed along roadsides and perched on fence-lines or overhead wires.

Movements

Considered mainly sedentary although some seasonal movements are thought to occur as a result of dispersal before (NSW) or after (SA) breeding. In the ACT certain populations exhibit altitudinal movements. Typical of most parrot species juveniles and sub adults tend to be more mobile. Eastern rosellas occur singly, in pairs or small groups, though rarely larger groups of up to one hundred have been observed. Daily movements are usually confined to local areas, often loafing in tree branches during the middle of the day.

Foods and Feeding Behaviour

Eastern rosellas prefer ground foraging and grasses and seeds are the major components of their diet throughout the year. However, shrub and tree seed, particularly eucalypt and acacia, fruits, flowers, buds, nectar and a variety of insects including caterpillars, lerp, psyllids, coccids and galls of eucalypt leaves are also often consumed when available. Foraging parties usually occur in small groups of less than 10, largest in the morning, smallest during the middle of the day and intermediate in the afternoons. Foraging in tree and shrub canopy for fruit, flowers, seeds or buds often occurs opportunistically throughout the day particularly where these are used as day perches. A greater proportion of the day is spent feeding in the cooler months.

Breeding

Eastern rosellas usually nest in hollows of mature eucalypts but also tree stumps, fence posts, nest boxes and hollows of a variety of other species including *Casuarina*, figs, *Melaleuca* and fruit trees. Suitable hollows in cleared and open woodlands, including orchards are selected in

August with breeding usually occurring between September and December. Nests are often used by the same pairs in consecutive seasons. Hollows are unlined or lined with small amounts of chewed bark, wood and plant material. Four to seven white oval eggs distinguishable from other rosella species by their size (27 x 23 mm) are laid at 2 day intervals. Females are fed by males whilst incubating and when young are newly hatched. Young are then fed by both sexes. Suitable nesting sites are often usurped by starlings and common mynas. Nesting failure is also attributed to desertion, infertile or broken eggs, or predation by lace monitors, brush tailed possums or rats.

Damage

Eastern rosellas are known to damage nuts, sunflowers, grain and a variety of fruit crops, including apples, grapes, cherries, pears, plums and pears. Impacts to viticulture includes chewing of growing vines and clipping young vine stems. Eastern rosellas damage fruit by biting medium sized chunks which often increase secondary losses from botrytis, molds, fungi or insect attack. Distinguish damage from other species by triangular shaped marks made by the lower beak and small fragments (<1 x 1mm) found underneath the fruit.

Protection Status Protected

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2.16 Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*)

Other names: Greenie, Lory, Green Keet; Green, Green and gold, Green and yellow lorikeet.

Field Identification

Only lorikeet with a completely green head. Bright red bill. Yellow borders to neck and breast feathers gives a scaly appearance otherwise a uniformly leaf green lorikeet with orange- red underwing. Spectacular underwing colour often used to distinguish species during flight. Scaly-breasted lorikeets exhibit similar habitat use, movement, feeding and breeding patterns to rainbow lorikeets and often co-occur in mixed flocks and will also occasionally interbreed. Voice: resemble calls of rainbow lorikeets but often sharper and louder.

Habitat

Similar distribution and habitats to rainbow lorikeets but more prevalent in open agricultural and coastal lowland areas and avoid rainforest. Common in *Eucalyptus*, *Melaleuca*, dry *Casuarina*, *Xanthorrhoea*, *Banksia* and *Callistemon* dominated woodlands and heath. Widespread in suburban parks and gardens and horticultural areas.

Movements

Nomadic species, like other lorikeets, with densities fluctuating according to flowering plants and shrubs. Mainly utilise coastal habitats, occasionally travelling inland along river systems. No substantial north-south movement is evident with seasons, but flocks can traverse large distances in short periods. The scaly-breasted lorikeet is predominantly a lowland species, more so than the rainbow lorikeet, although northern populations will venture to higher altitudes. Some individuals display more sedentary traits, especially in urban areas. An isolated breeding population has established around Melbourne from aviary escapees, also with largely resident birds.

Gregarious, particularly when feeding and roosting. Travel from roosting sites at dusk and congregate in feeding trees usually high in the canopy. Typically loaf in nearby trees during the middle of the day before pre-roost feeding activities.

Foods and Feeding Behaviour

Primarily nectivorous, utilising a range of native species, particularly *Eucalypts*, *Melaleuca*, *Tristania*, *Banksia*, *Callistemon* and *Xanthorrhoea*. Trees and shrubs planted in urban areas are also commonly visited for their blossoms including coral trees (*Erythrina indica*), flowering rain (*Pithecolobium saman*) and umbrella trees (*Schefflera actinophylla*). Fruit, flowers, pollen, seeds and insects also comprise various proportions of their diet. Fruits of figs (*Ficus* sp.), mistletoe (e.g. *Notothiox cornifolius*), native elms (*Aphananthe philippinensis*) and horticultural cultivars are commonly consumed when available.

Mixed flocks with rainbow, musk and little lorikeets often form at feeding sites where large groups can congregate (over 500). Typically feeding groups are smaller averaging around 5. Scaly-breasted lorikeets are acrobatic feeders, but are usually first acknowledged by their noisy chattering rather than sight due to their leaf green plumage. They habitually forage in

the outer canopy branches where blossoms are often more abundant. Occasionally pairs or individuals may defend food trees driving other species away such as noisy miners and other lorikeets, although this is uncommon, particularly in areas of abundant fruit or nectar. Groups will feed throughout the day but peak feeding usually occurs in early mornings and late afternoons.

Breeding

Breeding can occur any time during the year, possibly in response to abundant flowering, but usually takes place between July and November. Hollows with small entrances, high in eucalypt trees are prepared by both sexes by chewing entrances and lining nests with a fine layer of wood dust. Considerable effort is given in removing decaying wood and any nesting material of other species. Two or rarely three eggs (25 x 20mm) are laid then incubated by the female for around 25 days. Both sexes feed the young and may roost inside the hollow for the eight weeks until the young leave the nest.

Damage

Scaly breasted lorikeets, often in association with other lorikeets can cause severe damage in vineyards and peach, nectarine, orange, mandarin, custard apple orchards. Damage can be severe particularly in localised areas of Queensland where large flocks cause considerable damage in short periods. They also damage a variety of other stone and pome fruits, including plums, cherries, apricots, apples and pears. Large flocks also invade grain crops, causing damage to sorghum and maize fields in Queensland and northern NSW. Chewing and consumption of buds, flowers and leaves of horticultural crops is common, hence cultivated flowers are also susceptible.

Protection Status Protected

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2.17 Rainbow Lorikeet (*Trichoglossus haematodus*)

Other names:

Bluey, Rainbow or Coconut lory, Swainsons, Blue-bellied, or Blue mountain lorikeet, Blue mountain parrot, Race *rubritorquis* 'Red-collared lorikeet'.

Field Identification

A well known brightly coloured lorikeet, Australia's largest (25-31 cm). Green upper wing, back and tail, dark blue head and abdomen, bright red bill and eye, red and dark grey underwing, yellow collar and under-tail and a bright yellow stripe through primaries and secondaries. In the 'Red collared' race red replaces the yellow collar which extends down the chest and the abdomen is a darker blue-black.

Voice: musical screech in flight, feeding chatter softer than other lorikeets.

Habitat

Inhabit a diverse range of habitats including tropical rainforest, wet and dry sclerophyll forest and woodlands, savannah woodlands, and farmlands. Commonly visit orchards and farmlands with remnant or replanted stands of eucalypts. Also abundant in suburban parks and gardens and widely dispersed through cities such as Brisbane and Sydney. Feral populations also occur in Perth where their distribution is restricted to suburban areas and associated with Musk lorikeets. Rainbow lorikeets tend to prefer the riverine habitat of tall open eucalypt woodland at lower altitudes, following nectar flows into other habitats when suitable species are flowering. They venture into the fringes of rainforest and wet sclerophyll at higher altitudes for blossoms of suitable feed trees such as *Acronychia imperforata* and umbrella trees (*Schefflera actinophylla*) or where artificial food sources are present. Coastal plains and heath, mangroves, and Melaleuca are also utilised for flowering species such as Banksia, Xanthorrhoea, Grevillea and Callistemon. However, unless flowering, the understorey structure appears relatively unimportant, with populations residing in woodlands and forests with dense shrub layers or an exclusively grass and herb understorey.

Movements

Rainbow Lorikeets are a nomadic species which often relocate to exploit nectar from a wide range of flowering plants. Abundance varies considerably between seasons, with mass departure during some years and peaks in abundance during ideal flowering conditions. As a result no regular large scale movements are apparent although individuals and flocks are able to travel large distances. In areas of reliable food sources particularly in suburbia some individuals have become more sedentary. This is likely due to the availability of a diverse range of flowering plants and supply of artificial feeding stations. However, even in these areas large numbers of transient birds can arrive suddenly during peak flowering periods. Some local populations are suspected to have declined as a result of clearing for agriculture.

Daily movements usually involve travelling several kilometres from large communal roosts at dawn to feeding sites. They then feed throughout the day often moving to other feeding sites; or loaf in tall nearby eucalypts. Flocks are often seen darting among the canopy between feeding sites. They return to the roost before dusk, which can comprise of several thousand birds, where they remain in dense foliage or hollow branches.

Foods and Feeding Behaviour

Like other lorikeets Rainbow lorikeets prefer nectar and pollen from flowers but will also consume native and orchard fruit, berries, seeds and insects. Flocks gather in various habitats utilising nectar from a wide variety of species, including red-flowering gum (*Corymbia ficifolia*), blue gum (*E. globulus*), northern woollybutt (*E. miniata*), forest red gum (*E. tereticornis*), blackbutt (*E. pilularis*), bottlebrush (*Callistemon*), paperbark (*Melaleuca*), *Banksia*, and blackbean (*Castanospermum australe*). They also commonly feed on blossoms of introduced plants such as coral trees (*Erythrina*), pepper tree (*Schinus molle*) and palms (*Phoenix canariensis* and *Washingtonia filifera*); seeds from *Casuarina*, pine trees (*Pinus*), *Lantana* and *Solanum* and fruit from orchards, figs (*Ficus* spp.), lilly pilly (*Acmena smithii*), camphor laurel (*Cinnamomum camphora*) and *Calytrix*.

Arboreal and agile foragers, rainbow lorikeets can hang upside in the outer canopy to reach flowers or fruit with their brush like tongues. High canopy branches are usually selected in preference. However, red-collared lorikeets (*Race rubritorquis*) will forage lower in the canopy during the dry season, and many low shrubs are often frequented. Feeding flocks range from solitary birds to thousands, but usually occur in groups of up to about 50. Will feed alongside scaly breasted, musk and varied lorikeets but are usually partially segregated. Early morning and afternoon are favoured feeding times with brief forays during the middle of the day.

Breeding

Rainbow lorikeets usually breed from September to November, but can extend from July through to January during ideal conditions, when they occasionally produce double broods. Pairs, which may bond for life, prepare cavities in hollow branches or knot holes at the tops (up to 25m) of tall trees often along watercourses. Open woodland dominated by *Eucalyptus*, *Angophora* or *Melaleuca* is preferred for breeding. Two white oval eggs (27 x 23 mm) are laid in a small layer of wood shavings. Females incubate eggs for 10 days when males regularly visit and roost inside hollows. Both sexes feed young until 2 or 3 weeks after fledging and birds reach sexual maturity after two years. Nest success has not been studied away from captivity but is thought to be affected by other hole nesting species such as common mynas, starlings and Australian ringnecks.

Damage

When good quality nectar is unavailable, large flocks can cause significant damage to mango, custard apple, plum, cherry, peach, nectarine, pear, and citrus orchards. Wine and table grapes are also susceptible. Fruit damage, as with other lorikeets is characterised by horseshoe-shaped marks made by the lower beak and triangular marks made by the upper beak. Chunks (~1 x 1cm) are taken from fruit, squeezed for their juice and the remaining pip and skin is discarded directly from the tree. They also occasionally damage to ripening corn or sorghum crops in Queensland and Northern NSW where flocks of thousands of rainbow and other lorikeets can feed opportunistically throughout the day. Nut crops are rarely damaged but growing shoots, buds and flowers can be clipped.

Protection Status Protected.

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2.18 Common Myna (*Acridotheres tristis*)

Other names: Indian myna, House myna, mynah.

Field Identification

Medium-sized but heavily built (25-26 cm) bird with mainly brown plumage. Dark brown to black head with a bright yellow mask, bill, legs and feet. White wing patch, under-tail coverts and tail tip. Often observed walking on the ground in small to very large groups. Voice: Varied repertoire, a coarse 'karrarr'; a high tri-syllable 'weeo'; and a brisk 'seeit' in alarm.

Habitat

Common inhabitant of urban areas, savannah, cleared agricultural lands, cultivated paddocks, plantations, canefields and roadside vegetation. Mynas are closely associated with human development, especially following initial introductions. Colonisation of surrounding agricultural areas and open woodlands can occur gradually usually commencing along roads or railways. They also have potential to colonise areas away from human settlement such as coastal mangroves, flood plains and open forest but are usually at lower density in these areas and avoid dense forests. In the Atherton Tablelands, Queensland they now occupy all habitats except thick rainforest and populations are steadily expanding into agricultural areas of New South Wales and Victoria. Once established, dramatic increases in density are apparent in urban centres, for example in Canberra, Melbourne and inner and surrounding areas of Sydney. Preferred roosts are well sheltered sites particularly introduced trees and shrubs with dense foliage such as Phoenix palms (*Phoenix canariensis*) or introduced pines, where they often observed with starlings and sparrows. Large communal roosts of up to 5000 can occur but smaller roosts of between 40 and 80 is more typical in Australia. Roosting behaviour involves loud calling at dawn and dusk and occasionally during the night.

Movements

Sedentary. No seasonal movements and only localised dispersal patterns are evident in Australia. Local fluctuations in density are most likely due to high rates of juvenile mortality, which is typical of highly fecund species. Density is therefore highest after the young leave the nest between December and March and lowest during the early stages of breeding in the following season. Intermittent juvenile or adult dispersal can occur along main roads and railways, and may become more frequent as populations increase. Daily movements are also confined to small areas often within 3 km of a roost site. Pre-roosting flocks assemble in the late afternoons in cleared areas or perching on powerlines, antennae, bridges or other human structures.

Foods and Feeding Behaviour

Highly adaptable omnivorous scavengers, mynas feed on a variety of food scraps, fruits, vegetables, grains, seeds, flowers, nectar, young birds, eggs, invertebrates and their larvae. Diet varies considerably with availability. Insects are regularly consumed in large quantities, particularly beetle and moth larvae, locusts, grasshoppers and flies. They are frequent dwellers of rubbish dumps and often consume food scraps around buildings, food processing plants and along roadsides. Mostly forage in pairs or small family groups on the ground but

larger groups can feed in trees and shrubs for fruit and seeds. Mynas rarely feed far from roosting or nesting sites, and in some urban areas with restrict foraging to within 0.1 km².

Breeding

Hole-nesting species with similar breeding habits to starlings, but more dominant. Pairs mate for life and vigorously defend territories and nest sites during the breeding season (Aug-March). Untidy nests of sticks, leaves, paper and other items are prepared in tree hollows, in the tops of palm trees, or in walls and ceilings of buildings. Two or sometimes three broods are raised per season, with 3-6 young per brood. Eggs are similar to those of starlings, only marginally larger (31 x 22 mm) and brighter blue in colour.

Damage

Mynas can cause considerable damage to ripening fruit crops, particularly grapes, but also figs, apples, pears, strawberries, blueberries, guava, mangoes and breadfruit. Cereal crops such as maize, wheat, rice are susceptible where they occur near urban areas. Commensal roosting and nesting habits with humans creates aesthetic and health concerns. Mynas are known to carry avian malaria and exotic parasites such as the *Ornithonyssus bursa* mite which can cause dermatitis in humans. They are also implicated in the spread of pest plant species such as *Lantana camara*. Usurping nests and hollows, killing young and destroying eggs of native species, including seabirds, parrots and small mammals is regularly observed although the extent this reduces populations remains unquantified (see Appendix 5 for further information on competition with native species).

Status Introduced. Unprotected

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2.19 Common Starling (*Sturnus vulgaris*)

Other names: European starling

Field Identification

Glossy black, small to medium sized bird (20-22cm) with iridescent red and purple, visible when perching. Juveniles are grey-brown with black beaks. At post-breeding moult, they gain fresh plumage with characteristic white spots, which they gradually lose as their plumage wears. Adults have long, sharp bills which are yellow in the breeding season and black with differently-coloured lower mandibles following annual moult. Lower mandibles are blue-grey on males and pink on females. They have short square tails. Voice: a high-pitched long downward whistle, a sharp 'tzzz-tzz'.

Habitat

Starlings are one of the most common species in lowland suburban and cleared agricultural areas of the south east but also occur in open woodlands, irrigated pasture, feedlots, mulga, mallee, reed-beds around wetlands, coastal plains, and occasionally alpine areas. They avoid dense dry sclerophyll woodlands, wet eucalypt woodlands and forest, rainforest and arid regions. Populations are more marginal in the north and western parts of their range, where climate may partially limit their establishment. Their failure to colonise the apparently suitable habitat of south-west is probably due to concerted efforts to control emerging populations and the barrier offered by the Nullarbor plains. Water availability appears important hence high rainfall regions, irrigated areas, temporary surface water, and flooded drainage swamps attract high densities.

Preferred night roosts are introduced plant species with dense foliage including Africa boxthorn (*Lycium ferocissimum*), firethorn (*Pyracantha*), hawthorn (*Crataegus momgyna*), plane tress (*Platanus*), palms, willows, cypress, pines, cedars, oak, and reed beds (e.g. *Typha* or cumbungi), or concealed cavities in human structures or cliffs. In comparison prominent areas such as powerlines, dead trees, building roofs, and aerials are often used throughout the day for perching and preening.

Movements

Sedentary in Australia. Although starlings will shift regionally movements are generally more localised than nomadic lorikeets and honeyeaters which travel larger distances seeking nectar from flowering plants. In comparison to many migratory populations in northern Europe, starlings in Australia display no large-scale seasonal movements, although distances of up to 2000 km can be flown by individuals dispersing natal colonies. In urban areas they are more sedentary with seasonal fluctuations in abundance due to high juvenile mortality and dispersal. However, small regional movements according to food availability are common, particularly in cultivated and cleared agricultural areas.

After sunrise, starlings depart highly aggregated groups of up to 25 000 at roosting sites and disperse in smaller groups to a variety of feeding areas. They usually feed within 2 km from the roost, but can travel up to 80 km in areas of lower food availability. During autumn and winter, they form larger flocks, leave the roost earlier, travel greater distances and have a

lower fidelity to particular feeding sites. During these seasons, short-term movements may centre around feeding areas rather than roosting or nesting locations. Hence, when travelling to distant feeding sites, they will often select alternative roosts to minimise necessary travel time. Before returning to the roost at dusk, they regularly gather in large groups often feeding in orchards or grain crops. They also form non-feeding groups in trees, shrubs, buildings, powerlines and antenna, where they preen and sing.

Foods and Feeding Behaviour

Starlings require protein to live and breed, invertebrates comprising over half their daily food intake. Other components of their diet are highly varied and can include fruit, berries, vegetables, meat and food scraps, and seeds of cultivated grains, palm trees, saltbush (*Atriplex*), clover, wild oats (*Avena fatua*), *Paspalum* and other grasses. The most commonly eaten food items are members of Coleoptera (beetles) and Lepidoptera (moths and butterflies). These are usually eaten in larval form and found beneath the soil surface using a probing action. Juveniles, present in early summer and mid autumn, will forage more often in arboreal habitats and consume more fruit than adult birds. Juveniles are less proficient at locating invertebrates beneath the soil and remain arboreal even if fruits are not available.

Starlings spend over half the day feeding, with the highest proportion of time spent in permanent open grasslands and gardens, preferring those with shorter grass. Other feeding sites vary seasonally and include orchards, vineyards, cereal crops, feedlots and rubbish sites. Feeding duration in cereal and horticultural crops is usually shorter, where large flocks can rapidly remove substantial quantities of fruit and grain. Once a feeding pattern is established starlings will utilise the same foraging sites for extended periods, but unlike other species have no consistent peak feeding times. Starlings feed in large flocks of up to 20 000 which improves their feeding efficiency and decreases losses from predators, such as brown goshawks, collared sparrowhawks, peregrine and brown falcons, swamp harriers, Australian hobbies, barn owls and corvids. As breeding season approaches feeding flocks become progressively smaller as more time is spent at feeding sites which are closer to the nest.

Breeding

Sexual activity and nest building peaks in early spring (August-September). Starlings form pairs and nest in tree hollows, holes in the ground and gaps or crevices in cliffs, shrubs, tree stumps, fence posts and eaves and under roofs of buildings. Males build a small cup-shaped nest within a bulkier untidy mass of sticks, leaves, feathers and grass. Males will establish territories and defend up to three nest holes but as breeding approaches are restricted to one by competing males and other species. Starlings produce 2-3 broods a year producing 4-6 blue unspotted eggs (30 x 21 mm) with each brood. The initial laying period of the first brood occurs in mid Spring (late October). Both successful and unsuccessful pairs may split, breed with other starlings and raise chicks in other nests for the second brood, usually in commencing early January. Incubation of the eggs requires females to spend 80 percent of their time on the nest for 12 days. Males also assist in incubation for occasional short periods through the day. Chicks are fed a high protein diet during the 14 days before fledging, comprising mainly soil invertebrates. Fledged young rapidly learn to fend for themselves and locate food by following adults to feeding sites. Food quality is now less critical and fruit becomes a larger proportion of their diet.

Damage

Starlings can cause significant damage to horticultural industries, particularly cherries, grapes, blueberries, olives, stone fruits, apples, pears and a range of vegetable crops. Dried fruit industries are also susceptible with damage evident in currants, sultanas, raisins and dried stone fruits, which occasionally includes birds removing fruit from drying racks. Fruit damage can commence up to six weeks before harvest but increases in frequency during various stages of ripening. Upper branches with sparse vegetation often attract heaviest damage. Whole berries from olives, grapes and cherries are removed and swallowed; larger fruits display a series of sharp peck marks.

Cereal crops are susceptible when grain is freshly sown and during ripening. Grain from feedlots, storage areas, piggeries, dairies, poultry farms is often consumed. They can also carry many parasites and diseases which raise concern in food factories and industrial areas and are a potential risk to livestock industries. For example, they are implicated in carrying and in some cases transmitting Salmonella, Cryptococci, Newcastle disease (poultry), transmissible gastroenteritis (pigs), Eastern encephalitis (horses) and foot-and-mouth disease (ungulates), although the risks remain un-quantified. Environmental impacts particularly usurping nest hollows is potentially serious for some native species, e.g. Coxens double-eyed fig parrot and turquoise parrot. The spread of environmental weeds such as olives, is also an emerging issue. Aesthetic problems are also common due to the formation of large roosts in urban areas.

Protection Status Unprotected. Introduced species

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2.20 Silvereeye (*Zosterops lateralis*)

Other names: Wax-eye, White-eye, Grey-breasted white-eye, Ring-eye

Field Identification

Small evasive and fast moving, silvereeyes are the smallest (10-13 cm) pest birds of horticulture. Olive green, yellow to white abdomen with a characteristic white eye-ring and a fine sharp bill. They are often seen in large flocks flying at height, or darting between foliage of shrubs and trees. Eight races are now recognised in Australia, distinguished by only slight variations in colour, behaviour and distribution. All races are grey-backed except the Western Australian race *chloronotus* with olive green back, green-yellow throat, and pale buff flanks. Grey-backed races include *lateralis* with deep rufous flanks, breeds in Tasmania and migrates overlapping mainland races extending as far north as Rockhampton; *cornwalli* with pale rufous flanks occurs from south-east Queensland to Victoria; *pinarochrous* as *lateralis* but duller resides in south-west South Australia; *vegetus* as *cornwalli* but smaller, coastal north-east Queensland. Isolated island populations are those of *chlorocephala*, the largest of the races with a heavier bill, restricted to the Bunker and Capricorn islands off Gladstone; *tephropleurus* Lord Howe island and *ochrochorus* King Island in the Bass Strait. The mainland races are implicated causing damage to horticulture hence the following sections focus on those races. Voice: A characteristic high sharp 'tseep' as a contact call, other calls vary from a series of shrill short notes to softer drawn-out mimicry.

(another possible race *westernensis* replaces *cornwalli* south and south-east Victoria)

Habitat

Frequent a diverse range of habitat types, including wet and dry sclerophyll forest and woodland, rainforest, mallee shrubland, coastal heath, mangroves, farmlands, parks, gardens, orchards and vineyards. Some regional preferences are evident, favoured habitats include marri (*Corymbia calophylla*) and coastal heath in Western Australia, manna gum (*Eucalyptus viminalis*)/ peppermint (*Eucalyptus radiata*) associations and red ironbark (*E. sideroxylon*) in the eastern states; *Banksia* and *Grevillea* shrublands; and fruiting trees and shrubs from suburbia and horticultural areas. Open savannah and arid areas are avoided.

Movements

Mainly migratory, travelling large distances particularly along Australia's east coast, where movements of up to 1600 km have been recorded. Southern populations, especially *lateralis* exhibit clear migratory patterns, regularly traversing Bass Strait in early Autumn extending as far as Rockhampton in Queensland by May. In eastern Australia, seasonal movements increase with latitude, hence northern races such as *vegetus* rarely migrate large distances. Instead are mainly sedentary or display regional nomadic movements in response to fluctuating food supplies. In Western Australia, silvereeyes (race *chloronotus*) are also primarily nomadic. This sub-population travels inland when coastal food sources diminish and return to utilise spring flowering species, rather than displaying innate migratory movements. In comparison numerous individuals of south-eastern mainland races such as *cornwalli* regularly move north during winter and are replaced by the Tasmanian race (*lateralis*) as they advance north. Most migrate at night following established routes and visit particularly sites in consecutive seasons. Some pairs and individuals will not migrate, with certain silvereeyes migrating in some years but not others.

Daily movements are highly varied with food availability. During the breeding season (August to February) males and females establish small territories which they defend but often traverse a larger home range and occasionally congregate around important food sources. They will also travel to distant food sources despite the presence of equivalent locally available food, perhaps for the benefits of communal feeding or to detract predators and other silvereyes from their nesting sites. Despite occasional forays for food, home range size during breeding is often confined to less than a hectare. After January large flocks congregate including many juveniles, which disperse natal areas or commence annual migration.

Foods and Feeding Behaviour

Silvereyes are generalist feeders, favouring insects, nectar and fruit. They prey upon a variety of insects and consume nectar, fruit and seeds from a range of native and introduced plants. High volumes of invertebrates are regularly consumed in larvae and adult form, particularly moths, bugs, scale insects, spiders, beetles, wasps and flies. They also often exploit nectar and fruit, preferring native trees and shrubs such as marri (*Corymbia calophylla*), karri (*E. diversicolor*), red ironbark (*E. sideroxyloni*), *Leptospermum*, *Callistemon*, seaberry saltbush (*Rhagodia*) and *Diplolaena dampieri*. Introduced species, including coral trees (*Erythrina indica*), lantana, holly (*Ilex aquifolium*), wild tobacco (*Solanum mauritianum*), cape gooseberries (*Physalis peruviana*) and many cultivated fruits are utilised especially when nectar from native species is scarce. Food scraps in suburban areas are also consumed on occasion.

Frequently arboreal they access lower branches of trees and shrubs, hawking insects and gleaning psyllids and other insects from leaves and twigs. Ground and high canopy feeding is also common. During migration, silvereyes travel large daily distances to visit feeding sites. Sedentary sub-populations often move short distances but vary their daily travel according to accessible food. Extremely large flocks can arrive at feeding sites. For example, 20 000 silvereyes have been shot in a single orchard during a growing season. Although flock sizes vary with latitude, largest flocks usually occur following the influx of juvenile birds after January.

Breeding

Both sexes build a small nest cup from hair, fine grass and spider-web, which is well concealed in outer foliage of shrubs, low tree canopy or grape vines. Two to four pale blue eggs (17 x 13 mm) are laid usually twice but up to four times in a season (August- February). Hence, populations can increase rapidly in ideal conditions, with maximum numbers of juveniles during January. The 10 day incubation period and feeding of young is shared between sexes. High mortality rates following breeding are likely but difficult to measure in migratory populations. Main causes are probably vulnerability to exposure and fatigue during migration and predators such as birds of prey, goannas, mice, rats and cats. Wild silvereyes are known to live up to 11 years from banding records, but average age is 2.

Damage

Silvereyes probably cause the greatest damage to Australian horticulture of any native bird. They frequently damage wine and table grapes, cherries, peaches, nectarines, plums, blueberries, apricots, apples, pears, tropical fruit, olives, tomatoes and capsicum. Losses are particularly severe when native nectar sources are unavailable and during migration when

high energy sources are sought after. Nectar and native fruit is preferred over horticultural crops but are often in short supply from clearing, during dry seasons through lack of flowers or excessive wet seasons which dilute the nectar. Although variable, higher nectar yields often occur following warm autumns and springs and cooler temperatures during nectar production.

Silvereyes puncture fruit with their sharp bills, creating small diamond- shaped holes and lap at the flesh with their brush tipped tongues. This often causes secondary losses by attracting insects such as wasps, bees, and ants and promotes the growth of botrytis, yeast, fungi and other infections. They will also feed on fallen and previously damaged fruit, in some cases targeting these in preference to unspoiled portions. They also potentially contribute to weed dispersal, such as bridal creeper (*Asparagus asparagoides*), lantana, Bitou bush (*Chrysanthemoides monilifera*) and privet (*Ligustrum sinense*), although they often avoid swallowing large fruit, hence maybe inefficient seed dispersers of large fruited plant species.

However, outside or during the early stages of the ripening period they can be an important predator of insects. For example, they are known to consume large volumes of codling moth (*Cydia pomonella*) larvae, a serious pest in apple orchards, and are implicated in controlling the potato moth (*Phthorimaea operculella*) via larvae consumption and as a vector for the granulosus virus.

Protection Status Protected

Sources and Further Reading

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3. ECONOMIC DECISION-MAKING

After appropriate problem definition and before implementing management action all available options should be reviewed (Section 1.2). Different types of economic analysis are available to assist in directing this process. These analyses can contribute in a descriptive or prescriptive way to decision-making (Mumford and Norton 1984). Descriptive models assist in our understanding of economic relationships. For example they may attempt to determine the level of bird control which has maximum economic benefit. These models require accurate measurements of a range of factors including costs, benefits and density-damage relationships. In comparison, prescriptive models incorporate value judgements and compare available options using specific, subjective criteria. These models are used for comparing strategies. Both economic models can be useful in assessing management options.

Five types of analysis are reviewed with an emphasis on birds in horticulture: economic threshold model, marginal analysis, cost effectiveness, direct cost benefit and decision theory. To promote practical application a simple stepwise procedure is then described to assist horticulturalists in selecting an optimal bird management strategy. This includes a description and an example of a simplified cost-benefit analysis, which explains the procedure of estimating the benefits and costs of particular activities. Where information is available this will incorporate some aspects of different analysis and provides a reasonable prediction of the most cost effective management regime.

3.1 Economic Threshold Model

The economic threshold model indicates the density of a pest population where the benefit of management just exceeds its cost (Stern *et al* 1959; Mumford and Norton 1984). This break-even point can be used to decide when or if a particular management strategy should be initiated. To apply this model managers need a knowledge of:

- Bird density
- Levels of damage resulting from a range of bird densities (density-damage relationships)
- The impact of different levels of management on bird density
- Value of output (e.g. \$/tonne)
- Costs of different levels of management options

For an example, consider a fully irrigated olive grove with 250 Manzanillo trees per hectare which incurs annual starling (*Sturnus vulgaris*) damage. The grove produces 10 000 kg/hectare and the manager receives \$0.60/kg. Measurement of starling feeding behaviour might suggest each additional starling/hectare reduces yield by 10 kg during the growing season. Lethal shooting might cost \$100/hectare but is only 50% effective in reducing damage. Applying the economic threshold concept in this case, a density of 33 starlings/hectare could be endured before initiating control.

3.2 Marginal Analysis

Marginal analysis determines the level of control that is most profitable for a particular pest density, or alternatively the pest density at which maximum profit occurs. As distinct from the economic threshold model, marginal analysis allows variable levels of treatment to be considered (Mumford and Norton 1984). It also relies on various assumptions including accurate knowledge of production relationships and that there is some point after which

increasing inputs will cause reduced incremental increases of output (law of diminishing returns) (Mumford and Norton 1984). This form of analysis has two components. *Marginal cost* which is the change in total cost resulting from a unit change in output, and *marginal benefit*, which is the change in total benefit resulting from a one-unit change in the benefit of pest management. The desired level of activity is where the marginal cost of the extra unit of input equals the marginal benefit of that unit (Hone 1994).

This model recognises different initial pest densities and optimum levels of control for each density. As initial pest density increases, so does the marginal value of pest control, which will justify more control inputs (Johnston 1991). This concept would encourage the use of appropriate levels of control. However, damage levels and how various levels of control will influence damage need to be known with reasonable certainty.

3.3 Cost-effectiveness Analysis

This type of analysis can be used to compare the cost-effectiveness of different methods (Hone 1994) and is used when benefit is difficult to measure. Instead of estimating monetary benefits it compares cost per animal with the number of animals removed per unit area. It is therefore more often used when comparing strategies which rely on direct population manipulation for reducing damage. It will allow consideration of alternative techniques when removing different levels of pest populations. For example it may be more cost effective to shoot starlings when they are at low density, but more effective to trap at higher densities. This method uses physical returns (e.g. number of starlings shot per km²) versus the costs (e.g. cost per starling shot).

3.4 Direct Cost-Benefit

Cost benefit analysis is a commonly used technique which compares benefit and cost at a particular level of activity. If benefits exceed costs the proposal is economically profitable. The benefit/cost ratio indicates the potential return from \$1 invested. Comparison of many benefit/cost ratios will enable a prediction of the most suitable management strategy and desired level of management activity. Incorporating risk into this analysis will improve its relevance. This normally involves discounting which takes into account declining monetary values over the management period. Discount rates measure the effects of inflation and the perceived risk of the management strategy. Higher discount rates reflect riskier management decisions.

3.5 Decision Theory (Pay-off matrix)

This form of analysis perhaps provides the most useful support to the practicing horticulturalist. Most other economic models require accurate measures of costs and benefits or assumptions of density damage relationships, which are often highly variable and difficult to estimate. This model can incorporate probabilities of different outcomes in a less formal way of assessing risk. These can be estimated from past experiences in your area or from general or subjective information on individual techniques or expected damage. Chapter 3 (Scientific Principles of Control) provides a useful guide to assist in determining the benefits of different strategies.

To illustrate with a simplified example consider silvereye damage to vineyards in the Margaret River area of south-west Western Australia. A study between 1971 and 1983 (Rooke 1983) suggested that the highest levels of silvereye damage coincided with poor nectar flows in marri (*Corymbia calophylla*), their preferred food source. Although highly dependent on rainfall and temperature, on average marri produces low quality and/or quantity of nectar 1 in every 4 years. Thus, the probability of suffering damage is 0.25, while the probability of no damage is 0.75. For comparing netting against no control assume; 60% losses occur during poor marri flowering seasons, net returns of \$10,600/hectare, and that bird netting costs \$1,120/hectare/year (including labour) and is 90% effective in reducing damage (i.e reduces damage down to 6%).

Table 14. Pay-off matrix of expected profits for two management options for silvereyes in vineyards

	State		Expected Profit
	No Pest (0.75)	Pest (0.25)	
ACTION			
No Netting	\$10600	\$4240	\$9010 ¹
Netting	\$9480	\$8844	\$9321 ²

$$^1 (\$10600 \times 0.75) + (\$4240 \times 0.25) = \$9010$$

$$^2 [(\$10600 - \$1120) \times 0.75] + [(\$10600 - \$636 - \$1120) \times 0.25] = \$9321$$

(After Mumford and Norton 1983)

The desirable option is one with the highest expected profits. In this example bird netting is more likely to produce better profits in the long term than no control. It would also be more beneficial in terms of consistent cash flow between seasons.

3.6 More Complex Models

The above models are simplistic in that they do not take into account many variables which influence the costs and benefits of management situations. For example, soil fertility, rainfall, climate, habitat and temperature may influence food availability, preferences and movements of pest bird species. These factors may help to predict when and where damage is likely to be most severe, or success of particular management options. Additional economic factors can also be incorporated such as more detailed information on accountability of development and operation costs, externalities and discount rates (Perkins 1994). Where these variables demonstrate consistent relationships, linear programming can be used (Luenberger 1984). Dynamic programming goes a step further and allows inclusion of factors which change in the way they influence or predict costs and benefits (e.g. Bauer and Mortensen 1992). Both models require expert knowledge of computer programming, as well as an understanding of how and when the range of biological and economic factors will influence pest populations, damage and management. Hence these are best used by experts and are applicable in evaluating management options and aiding policy development and funding decisions on a regional or national level, but could also then be used to improve property-based decision making.

3.7 Stepwise Approach

The following section provides a simple guide in deciding when, where and how to implement bird management and will provide a reasonable prediction of the most cost effective management regime (modified from Bomford et al 1995). Horticulturalists could use a step-wise approach to optimise management strategies for birds, which incorporates some components of the above models. The steps are:

1. Estimate the cost of bird damage

Estimating the cost of the damage will give you a basis for deciding how much you should spend on managing the problem. Methods for estimating damage are outlined in Section 2.1.

2. List the cost of management options

List all management options and how much they would cost to implement. Management options can include individual techniques or combinations, and different levels of application. Also consider carefully the labour involved in each option. Growers often underestimate the time and money spent maintaining different techniques.

3. Consider the effectiveness and benefit of each option

Estimating the benefits of each management option is difficult as horticulturalists seldom have the resources to trial different techniques. It is also unrealistic to provide prescriptive guidelines of when techniques will work for every situation, particularly when using a combination of strategies. In this case objective consideration of the range of available techniques and their relative effectiveness is required (discussed further in other sections of the guidelines). Consider how applicable and effective these are in your situation and estimate the benefits of their implementation.

4. Calculate cost-benefit ratios for management options

Using the information from steps 1-3 estimate the costs and predicted benefits of implementing each management option. If the benefits exceed the costs then the ratio of benefits/costs is greater than one and the management option is economically profitable. The desirable management option is one that will provide the maximum benefit-cost ratio.

5. Construct a table listing the options and their costs and benefits (pay-off matrix)

This will allow comparison of different options after considering current conditions. For example, you may wish to construct different matrices for different bird densities, seasonal conditions or commodity prices. Including probabilities of the likelihood of each state will aid decision making. An example of a pay-off matrix for different pest densities and probabilities is given below.

		STATE			
		Level of bird damage			
			Low (L)	Medium (M)	High (H)
		Probability	P1	P2	P3
Bird management strategies	Do Nothing (0)		Outcome L,0	Outcome M,0	Outcome H,0
	(1)		Outcome L,1	Outcome M,1	Outcome H,1
	(2)		Outcome L,2	Outcome M,2	Outcome H,2
	(3)		Outcome L,3	Outcome M,3	Outcome H,3

Figure 36. Pay-off matrix of management options for different bird pest densities. Management strategies could include: (1) shooting. (2) visual and acoustic deterrents with reinforcement. (3) netting. (Norton 1988)

6. Decide when to implement

Some of the economic models discussed can be used to identify the level of control that is most profitable for a particular bird density. For example, these models can take into account the relationships between density and damage and differences between costs of controlling different densities of pests. An optimal level of control could theoretically be estimated for fluctuating bird density and implemented when benefits exceed costs.

In practice density-damage relationships of pest birds in horticulture are not accurate and can be highly variable. Even when good information is available it is often not practical for horticulturalists to be immediately responsive to short term fluctuations in density or damage. When damage becomes significant it is usually too late to implement control. For example, effective use of scaring often requires a ‘start early’ approach to prevent birds establishing a feeding pattern. Similarly, investment in netting cannot be simply withdrawn for seasons in which damage is below the cost-benefit threshold. Instead horticulturalists need to look at costs and benefits over a longer time frame and make decisions accordingly. Where damage in your area is likely to be high or you have a history of high damage you will be more inclined to invest in continuing management action, even though damage is highly variable between seasons.

3.8 Other Factors to Consider

With any management decision there are always components of risk. Different bird management options will have varying levels of risk. Managers who are risk averse will

select options that will provide reasonable returns under the widest range of conditions, but a potential trade-off may be lower profits. If a manager's priority is to maximise profit in the long term, the preferred options will be those that are likely to give the highest returns even though there may be increased risk of no returns or losses during bad seasons. Direct cost-benefit and decision theory models allow managers to account for some of the risks of damage or management success.

Economic models attempt to draw simple conclusions from dynamic, complex systems. They are more applicable when dealing with single pests, where reductions in pest density results in corresponding reductions in damage, or when costs and benefits are easily measured. Birds in horticulture rarely conform to these ideals. Incorporating a range of other factors will improve their relevance but also their complexity.

Population control of birds has often been unsuccessful in reducing long term populations of birds or agricultural damage. Although mostly unquantified in Australia, bird damage is also highly patchy and it is usually a small percentage of growers who receive significant losses, with the majority receiving very little. Management action would therefore be more efficiently targeted at those small numbers of growers instead of aiming for broad-scale reductions in bird density. There is a diversity of native bird species which also cause damage but it is often undesirable ecologically and politically to reduce populations of these species. Birds are highly mobile, have high rates of recruitment, and can quickly re-establish to pre-control levels. These factors highlight difficulties applying economic models that rely on reduction of density to reduce damage to horticultural enterprises.

Legal, social and environmental considerations are additional factors which should be considered in decision making. Some of these include:

- Neighbour relations- will an intensive scaring campaign inhibit future cooperation between neighbours?
- Off site considerations- does a control strategy adversely influence adjacent land use?
- Environmental- is the management action environmentally responsible?
- Animal welfare- is the technique humane?
- Occupational Health and Safety- are the management practices safe for staff?
- Legal- will bird control breach any legislative requirements?
- Indirect effects of control- will reduced numbers of birds in vineyards increase harmful insect loads?
- Debt servicing- do you need consistent cash flow to ensure loan repayments are met?

PART F: EXTENSION AND EDUCATION

1. GENERAL

The success of this project is attributed to the input from many collaborators. The Orange Region Vignerons Association (ORVA) have provided feedback and contributions throughout the course of this study. Continual liaison with vignerons has increased the relevance and applicability of project outcomes. Considerable effort has been given to ensure research is meeting the needs of the wine grape growers by facilitating meetings and workshops; attending field days and presenting on-site demonstrations and discussions. For example there have been over 25 scientific papers and extension articles (Appendix 6) to promote the outcomes of this project, share information within scientific community and encourage the adoption of results by vignerons on a practical level. These include extension reports to specific vineyards (e.g. Appendix 1. Report to Rosemount) as well as surveys across the Orange region (Part E).

There has been on-going communication with scientific community including experts in ornithology and other scientists working on bird pests in Australia and internationally. This has been a result of a commitment to regular communication and attendance at relevant meetings and conferences (contributed papers are outlined in Appendix 6).

In addition, a major education component of the project was initiated through collaboration with the NSW Science Teachers Association, Orange Field Naturalists and Conservation Society, Orange Region Vignerons Association, and local high schools. This education program involved training of students and experienced bird observers in bird identification and research techniques; and resulted in achievement of education and awareness outcomes, increased research inputs and provided local vignerons with information on bird pest abundance. Skilled bird observers from the Orange Field Naturalists and Conservation Society contributed greatly to this program. Initial cooperation with the NSW Science Teachers Association consequently resulted in training and considerable assistance from Orange High School, Kinross Wolaroi High School and Molong Central School.

Further links were established with the Central Ranges Apiarists Association for potential to produce quantifiable results on nectar flows for predicting honeyeater movements. We are continuing to work closely with local vignerons, adjacent landholders and apiarists and have received positive input from research results.

Another significant outcome of this project has been the increased advisory capability of staff of the Vertebrate Pest Research Unit, Agriculture Protection Program and NSW Rural Lands Protection Boards. Staff now communicate and regularly provide advice to Australian horticulturalists as well as national and international experts on bird pest management. The adoption of our damage assessment and analysis techniques in New Zealand and South Africa is an example of the applicability of this research.

Further promotion of this project is also achieved through established methods of information transfer through NSW Agriculture's media liaison unit.

2. BIBLIOGRAPHIC INFORMATION PACKAGE

A bibliography of key scientific papers and reports on bird pests was collated from contributions from relevant experts and researchers in Australia and New Zealand in 1999. As an on-going component of this project this database was updated weekly and currently contains around 5700 entries. It was compiled using Procite 4 for Windows and has been made available in range of formats in the form of a CD-ROM (Figure 36). Updated versions are available from John Tracey, Vertebrate Pest Research Unit, NSW Agriculture, Forest Road, Orange NSW 2800; (02) 63913952, john.tracey@agric.nsw.gov.au. This information package was intended as a resource for land managers and researchers with an interest in bird pests. It contains references from areas such as biology, feeding habits, habitat preferences, breeding and movement behaviour, distribution, damage assessment, and management of the key bird pest species to agriculture, the environment, and in urban areas. While emphasis was Australasia, key international references were also included. Each reference was key-worded to assist in searching the relevant information.

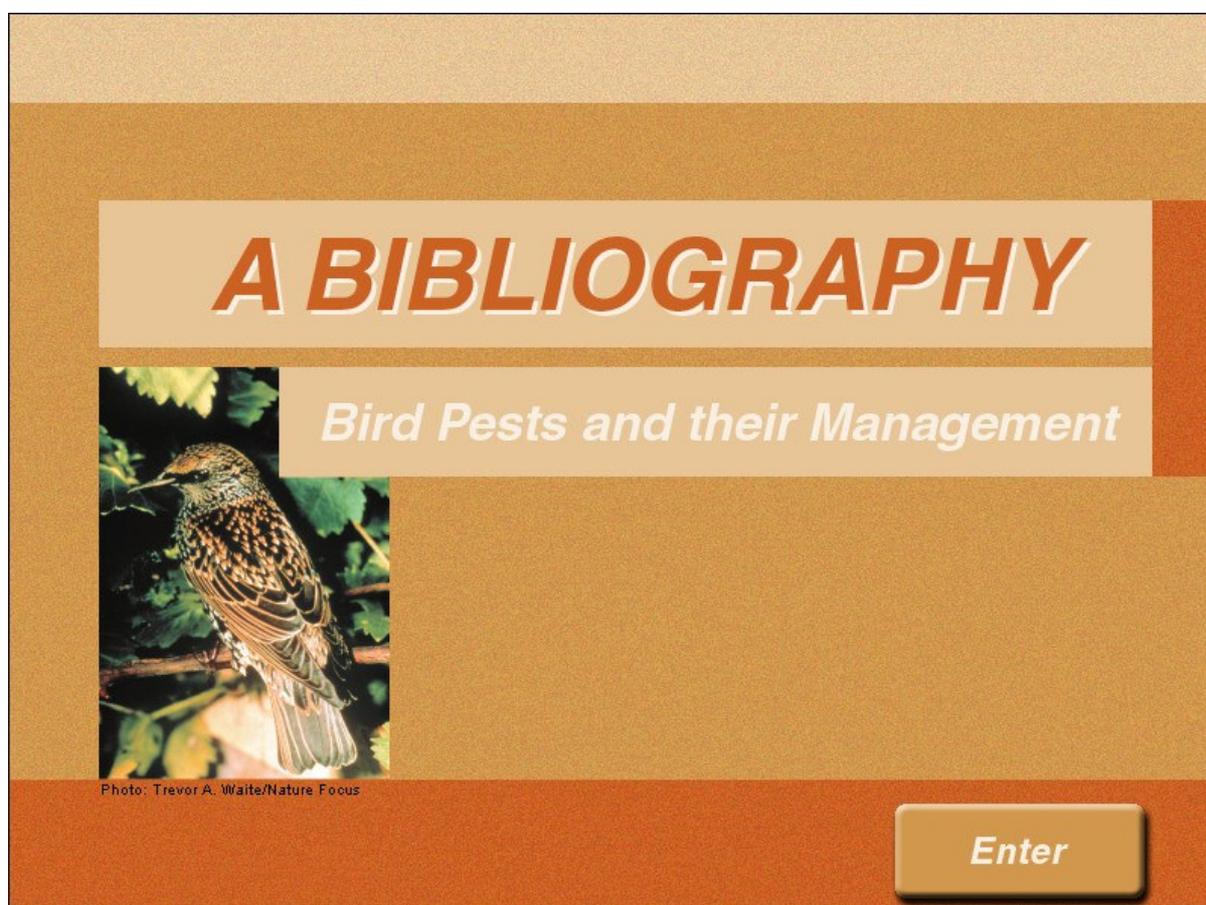


Figure 37. Front cover of CD-ROM bird pest bibliography information package.

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APPENDIX 1: Report to Rosemount Estate

1. Project Outline

The following report provides an overview of results from intensive bird observations and sampling for damage on Rosemount Estate (Mount Canobolas vineyard, Orange) during 2000 and 2001. This was forwarded to managers of this vineyard in July 2001 to provide feedback and continue collaboration.

1.1 Study site description

Mount Canobolas vineyard produced grapes from between 50 and 60 hectares of vines during the 2001 ripening period (Figure 1 and 2). It can be divided into two areas, Mount Canobolas North and Mount Canobolas South (Figure 1). It should be noted that Nioka vineyard is 450m from the northern boundary of Mt Canobolas and is 25% its total size.

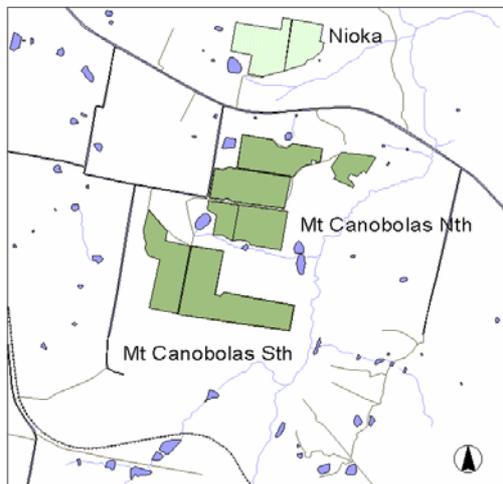


Figure 1: Mount Canobolas Rosemount Estate and neighbouring vineyard.

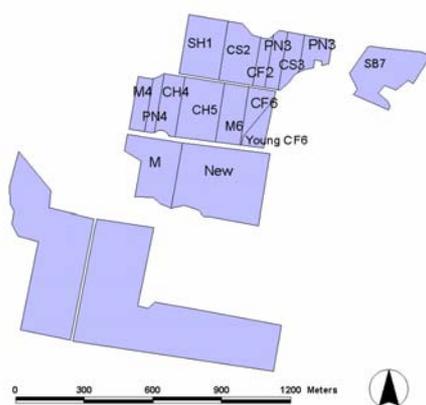


Figure 2: Mount Canobolas Rosemount Vineyard grape varieties.

1.2 Acknowledgments

Many thanks to all those who participated in last years questionnaire survey. It is anticipated that these survey results will be incorporated with additional data collected by research staff for both 2000 and 2001 grape ripening periods. Data collected over the 2001 grape ripening period will be sent out to vignerons. Information has been collected on aspects of bird damage, behaviour, movements, species composition and density estimates. A supplementary questionnaire for the grape ripening period of 2001 is pending. It is hoped that the new surveys may be compared to last years survey in order to gain a better understanding of current bird damage levels from a vigneron's perspective.

We are grateful for the continued valuable contribution made by the management staff of Mount Canobolas Rosemount vineyard including vignerons Cameron Johnson, Andrew O'Shanesy and Chris Coddington for the interest they have showed in this research project. An objective of this research is to improve on what is currently understood about the damage bird cause to wine grapes, and how, when and where they damage grapes. These fundamental issues need to be built into a strategic control program to lessen the overall negative impacts of birds on wine production. We feel the positive contribution being made by Mount Canobolas Rosemount Estate will greatly enhance our ability to answer these and other questions to develop such a strategic framework for minimising bird damage, which in turn will improve the value of the wine and grape industry.

The bird surveys were undertaken with the support of the Orange Field Naturalists, Orange High School, Kinross Wolaroi and Molong Central School, Bill Freier (University of Queensland) and numerous volunteers.

2. Progress and methodology

The following research project has comprised four components that have been undertaken at various stages during 2000 and 2001. The following is a summary of what has been investigated to date.

2.1 Damage Assessment

Repeated grape damage assessment has been undertaken in both 2000 and 2001. This has involved visual examination and scoring of bird damage to grape bunches randomly selected across all varieties. In most instances, damage assessment was recorded on several occasions providing an accurate picture of progressive damage to each variety. Damage assessment commenced at Mount Canobolas Vineyard on 2 February, 2001 and was undertaken for each variety until final harvest at 26 April 2001.

Damage data for 2000 has been examined and total damage at harvest is presented in this report. Although the equivalent data for 2001 remains to be examined, it is anticipated that it will be included within the next report to Mount Canobolas Vineyard.

Both damage data-sets covering two growing seasons will be examined for trends across time, to establish whether the amount damage to the vineyard changes throughout the season, and to examine how and where each variety is damaged as it becomes increasingly ripe. It is anticipated that these details will direct the use of control resources to specific damage

hotspots. In addition, the data will be examined to establish the influence of surrounding landscape features, such as woodlands, powerlines, plantation windrows and human infrastructure on damage to grapes. This may facilitate the recognition of additional management options.

2.2 Bird species abundance surveys

Throughout the 2000 ripening season, an index of bird density was established through recording species as they were seen and heard along vine rows. Species were ranked as low, medium, high, or very high abundance.

During 2001 a different method for assessing bird species abundance was implemented. Bird species abundance was recorded at 26 randomly selected sites within each available habitat. This was conducted on a weekly basis from 21 February to 16 May 2001, and monthly from May to July. It is anticipated, pending continued approval from Mount Canobolas managers, that monthly bird surveys will be ongoing throughout the remainder of 2001. Preliminary data from these surveys have been presented in this report to provide an indication of the proportions of birds observed at Mount Canobolas, and at all surveyed vineyards for 2001. Concurrent surveys were undertaken at several other vineyards, although these data will likely be contained within future reporting to Mount Canobolas Vineyard.

2.3 Behavioural study on starlings - spatial and temporal movements

The behavioural component of this project involved careful documenting the movements and foraging behaviour of groups of starlings across Mt Canobolas Vineyard between late February and June 2001. This included recording the monitoring the movements, perching and feeding behaviour of groups of starlings. Other observation data from September and October 2000 were used to compile distribution maps, but surveys were limited to the northern portions of Mt Canobolas Vineyard. As a result, there was only small quantities of movement data collected during this time period, and they have not been presented in this report.

The data presented in this document offer important information about the movements of starlings. The data represents starling distribution/home-range areas, and depicts the main activity centres for starlings during March, April and May, 2001. These dates also correspond with the ripening and harvest of grapes at Mt Canobolas (10 March to 26 April), and when grapes had been harvested (May) during 2001.

It is important to note that these high activity areas represent the distribution of observations made on starling groups, and do not represent the number of starlings or group sizes observed at these locations. It represents the 'core activity areas' for starlings based on observations made from several carefully selected vantage points across the Estate. With this in mind, it should be carefully interpreted. However, this data do provide a guide to distribute control techniques throughout ripening and harvest.

3. Results and Discussion

3.1 Results of damage assessment for 2000 and 2001

The damage observed between vineyards and grape varieties during the season of 2000 varied markedly. Damage ranged from 0.3% to 83% across vineyards. However, an extended ripening period during 2000 due to unseasonable weather conditions may have caused unusually high damage levels in some vineyards.

There are two important characteristics to recognise from these data within Mount Canobolas Rosemount vineyard. Firstly, Chardonnay received the least damage, Merlot grapes received the greatest damage and other varieties received moderate damage. In contrast to other vineyards, Mount Canobolas Rosemount received greater damage to Pinot Noir and Shiraz, and less damage to Cabernet Sauvignon, Cabernet Franc, Sauvignon Blanc, Chardonnay, and Merlot than other vineyards. It is imperative to note that this comparison was made between vineyards producing different combinations of grape varieties, and as such, comparisons between varieties were often made between only two or three vineyards simultaneously. This implies that the observed damage may not reflect the damage to these varieties across the region, but indicates that these vineyards differ in their levels of damage substantially.

The second important aspect to recognise is that there was no consistent trend in damage to any particular grape variety across these sampled vineyards. This indicates birds are not showing strong preference to any particular grape varieties, causing different damage at each vineyard. This implies damage levels are being influenced by other factors, such as their location within vineyards and/or ripeness. Previous research has demonstrated that location can influence the spatial distribution (geographical location) and intensity of damage (Graham, 1996). Some other vineyard features recognised to influence damage to grapes include grape ripeness, foliage cover, vine block size and exposure, proximity to surrounding habitat features, and exposure and intensity to control (Graham, 1996). The variation in features/conditions within the vineyards surveyed may account for the observed variation in damage to grape varieties during 2000.

Furthermore, the vineyards examined in this study have different grape varieties at various levels of maturity, and are in differing landscapes. It is not unexpected that these attributes may have lead to dissimilar levels of grape damage within these vineyards, and within Mount Canobolas Rosemount vineyard, thus warrant different bird management strategies.

Damage assessment data for 2001 are still being compiled for comparison between seasons. It is anticipated that further trends in grape damage will be established for each grape variety, affording a better understanding of damage to grape varieties and the associated economic loss of production. With this information, it will be possible to develop more accurate and precise recommendations for the management of bird damage at Mount Canobolas Rosemount vineyard, and for managing the impacts of birds in vineyards.

3.2 Results of bird species abundance surveys for 2000 and 2001

3.2.1 Species diversity and abundance.

The information presented in this section come from two seasons bird surveys. During 2001, bird surveys were conducted at 26 locations across the Mount Canobolas Rosemount vineyard and surrounding landscape. During 2000, the bird surveys were limited to within the vineyard rows.

The foremost trend to recognise from both 2000 and 2001 seasons is that there was a high diversity of bird species observed within Mount Canobolas Rosemount Vineyard (Figure 5a and b) and within all vineyards (Figure 6a and b). There were an equal number of bird species observed in all vineyards between 2000 and 2001 (see Figures 6a and b). Interestingly, more species were recorded at Mount Canobolas Rosemount in 2001 compared with 2000 (see Figures 5a and b). The most abundant species included starlings, Silvereyes, Pied Currawongs, and Noisy Friarbirds (Figures 5a and b, 6a and b).

Starlings were the most abundant species observed at Mount Canobolas Rosemount Vineyard in 2000 and 2001 (79% and 60% respectively)(see Figure 5a and 5b). The remainder of birds observed at the vineyard comprised species in relatively low abundance compared with starlings. In contrast to all other vineyards combined, Mount Canobolas Rosemount Vineyard contained considerably higher numbers of starlings (both years)(Figures 6a and 6b). Mount Canobolas vineyard also had fewer Noisy Friarbirds in 2000 (Figures 5a and 6a) and fewer Pied Currawongs during 2001 in contrast to all other vineyards (Figure 5b and 6b).

It is imperative to recognise that bird abundance does not necessarily correspond with damage to vineyards, nor reflect the damage they cause in other habitats. Similarly, it has certainly not been established that all these bird species actually damage grapes. For these reasons, caution should be taken in interpreting these findings. Throughout this project, we are progressively gathering valid and verified information on grape damaging species.

High species diversity may be a direct result of high resource opportunities for birds. In general, diverse landscapes support species rich communities (high number of species)(Begon et al., 1986). Mount Canobolas Rosemount vineyard and the surrounding landscape comprise relatively low level habitat diversity in comparison with other vineyards examined in this survey. This may contribute to the high abundance of a single species (such as starlings) at Mount Canobolas Rosemount Vineyard. During the two seasons surveys, starling abundance appeared to decline. This may actually reflect reduced population size in 2001. However, an alternative explanation for the decreased abundance of starlings observed in 2001 may be that there were differences in sample techniques between seasons. During 2000, only the birds observed in the vineyard rows were recorded, whereas during 2001, a more comprehensive assessment was made across the entire vineyard landscape (including non-vineyard habitats). This may have lead to increased detection of other species, which is verified in the data (Figures 5a and b).

Species richness observed during 2000 and 2001 within all vineyards was almost equal (n=12 and n=14 respectively). This suggests the 2000 survey was marginally less capable of detecting the species present. Thus, the trend indicating increased species richness at Mount

Canobolas Rosemount in 2001 is likely a valid result, implying the number of species is rising, or that the 2001 method is more receptive to detecting species in low abundances.

Despite these findings, the most important information to acknowledge is that starlings were clearly more abundant in Mount Canobolas Rosemount Vineyard over both seasons than any or all other species combined (Figures 5a and 5b). Similarly, starlings were more abundant than in all other vineyards (Figures 6a and b). The Mount Canobolas Rosemount vineyard landscape differed from other vineyards in size and vegetation composition. Many other vineyards contain remnant and regrowth woodlands, scattered timber and vegetated creeks. Mount Canobolas Rosemount vineyard is contained within a more open treeless landscape. This may have discouraged native birds and encouraged exotic birds, leading to substantially different species compositions. This is an important aspect to recognise when planning and implementing bird management at Mount Canobolas Rosemount Vineyard.

3.2.2 Birds species observed at Mount Canobolas Rosemount Vineyard throughout the ripening season.

There were many species of birds observed at Mount Canobolas Rosemount vineyard during 2000 (Figure 5a). Preliminary data suggests eight species were observed on over 20% of occasions within and between vine rows (Figure 7). These data present the occurrence of bird species within vine rows, but not their relative abundances. For instance, starlings were the most commonly observed species, and almost 40% of observations were made within vine rows, and 60% within other habitats (Figure 7). In addition, 43% of Black-faced Cuckoo Shrike were within vine rows, the remainder were in other habitats. In contrast, Noisy Miners were not seen within vine rows, all were observed in other habitats (Figure 7). This indicates many species are regularly observed within vine rows, but they also occupy many other habitats as well. This implies that effective management of the damage birds cause may require recognition of their use of non-vineyard habitats.

There are a few constraints to this data that currently limit what can be deduced about bird use of habitats at the vineyard. Firstly, there are an unequal number of observations per species, and some have small sample sizes. As a result, we should not be overly confident that these early results are entirely accurate, nor should we be too hasty in comparing between species. Secondly, these data do not imply species selection of particular habitats, because each habitat varies in its availability. For instance, vines occupy a large proportion of the Mount Canobolas Rosemount landscape, and some birds may be observed within the vines through chance alone. These factors can be overcome with further analysis.

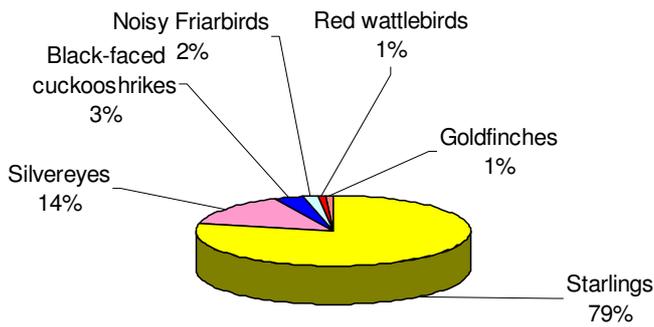


Figure 5a: Bird species abundance at Mount Canobolas Rosemount vineyard during 2000

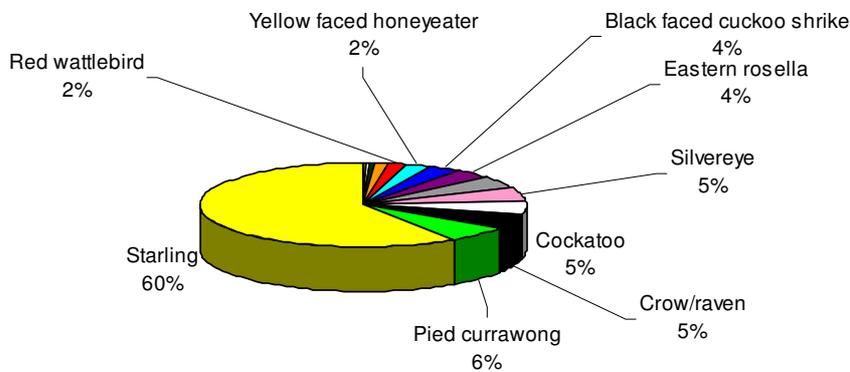


Figure 5b: Bird species abundance at Mount Canobolas Rosemount vineyard during 2001 (partial data-set)

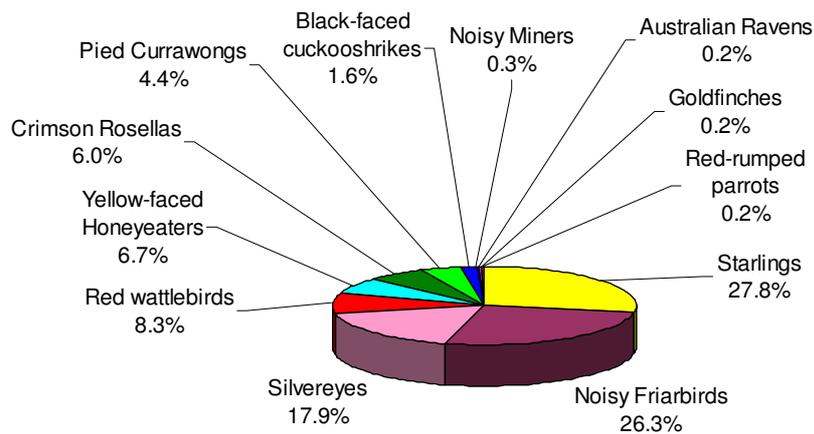


Figure 6a: Bird species abundance within all other surveyed vineyards during 2000

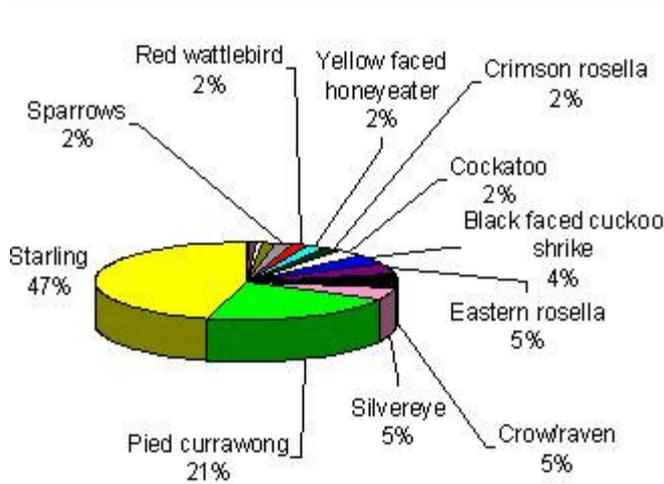


Figure 6b: Bird species abundance within all other surveyed vineyards during 2001 (partial dataset)

The availability of habitats at Mount Canobolas Rosemount differ, as does the sight-ability of each bird species within each habitat. For example, birds are more easily seen in open habitats than within the vegetated areas. As a result, caution is required when interpreting the above data as the preliminary datasets have not yet been scaled for habitat availability, nor species sight-ability. Further examination of full datasets will provide valuable understanding of species habitat relationships that may be used to develop management options for minimising overall bird damage.

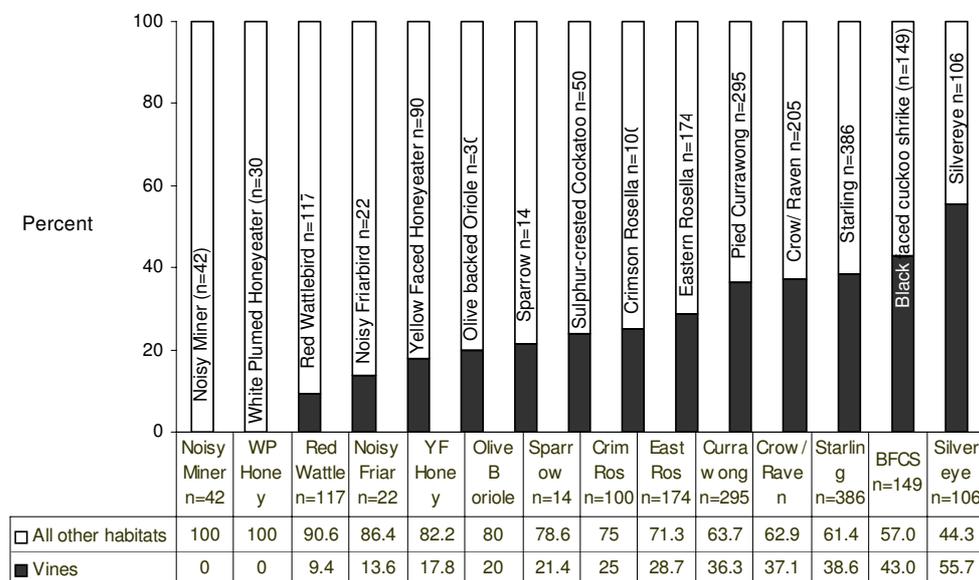


Figure 7: Percent occurrence of bird species within vineyard habitat during 2001: Note: starlings were observed in the highest abundance of all species.

3.2.3 Selection of habitats within the Mount Canobolas Rosemount vineyard

3.2.3.1 Temporal change in birds observed throughout the ripening season.

The number of birds observed in Mount Canobolas Rosemount vineyard during the 2001 bird surveys increased progressively throughout the season (Figure 8). Alarming, the abundance of perceived crop damaging species declined throughout the season (Figure 9), despite anecdotal evidence suggesting starling groups increased as the season progressed (P West pers. obs.). It is important to note that these findings are from partial datasets, and are therefore inconclusive. Full examination of these data is pending. It is anticipated that the data will reveal precisely when the greatest abundance of crop damaging birds are present, to provide accurate guidance on the most suitable time for management.

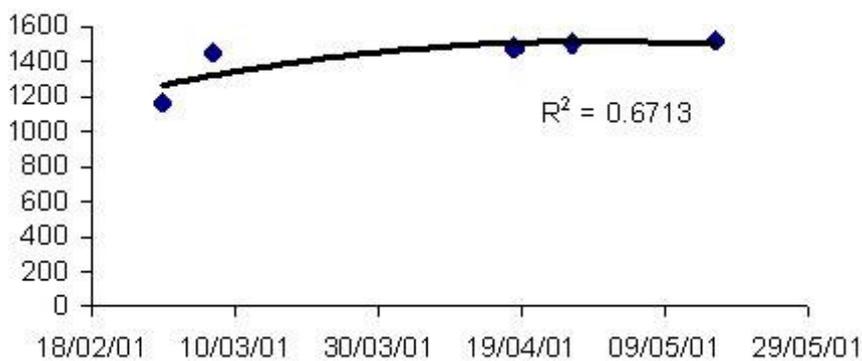


Figure 8: Number of birds observed within Mount Canobolas Rosemount Vineyard during 2001 (partial data-set)

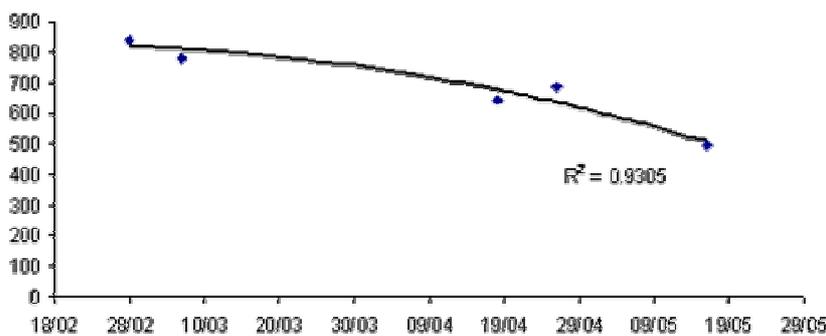


Figure 9: Number of perceived crop damaging birds observed within Mount Canobolas vineyard during 2001 (partial data-set)

3.3 Results of Behaviour study 2001

3.3.1 Spatial and temporal movements of starlings.

There were six months of behavioural data collected at Mount Canobolas Rosemount vineyard. Assessments during March, April and May 2001 broadly corresponded with ripening, harvest and post harvest of grapes. The starling distribution data presented overleaf

for March, April and May were compiled from n=166, n=394 and n=73 observations respectively. Although we have data for other months, they contained fewer observations and were overlooked for this inquiry.

Firstly, it is important to recognise that starlings are inhabiting a large area at Mount Canobolas Rosemount vineyard. Preliminary movement results suggest starling home-range size displayed an expansion during the ripening period (between March and April), followed by a contraction after the final grapes were harvested (within May) during 2001 (Figure 9). This contraction suggests the resources available within grape producing vines, offer starlings opportunities that would otherwise be unavailable. This in-part implies that grapevines are supporting starlings, and the problem/s they cause are likely to be ongoing. As a result, managing this ongoing problem warrants a well-planned strategy to reduce their negative impacts. The observed expansion and contraction is important for recognising the dynamic problems associated with these birds, and will help in assigning long-term management strategies.

The data presented in this document offer important information about the movements of starlings. The data suggest the main activity areas for starlings during March, April and May. These months broadly correspond with the harvest of grapes at the vineyard (10 March to 26 April) and post harvest period (May) during 2001.

During March 2001, the main starling activity centre was located in the northern portions of the vineyard (Figure 11). However, there were a high abundance of observations in the west of the southern portions of the vineyard (Figure 11).

During April, most starling activity was distributed between both the northern and southern portions of the vineyard, with epicentres of activity corresponding with the northern fringe of the northern portions of the vineyard, and the centre of the southern portions of the vineyard respectively (Figure 12).

The May distribution corresponds with the post harvest of grapes at the vineyard. There is a substantial contraction in starling home-range size and shape (Figure 13). The post harvest distribution concentrates north of the northern parts of the vineyards and along the creek to the east of the Estate. During this period, starlings were observed foraging under vine rows and in many grassy habitats. These aspects may be beneficial in implementing follow-up control.

These movement/behaviour data will be compared with the measured grape damage data to establish whether observations of starling movements can be used to predict damage to grape varieties.

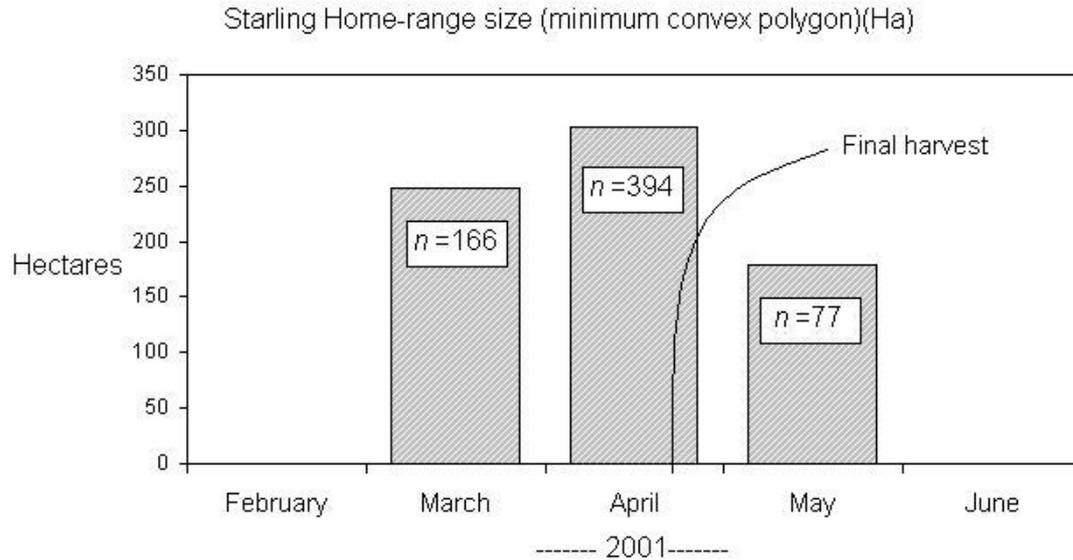


Figure 10: Starling home-range size (minimum convex polygon) derived from behavioural observation data during ripening of 2001.

These data investigate the relationship between grape ripeness and starling home range size. It indicates a contraction, followed by expansion in starling home range size, however, the relationship is unclear and requires verification, because home-range size correlates with the number of observations made for each month. In other words, the sample sizes for March (n=166), April (n=394) and May (n= 73) correspond with an increase and decrease in home-range size (see Figure 9). This is an expected relationship, but requires some further analysis or confirmation over subsequent ripening seasons.

It is important to recognise that these data represent locations where starlings were seen at the vineyard, which includes foraging, feeding in vines, roosting, perching, drinking, and bathing, and does not represent the number of starlings at each location. We stress that the information should not be taken to reflect where the highest densities of starlings occurred, but rather where most observations were made. As a result, judgement of abundance/density is required.

In coming months, these data will be more rigorously examined/analysed for starling movement patterns and foraging effort.



Figure 11: High activity areas for starlings for March 2001 derived from behavioural movement data

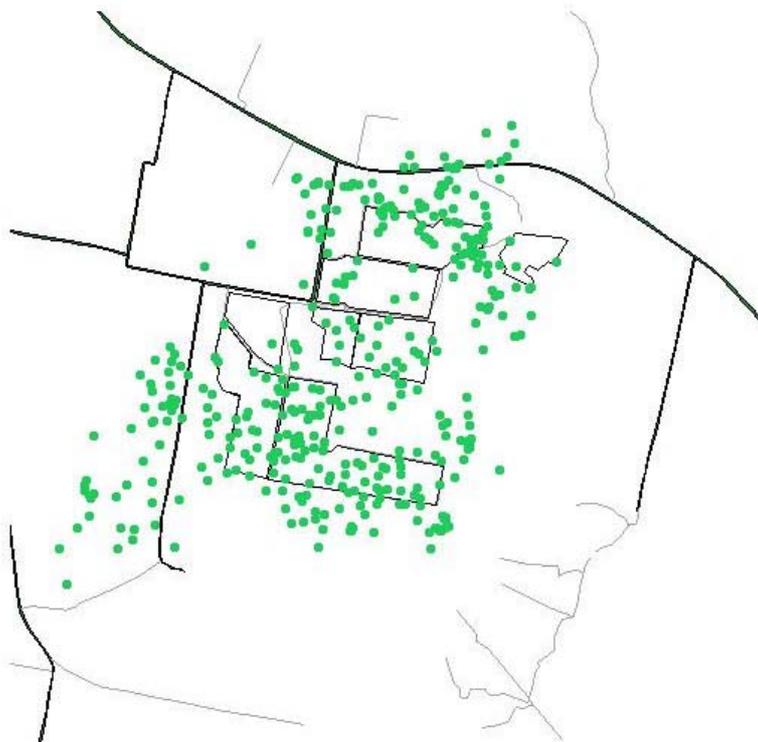


Figure 12: High activity areas for starlings for April 2001 derived from behavioural movement data.



Figure 13: High activity areas for starlings for May 2001 derived from behavioural data.

4. Synopsis

To summarise, levels of damage to grapes varied markedly between vineyards during 2000. Each vineyard examined contained a different combination of grape varieties, and there was no consistent trend in damage to any particular variety of grapes across the Orange region during 2000. Damage appears to be occurring on a site-specific basis, each vineyard experiencing differing damage patterns. Further research aims to identify whether site-specific circumstances override preference for particular grape varieties.

There was a high diversity of bird species within Mount Canobolas Rosemount vineyard, more species were detected in 2001 compared with 2000. Introduced starlings (*Sturnus vulgaris*) were by-far the most abundant species across all vineyards, and Mount Canobolas Rosemount vineyard contained significantly more starlings than other vineyards. This is possibly associated with the scarcity of remnant vegetation within the vineyard environment (C Kinross pers. comm 2001). A possible explanation for the variation in bird species observed between vineyards could be that each vineyard surveyed occupies slightly different landscapes: with differing vineyard size and shape, different surrounding vegetation, topography, proximity to alternate resources, and being subjected to different control programs. These characteristics may influence species composition markedly.

When interpreting the information, it is important to remember that bird abundance does not necessarily reflect damage, and caution should be taken not to presume that where bird abundance is high implies damage will be high, particularly given that some species have not yet been identified to cause damage to grapes.

Many bird species were noted utilising habitats outside vines at Mount Canobolas Rosemount vineyard, suggesting recognition of this is needed for effective management of the damage birds cause to wine grapes. More birds were observed as the grape ripening season progressed, yet those birds (perceived as crop-damaging species) declined. These results were inconclusive and require further investigation. Continued research will investigate how species diversity varies throughout the non-ripening and ripening periods to clarify the relationship between ripening grapes and bird species diversity.

Many groups of starlings were observed over a large proportion of Mount Canobolas Rosemount vineyard throughout the ripening and harvest of grapes in 2001. The home-range (main area of starling activity) appeared to expand as grapes ripened at the vineyard, followed by a contraction as blocks were harvested. The centre of activity could be generally described as being located in the northern portions of the vineyard during March 2001, being located at both the north and south of the vineyard during April 2001, and then contracted to the northern edge of the vineyard in May 2001. These movement patterns and trends require verification, and are important for making decisions about where to position control methods (such as gas guns) to reduce the damage starlings cause to grapes.

The Vignerons questionnaire for 2000 revealed bird damage to wine grapes is significantly widespread in the Orange region. According to the questionnaire, damage varied markedly between vineyards, some vineyards experienced high levels of damage, whilst others experienced low levels of damage during 2000. There was a perception that crop damaging birds were more abundant during ripening, and that Silvereyes, starlings, Pied Currawongs, and Noisy Friarbirds were the main species responsible for the damage that occurred.

Many vignerons indicated up to 80% of lost production resulted from grapes being pecked, whilst others indicated up to 100% were removed (total loss of production). As different species exhibit different feeding strategies, the variation in damage types across vineyards may reflect differing species compositions. Continued analysis of existing data, with follow-up surveys may assist establishing the relationship between different species and types and levels of damage.

Sauvignon Blanc was thought to be the most damaged, and Shiraz the least damaged variety of grapes. Prolonged ripening and adjacent vegetation were perceived to increase grape damage, while there were mixed results regarding whether human activity, overhead powerlines, and neighbouring vineyards increased or decreased damage to vine grapes. This project intends to examine with the aid of computer mapping software how these habitat features may influence (or not influence) grape damage.

There were various methods utilised for control of bird species. Shooting was indicated to be the most commonly used control techniques, and was often used in combination with other control techniques over large proportions of vineyards. However, many vignerons indicated that shooting was not an overly effective control method, which suggests perhaps the perception of the usefulness, cost effectiveness and utility of shooting needs to be reviewed to improve bird management in vineyards. Gas guns were thought to provide protection for large areas of vineyard, but netting was regarded as the single most effective method to reduce damage.

5. Management direction

5.1 Management of birds at Mount Canobolas Rosemount vineyard.

Mount Canobolas Rosemount vineyard currently perceive birds as a problem due to their feeding habits reducing grape production. There are many species thought to be damaging grapes, but prior to this research there was little direct evidence on how much damage was being caused by birds, where it was occurring and what overall economic losses to annual production were being endured. Furthermore, there lacks rigorous evaluation of many control techniques being used by vignerons.

Preliminary data presented in this document provide a sound basis for addressing some of these concerns, although it does not yet provide conclusive evidence. Further analysis and research seeks to reach more substantial results. Although it has not been established what levels of damage Mount Canobolas Rosemount vineyard experiences, information from this research indicates where the greatest economic loss is occurring, to which grape varieties and at what stages of development. This has previously been unavailable, and is required to fully understand the complex nature of bird damage to vineyards.

Mount Canobolas Rosemount vineyard is currently utilising several control methods for minimising the damage bird cause to grapes. These methods include lethal shooting, gas guns, and visual deterrents (management staff and their vehicles). There is anecdotal evidence suggesting the use of these control methods at the vineyard deter feeding birds from vines. Bird damage has been established to be occurring around the periphery of vine blocks, supported by anecdotal evidence of feeding behaviour. Continuation of control around the periphery of vine blocks is encouraged to reduce edge foraging.

The removal of vegetation perceived as perching sites for crop-damaging birds is not seen as providing any long-term relief from bird damage. Anecdotal evidence (yet to be confirmed from behavioural data) suggests starlings (and perhaps other species) respond opportunistically by utilising the adjacent perching sites, regardless of their distance/proximity to vines. The perception that vegetation supports crop-damaging birds thereby increases damage may require re-evaluation, particularly given many other vineyards exhibit far larger remnant woodland communities.

5.2 Recommended ways to improve your ability to manage birds and reduce the impacts they cause

Keep a bird list and make a concerted effort to identify bird species during future grape ripening periods. Having current knowledge of your pest birds may help to deliver a more species specific control effort. The main species observed during 2000 can be seen in Figure 5a, and the main species observed in 2001 can be seen in Figure 5b. Starlings were the most abundant, and have been implicated with damage at Mount Canobolas Rosemount. Because species abundances change seasonally, and are different from year to year, it is important to keep records of how this is occurring. Make an advanced list of species in coming seasons to establish this variation. This will assist the development of an effective species-specific management approach, which should target the problem bird species each season.

Make general observations of where damage is occurring in your vineyard, and note any habitat features that may be influencing this damage eg. powerlines. This may help focus your

control effort and allow more precise placement of your chosen control technique(s). Mount Canobolas Rosemount vineyard has many different habitat features surrounding the vineyard environment. How birds use these across the ripening period may differ to how they utilise these features throughout the off-season. Be diligent to monitor the use of habitats were feasible to improve your understanding of birds in your vineyard.

Take note of the arrival and departure patterns of bird species during future grape ripening periods. Predicting seasonal and opportunistic movements of your pest birds, from previous seasons, may help to identify the amount, type and likely areas where damage will occur, and further help in the appropriate timing and delivery of effective control. Yellow-faced Honeyeaters and other species migrate through Orange each year, attempt to determine which direction they travel. This may help with the positioning of control methods and the development of control strategies. Furthermore, note the central bird activity areas (such as those described in this report for starlings), allowing the placement of control devices within key areas to combat the damage birds cause. This will target the problem at its centre.

Measure and record the proportion of your grapes that are pecked or removed during future grape ripening periods. This information will help identify the type (peckers or removers) of crop-damaging birds that cause damage in your vineyard. This may aid in choosing a more appropriate type of control.

Communicate with other vignerons in your local area to discuss the effectiveness of different control techniques. This information may be very helpful, although it will only have particular relevance providing damage occurs from similar bird species on similar grape varieties. Converse with Nioka vignerons and those creating new vineyards, to develop a strategic control program across a larger landscape. This is thought to be the best method for reducing the negative effects of pest animals.

Make notes of where previous control devices/techniques were set up and evaluate whether these positions were appropriate. Evaluation may be achieved by monitoring the amount of bird damage and observing the number of birds surrounding positioned control devices/techniques during future grape ripening periods. More specifically, mark on maps the location, date and duration of control techniques near or around vine blocks.

Adopt a planned approach to trial different ideas or control techniques, anything is possible, you may have a more effective solution. For example, trial a combination of control techniques rather than a one off control. A preventative management approach may be far more effective than one that is reactive (responding after damage occurs).

5.3 Continuation of project

Mount Canobolas Rosemount vineyard is contributing valuable support in this research project which aims to improve current understanding of bird vineyard interactions to improve management of pest birds in vineyards. During the remainder of 2001 and the season approaching, it is hoped that research will be ongoing with regard to assessing grape damage to the vineyard, bird species surveys, and starling behavioural research.

The increased numbers of starlings observed during the ripening period (February to May) in vineyards is generally believed to be a result of increased food availability. However, overseas research suggests starlings may lay up to three broods per year with four-six per clutch, depending on environmental conditions (e.g. Feare 1984). This allows potential 6 fold increases in the populations of starlings in vineyards just prior to ripening. Control programs in this period are therefore unlikely to reduce populations in the long term due to the large number of juveniles and high rates of natural mortality in the first year. However, control programs that target breeding birds have the potential to cause longer reduction in starling numbers.

There is no information available in Australia on the timing of breeding, reproductive success or potential rates of increase of starling populations, which are necessary to develop the effective control of starlings in the breeding season. The involvement of Mount Canobolas Rosemount vineyard will allow this to be investigated, potentially improving the ability of land managers to minimise the damage starlings cause.

In October 2000, at Mount Canobolas Rosemount vineyard, starling nests were continuously monitored for two weeks by systematically searching for nest sites and recording the numbers of eggs and offspring found in each nest. This provided an instantaneous census of nests and nesting hollows on the study site. To obtain more quantified information on breeding behaviour and to ascertain the timing and length of the breeding season, we plan to monitor artificial and natural nesting hollows between August 2001 and April 2002.

Nest selection by starlings will be investigated to establish whether there is selection/preference for nesting opportunities in close proximity to vineyard resources. This information is valuable as knowledge of starling nesting and breeding behaviour will aid in identifying target areas, and could assist in assessing the feasibility and development of control techniques involving nesting areas to reduce impacts of wine grapes.

Existing grape damage data is currently being examined to explore the spatial dimensions to bird damage in vines (and their associated economic implications), examining variety trends, spatial and temporal trends to damage, and the influence of distance to surrounding habitat features on levels and locations of damage. We are also embarking on analysis to examine whether there is a correlation between starling foraging activity and where main grape damage is occurring, to establish whether they can be linked to specific damage rates.

APPENDIX 2: Contact Details for Key Grape and Wine Industry Organisations

National:

Australian Wine and Brandy Corporation
555 The Parade, Magill 5072
PO Box 595, MAGILL 5072
Tel: +61-8-8364-2828
Fax: +61-8-8364-5151

Australian Wine Export Council
555 The Parade, Magill 5072
PO Box 622, MAGILL 5072
Tel: +61 8 8364 1388
Fax: +61 8 8364 2290
Email: awec@awbc.com.au

Grape and Wine Research and Development Corporation
555 The Parade, Magill 5072
Tel: +61 8 8364 2688
Fax: +61 8 8364 3315
Email: gwrdc@camtech.net.au

Wine Australia Pty Ltd
555 The Parade, Magill 5072
Tel: +61-8-8364-1122
Fax: +61-8-8364-4489
Email: wineaust@ozemail.com.au

Wine Industry Information Service
First point of contact for general enquires about the Australian wine industry.
Ms Susan Bell
PO Box 595, MAGILL 5072
Tel: +61-8-8331-2220
Fax: +61-8-8364-5151
Email: susan.bell@awbc.com.au

Wine grape Growers' Council of Australia Inc
555 The Parade, Magill 5072
Tel: +61 8 8364 3990
Fax: +61 8 8364 0907

Winemakers' Federation of Australia Inc
555 The Parade, Magill 5072
PO Box 647, MAGILL 5072
Tel: +61 8 8364 1122
Fax: +61 8 8364 4489

WINETAC Inc.

1st Floor, 206 Greenhill Road, Eastwood 5063

Tel: +61 8 8364 5322

Fax: +61 8 8331 0722

CRC for Viticulture

Plant Research Centre Hartley Grove Urrbrae SA 5064 or

PO Box 154 Glen Osmond SA 5064 Australia

Tel 61 8 8303 9405

Fax 61 8 8303 9449

E-mail hardie.jim@pi.sa.gov.au

State and Regional:

ACT

+Canberra District Vignerons' Association. Mr David Madew, mobilephone 0411-380-677

GPO Box 2474, CANBERRA 2601 Tel: +61-2-6238-0256 Fax: +61-2-4848-0026

QUEENSLAND

+Queensland Winemakers' Association. Mr Angelo Puglisi, President PO Box 26,

BALLANDEAN 4382. Phone +61-7-4684-1187 Fax +61-7-4684-1187

NEW SOUTH WALES

+New South Wales Wine Industry Association. PO Box 1638, GRIFFITH 2680 Phone +61 2 6964 4762 Fax +61 2 6964 3526

Broke Fordwich Winegrowers Association. Mr Chris Elsmore, President PO Box 32, BROKE 2330 Phone +61-2-6579-1334 Fax +61-2-6579-1334

Hilltops Vineyards Association Inc. Mr Brian Mullany, Secretary C/- 48 Boorowa Street, YOUNG 2587 Phone +61-2-6384-4272 Fax +61-2-6384-4292

Perricoota Grape Growers Association. Mr Kron Nicholas, Secretary PO Box 150, MOAMA 2731

Shoalhaven Grapegrowers and Winemakers Association. Mr Ray Cleary, President C/- The Silos Estate, B640 Princes Highway, JASPERS BRUSH 2535 Phone +61-2-4464-1596 Fax +61-2-4464-1596

Tumbarumba Vignerons Association. Mr Frank Minutello, President PO Box 82, TUMBARUMBA 2653 Phone +61-2-6948-4457 Fax +61-2-6948-4457

NORTHERN TERRITORY

The only Northern Territory winery is Chateau Hornsby in Alice Springs

SOUTH AUSTRALIA

+S A Wine and Brandy Industry Association. Inc 555 The Parade, Magill 5072 Phone +61 8 8331 0042 Fax +61 8 8331 0722 Email linda@winesa.asn.au

+Phylloxera and Grape Industry Board of SA. 15th Floor, 25 Grenfell Street, Adelaide 5000 PO Box 1671, ADELAIDE 5001 Phone +61 8 8226 0430 Fax +61 8 8226 0425

Koppamurra Grape growers Association. Mr James Wark, President PO Box 717, NARACOORTE 5271

Limestone Coast Wine Industry Council Mr Doug Balnaves, President PO Box 2B, COONAWARRA 5263 Phone +61-8-8737-2946 Fax +61-8-8737-2945

TASMANIA

+Vineyards Association of Tasmania Inc. Ms Di McArthur, Executive Officer 58 Tamar Street, LAUNCESTON 7250 Phone +61-3-6334-9721 Fax +61-3-6331-3496 Email branch.office@tassie.net.au

VICTORIA

Alpine Valleys Winegrape Growers Association Mr Lorenzo Cossignani, Chairman PO Box 600, MYRTLEFORD 3737 Phone +61-3-5752-2349 Fax +61-3-5751-1686 Email merlot@bigpond.com

Ballarat and District Vignerons Association Mr Bill Wallace, President 16 Albert Street, DAYLESFORD 3460 Phone +61-3-5348-1345 Fax +61-3-5348-4077 Email leuragln@netconnect.com.au

Central Victorian High Country Association Inc Mr Robert Ritchies, C/- Delatite Winery PO Box 246, MANSFIELD 3733 Phone +61-3-5775-2922 Fax +61-3-5775-2911

Diamond Valley Viticultural Association Mr Malcolm Lovegrove, President 1090 Strathewen Road, STRATHEWEN 3099 Phone +61-3-9714-8484 Fax +61-3-9714-8484

Far South Western Victoria Viticultural Association Mr Jack Doeven, President RMB 4735, HAMILTON 3300 Phone +61-3-5572-4344 Fax +61-3-5572-4446

Kyneton Vignerons Group Mr Jim Leach, President PO Box 502, KYNETON 3444 Phone +61-3-9802-3832

Maryborough Winegrowers Association Mr Robin Lietch, President PO Box 468, MARYBOROUGH 3465 Phone +61-3-5461-3312 Fax +61-3-5461-3312

Mid-Murray Wine Grape Growers Mr Colin Free, President PO Box 53, TRESCO 3583 Phone +61-3-5037-2657 Fax +61-3-5037-2657

Robinvale Winegrape Growers Mr Brian Englefield, President PO Box 739, ROBINVALE 3549 Phone +61-3-5026-0255

Sunbury Winemakers Association Mr Pat Carmody, C/- Craiglee PO Box 2, SUNBURY 3429 Phone +61-3-9744-4489 Fax +61-3-9744-4489

WESTERN AUSTRALIA

+Wine Industry Association of WA Inc R.A.S. Showgrounds, Claremont 6010 PO Box 83, CLAREMONT 6010 Phone +61 8 9385 1699 Fax +61 8 9385 1538

Mount Barker Wine Producers Association Mr Tony Smith PO Box 155, MOUNT BARKER 6324

South West Coastal Wine Producers' Association Mr William Nairn, President C/- Baldivis Estate, RMB 249A, River Road, BALDIVIS 6171 Phone +61-8-9525-2066 Fax +61-8-9525-2411

+ Major state industry associations

APPENDIX 3: Report on the use of Alpha-chloralose to Sample Native Birds following a Newcastle Disease Outbreak at Rylstone, September 1999

Newcastle disease is a potential detrimental disease of domestic poultry. Commonwealth, states and territories have provided assistance for the containment of this disease using contingency management procedures. NSW Agriculture, as the lead agency for animal emergencies in New South Wales is responsible for coordinating the state's response. On the 22nd September 1999, Newcastle disease was confirmed present at a free-range poultry farm 20km ESE of Rylstone in the Central Tablelands of NSW. In an effort to contain the disease, all domestic birds including poultry and domestic pets were euthanased and disposed of according to recommended procedures. Due to the free-range nature of the farm and accessibility of litter and surplus feed to native birds a sampling regime was implemented in an attempt to detect the presence of the disease in native bird populations. Free-feeding sites were set up and monitored continuously throughout the two-day sampling period (30th September to the 1st October 1999). Alphachloralose was supplied by Animal Control Technologies on grain bait as per National Registration Authority for its emergency use. This poison feed was applied to one feeding location. A time-line of events is provided below (Figure 1).

Galahs (*Eolophus [Cacatua] roseicapillus*) and crested pigeons (*Ocyphaps [Geophaps] lophotes*) were the only species regularly observed at the targeted feeding location (see Figure 2). However, common starlings (*Sturnus vulgaris*), red-rumped parrots (*Psephotus haematonotus*) and Australian magpies (*Gymnorhina tibicen*) were observed at the same site but on fewer than three occasions. Galahs and crested pigeons were the only species noticeably affected following consumption of the poison grain. Alphachloralose was slow acting on galahs, despite considerable bait consumption. In contrast upon consuming much less crested pigeons appeared highly susceptible. All galahs that were visibly affected by Alphachloralose were observed leaving and were found away from the feeding site. Individual galahs sampled were found in a comatose state, no deceased galahs were discovered despite extensive searching of the surrounding area. However seven crested pigeons had deceased at the feeding location prior to sampling, which highlights their increased susceptibility. After 24 hours following the first application of the bait, 18 crested pigeons and 13 galahs were known to be comatose or deceased.

Remaining samples (34 galahs and 1 red-rumped parrot) were collected using a .22 calibre rifle with subsonic ammunition and a 12 gauge shotgun. To avoid dispersing feeding flocks shot samples were taken in the vicinity, close to but not at the feeding site and only individuals or small groups of birds were targeted. In total, blood samples were taken from 19 crested pigeons, 50 galahs and 1 red-rumped parrot. None of these were tested positive to Newcastle disease.

Figure 1: Timeline of events for native bird sampling following the containment of a Newcastle disease outbreak at Rylestone September 1999.

Wednesday 30th September 1999

8:15-9:00	Site coordinator and staff arrive: John Druhan (NSW Ag), John Tracey (NSW Ag), Ken England (NPWS), David Sampson (NPWS), Tom Braz (NSW Ag Video)
9:30	Alphachloralose arrived (Mal Leeson Mudgee RLPB Ranger)
11:30	3 Virkon Caps of poison grain placed at a single feeding location
12:05	6 Galahs started feeding on grain trail (tentatively at first)
12:10	3 Galahs land at the feeding site.
12:15	Galahs dispersed
12:30	15 Galahs arrived
12:35	Galahs dispersed
12:35	4 Galahs arrived
12:36	2 Galahs, 2 crested pigeons arrived
12:37	2 Galahs arrived
13:05	1 Crested Pigeon down (Stunned not dead)
13:30	Crested Pigeon collected and sampled
13:50	Some individual galahs appeared dazed and dizzy following bait consumption but flight was only marginally affected.
14:00-18:30	Ongoing visitation to feeding site by Galahs and occasionally Crested Pigeons throughout the afternoon. Area searched opportunistically throughout the afternoon for birds affected which had dispersed the feeding site. Sample of 17 Crested Pigeons and 13 Galahs
18:30	All staff disinfected and left the location

Thursday 1st October 1999

6:00	Broad scale ground search of area (John Druhan and John Tracey). 1 Galah and 1 Crested Pigeon found. Galah sampled.
6:00-8:00	Galahs feeding and 2 Galahs sampled.
8:00	Mal Leeson (RLPB Ranger) arrived
8:00-10:00	Only the occasional bird feeding no new samples.
10:00-13:00	Shot sample of 34 galahs and 1 red-rumped parrot was collected. Total sample of 19 Crested Pigeons, 50 Galahs and 1 Red Rumped Parrot.
13:00-13:30	ALL remaining grain was collected and removed from the feeding site and buried (at least 50cm below the ground). Blood sampling area washed down and disinfected. Area searched for any birds.

Figure 2: Birds observed at the Rylstone free-range poultry farm 30th September – 1st October 1999.

Galah*+	Welcome Swallow	Australian Raven
Crested Pigeon*+	Australian Pelican	Nankeen Kestrel
Common Starling*	Crimson Rosella	Willie Wagtail
Red-rumped Parrot*	White faced Heron	White Plumed Honeyeater
Australian Magpie*	Dusky Woodswallow	Eastern Rosella
Sulphur Crested Cockatoo	Sacred Kingfisher	Pipit
Little Corella	Magpie Lark (Peewee)	Wood (Maned) Duck
Laughing Kookaburra		

* visited the actual feeding site. + noticeably affected from Alphachloralose

APPENDIX 4: Summary of the main pest birds of horticulture in Australia.

Common Name	Species	Family	Movements	Status
Grey Teal	<i>Anas gracilis</i>	Anatidae	S-RM	Native
Pacific Black Duck	<i>Anas superciliosa</i>	Anatidae	S-RM	Native
Australian Wood Duck	<i>Chenonetta jubata</i>	Anatidae	S-RM	Native
Black swan	<i>Cynus atratus</i>	Anatidae	S-RM	Native
Magpie Goose	<i>Anseranas semipalmata</i>	Anseranatidae	RM	Native
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	Cacatuidae	RM-S	Native
Major Mitchell's Cockatoo	<i>Cacatua leadbeateri</i>	Cacatuidae	S	Native
Little Corella	<i>Cacatua sanguinea</i>	Cacatuidae	RM-S	Native
Long-billed Corella	<i>Cacatua tenuirostris</i>	Cacatuidae	RM	Native
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	Cacatuidae	S-RM	Native
Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii</i>	Cacatuidae	RM	Native
Yellow-tailed Black-Cockatoo	<i>Calyptorhynchus funereus</i>	Cacatuidae	RM	Native
White-tailed Black Cockatoo	<i>Calyptorhynchus baudinii</i>	Cacatuidae	RM	Native
Galah	<i>Elophus (Cacatua) roseicapilla</i>	Cacatuidae	RM-S	Native
Corvids	<i>Corvus spp.</i>	Corvidae	RM	Native
Currawongs (Pied, Black, Grey)	<i>Strepera spp.</i>	Craeticinae	RM	Native
Emu	<i>Dromaius novaehollandiae</i>	Dromaiidae	RM-S	Native
European Goldfinch	<i>Carduelis carduelis</i>	Fringillidae	S	Introduced
European Greenfinch	<i>Carduelis chloris</i>	Fringillidae	RM-S	Introduced
Australian Brush Turkey	<i>Alectura lathami</i>	Megapodiidae	S	Native
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	Meliphagidae	RM	Native
Red Wattlebird	<i>Anthochaera carunculata</i>	Meliphagidae	S	Native
Blue-faced Honeyeater	<i>Entomyzon cyanotis</i>	Meliphagidae	M	Native
Yellow faced Honeyeater	<i>Lichenostomus chrysops</i>	Meliphagidae	M	Native
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	Meliphagidae	RM-S	Native
Yellow-throated Miner	<i>Manorina flavigula</i>	Meliphagidae	S	Native
Noisy Miner	<i>Manorina melanophrys</i>	Meliphagidae	S	Native
Noisy Friarbird	<i>Philemon argenticeps</i>	Meliphagidae	RM-M	Native
New Holland Honeyeater	<i>Phylidonyris nigra</i>	Meliphagidae	M	Native
Common Blackbird	<i>Turdus merula</i>	Muscicapidae	S	Introduced
Song Thrush	<i>Turdus philmelos</i>	Muscicapidae	S	Introduced
Yellow Oriole	<i>Oriolus flavocinctus</i>	Oriolidae	S-RM	Native
Olive-backed Oriole	<i>Oriolus sagittatus</i>	Oriolidae	M	Native
Figbird	<i>Specothes viridis</i>	Oriolidae	M	Native
Black-faced cuckoo-shrike	<i>Coracina novaehollandiae</i>	Pachycephalinae	M	Native
House Sparrow	<i>Passer domesticus</i>	Passerinae	S	Introduced
Australian King Parrot	<i>Alisterus scapularis</i>	Psittacidae	S	Native
Australian Ring-neck	<i>Barnardius zonarius</i>	Psittacidae	S	Native
Musk Lorikeet	<i>Glossopsitta concinna</i>	Psittacidae	M	Native
Pale-headed Rosella	<i>Platycercus adscitus</i>	Psittacidae	S-RM	Native
Green Rosella	<i>Platycercus caledonicus</i>	Psittacidae	S	Native
Adelaide Rosella	<i>Platycercus elegans adalaidae</i>	Psittacidae	S	Native
Crimson Rosella	<i>Platycercus elegans elegans</i>	Psittacidae	S	Native
Yellow Rosella	<i>Platycercus elegans flaveolus</i>	Psittacidae	S	Native
Eastern Rosella	<i>Platycercus eximius</i>	Psittacidae	S	Native
Western Rosella	<i>Platycercus icterotis</i>	Psittacidae	S	Native
Regent Parrot	<i>Polytelis anthopeplus</i>	Psittacidae	RM-S	Native
Red-capped Parrot	<i>Purpureicephalus spurius</i>	Psittacidae	S	Native
Scaly-breasted Lorikeet	<i>Trichoglossus chlorolepidotus</i>	Psittacidae	RM	Native
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	Psittacidae	M	Native
Satin Bowerbird	<i>Ptilonorhynchus sp. and Chlamydera spp.</i>	Ptilinorhynchidae	S	Native
Great Bowerbird	<i>Ptilonorhynchus sp. and Chlamydera spp.</i>	Ptilinorhynchidae	S	Native
Common Myna	<i>Acridotheres tristis</i>	Sturnidae	S	Introduced
Common Starling	<i>Sturnus vulgaris</i>	Sturnidae	RM	Introduced
Silvereye	<i>Zosterops lateralis</i>	Zosteropidae	M	Native

Summary of the main pest birds of horticulture in Australia (cont)

Common Name	Breeding	Casual breeding	State
Grey Teal	Jan-Dec	Jan-Dec	All states and territories
Pacific Black Duck	Mar-May,Jul-Oct	Jan-Dec	All states and territories
Australian Wood Duck	Jan-Mar,Aug-Oct	Jan-Dec	All states and territories
Black swan	Feb-Apr, Jun-Sep	Jan-Dec	All states and territories
Magpie Goose	Mar-May	Feb-Jul	NT, QLD, WA', NSW', VIC'
Sulphur-crested Cockatoo	July-Dec	May-Jan	NSW, TAS, VIC
Major Mitchell's Cockatoo	May-Nov	May-Dec	VIC
Little Corella	May-Oct	Feb-Nov	NSW
Long-billed Corella	Aug-Oct	Jul-Dec	VIC, SA, NSW
Gang-gang Cockatoo	Nov-Jan	Oct-Jan	VIC, TAS', NSW'
Red-tailed Black-Cockatoo	Mar-Dec	Feb-Dec	NSW
Yellow-tailed Black-Cockatoo	May-Jan	May-Feb	NSW,TAS
White-tailed Black Cockatoo	Sep-Dec	Aug-Dec	WA
Galah	Feb-May,Aug-Nov	Jan-Dec	NSW, SA, VIC
Corvids	Jul-Oct	Apr-Dec	All states and territories
Currawongs (Pied, Black, Grey)	Sep-Nov	Aug-Dec	NSW
Emu	Apr-Oct	Mar-Nov	All states and territories (except TAS)
European Goldfinch	Sep-Nov	Aug-Feb	NSW
European Greenfinch	Oct-Jan	Sep-Feb	VIC, SA', TAS', NSW'
Australian Brush Turkey	Aug-Feb	Jul-Apr	QLD, NSW
Spiny-cheeked Honeyeater	Jul-Feb	Jan-Dec	NSW
Red Wattlebird	Jul-Feb	Jan-Dec	NSW
Blue-faced Honeyeater	Jul-Jan	Jun-Mar	NSW
Yellow faced Honeyeater	Jul-Jan	Jul-Mar	NSW
White-plumed Honeyeater	Jul-Jan	Jan-Dec	NSW
Yellow-throated Miner	Jul-Jan	Jan-Dec	All states and territories (except TAS)
Noisy Miner	Jun-Jan	Jan-Dec	VIC, NSW, QLD, TAS, SA
Noisy Friarbird	Aug-Jan	Jul-Feb	NSW
New Holland Honeyeater	Mar-May,Jul-Jan	Jan-Dec	NSW
Common Blackbird	Aug-Feb	Jul-Apr	NSW
Song Thrush	Aug-Feb	Jul-Mar	NSW
Yellow Oriole	Aug-Jan	Jul-Mar	QLD, NT, WA
Olive-backed Oriole	Aug-Jun	Jan-Dec	QLD, NSW, VIC, NT, WA
Figbird	Sep-Feb	Aug-Apr	QLD, NSW, NT, WA, VIC, TAS
Black-faced cuckoo-shrike	Aug-Jan	Jan-Dec	All states and territories
House Sparrow	Sep-Feb	Jul-Apr	NSW, TAS, VIC, SA, QLD
Australian King Parrot	Oct-Dec	Sep-Jan	NSW, QLD, VIC
Australian Ring-neck	Mar-May,Sep-Dec	Jan-Dec	WA, SA, NT
Musk Lorikeet	Sep-Nov	Aug-Jan	VIC, NSW, SA, TAS, QLD
Pale-headed Rosella	Apr-Jun,Oct-Dec	Mar-Jul,Sep-jan	QLD, NSW'
Green Rosella	Nov-Jan	Oct-Feb	TAS
Adelaide Rosella	Oct-Dec	Aug-Jan	SA
Crimson Rosella	Oct-Dec	Aug-Jan	NSW, VIC, QLD
Yellow Rosella	Oct-Dec	Aug-Jan	NSW, SA, VIC
Eastern Rosella	Sep-Dec	Aug-Jan	NSW, TAS, VIC
Western Rosella	Sep-Nov	Aug-Dec	WA
Regent Parrot	Sep-Dec	Aug-Jan	WA, SA', VIC', NSW'
Red-capped Parrot	Sep-Nov	Aug-Dec	NSW, WA
Scaly-breasted Lorikeet	Jul-Nov	May-Jan	QLD, NSW, VIC
Rainbow Lorikeet	Sep-Nov	Jul-Jan	NSW, SA, VIC
Satin Bowerbird	Oct-Feb	Sep-Mar	NSW
Great Bowerbird	Oct-Feb	Sep-Mar	NT, QLD, WA
Common Myna	Aug-Mar	Jan-Dec	VIC, NSW, QLD
Common Starling	Aug-Apr	Jan-Dec	ACT, NSW, TAS, VIC, SA, QLD
Silvereye	Aug-Feb	Jul-Apr	VIC, NSW, WA, TAS, SA, QLD

Summary of the main pest birds of horticulture in Australia (cont)

Common Name	Damage to horticultural crops
Grey Teal	Vegetables
Pacific Black Duck	Vegetables
Australian Wood Duck	Vegetables
Black swan	Vegetables
Magpie Goose	Vegetables
Sulphur-crested Cockatoo	nuts, apples, pears, grapes, stonefruit, blueberries, tropical fruit, citrus, vegetables, shoots, buds, flowers.
Major Mitchell's Cockatoo	apples, stonefruit, walnuts, chestnuts, almonds
Little Corella	citrus seeds, young apples, stone fruit, fruit trees and vine foliage
Long-billed Corella	fruit, nuts, apples, grapevine shoot and almonds(SA Vic),
Gang-gang Cockatoo	apples, stonefruit , walnuts, chestnuts, almonds
Red-tailed Black-Cockatoo	fruit, flowers
Yellow-tailed Black-Cockatoo	fruit, apples(Tas)
White-tailed Black Cockatoo	apples
Galah	fruit, nuts, apples, stonefruit, walnuts, chestnuts, almonds(SA, Vic)
Corvids	fruit, , vegetables, tropical fruit, grapes, nuts, olives, cherries
Currawongs (Pied, Black, Grey)	fruit, grapes, olives, nuts
Emu	
European Goldfinch	fruit
European Greenfinch	fruit
Australian Brush Turkey	potatoes
Spiny-cheeked Honeyeater	fruit
Red Wattlebird	grapes, peaches, plums, figs, cherries, olives, loquat, apples, apricots, pears, blackberries.
Blue-faced Honeyeater	fruit
Yellow faced Honeyeater	fruit
White-plumed Honeyeater	fruit
Yellow-throated Miner	fruit
Noisy Miner	fruit
Noisy Friarbird	grapes, cherries, stonefruit, blueberries, tropical fruit, mulberries, bilberries,blackberries, figs, plums, pear.
New Holland Honeyeater	grapes, flowers
Common Blackbird	fruit, grapes, cherries
Song Thrush	fruit
Yellow Oriole	fruit
Olive-backed Oriole	fruit
Figbird	fruit
Black-faced cuckoo-shrike	fruit
House Sparrow	fruit, grain, vegetables, grapes, stonefruit
Australian King Parrot	apples
Australian Ring-neck	cherries, grapes, stonefruit, olives, blueberries, apples and pears (W.A.), flower crops
Musk Lorikeet	pears, peach, cherry, apricot, apples, plum, grapes, nashi, stonefruit, vegetables, flowers, nuts, loquat.
Pale-headed Rosella	cherries, grapes, stonefruit, blueberries, tropical fruit
Green Rosella	apples, cherries, raspberries
Adelaide Rosella	cherries, grapes, stonefruit, blueberries, tropical fruit, apples, pears, Almond buds and flowers
Crimson Rosella	cherries, grapes, stonefruit, blueberries, tropical fruit, apples, pears, Almond buds and flowers
Yellow Rosella	cherries, grapes, stonefruit, blueberries, tropical fruit, apples, pears, Almond buds and flowers
Eastern Rosella	grapes, cherries, stonefruit, blueberries, tropical fruit, apples, pears, blackcurrants
Western Rosella	cherries, grapes, stonefruit, blueberries, tropical fruit, apples(W.A.)
Regent Parrot	fruit, stonefruit (Vic)
Red-capped Parrot	fruit, apples, pears, plums, nectarines (W.A.)
Scaly-breasted Lorikeet	stonefruit, apples, pears, cherries
Rainbow Lorikeet	mangoes, grapes, nuts, stonefruit, apples, pears, cherries, vegetables, flowers
Satin Bowerbird	grapes, fruit, berries, vegetables
Great Bowerbird	fruit, berries, vegetables, pawpaw (personal communication)
Common Myna	fruit, blueberries
Common Starling	fruit, blueberries, grapes, olives, stonefruit, cherries
Silvereye	grapes, cherries, stonefruit, blueberries, tropical fruit, apples, pears

Summary of the main pest birds of horticulture in Australia (cont)

Common Name	Other damage	Legal status
Grey Teal	rice, fish hatcheries, yabbie farms	Protected
Pacific Black Duck	rice, fish hatcheries, yabbie farms	Protected
Australian Wood Duck	rice, lupins, fish hatcheries, yabbie farms	Protected
Black swan	rice, fish hatcheries, yabbie farms	Protected
Magpie Goose	grain	Protected
Sulphur-crested Cockatoo	trees, buildings	Locally unprotected
Major Mitchell's Cockatoo		Protected
Little Corella	saplings, sprouting crops, grain	Protected
Long-billed Corella	sprouting crops, haystacks,	Protected
Gang-gang Cockatoo		Protected
Red-tailed Black-Cockatoo	crops	Protected
Yellow-tailed Black-Cockatoo	pine plantations	Protected
White-tailed Black Cockatoo		Protected
Galah	haystacks, grain, grain storage, playing fields	Locally unprotected
Corvids	grain (Torresian)	Locally unprotected
Currawongs (Pied, Black, Grey)	grain, environmental -nest predation	Protected
Emu	wheat, fences	Protected
European Goldfinch	competition with native species	Unprotected
European Greenfinch	competition with native species	Unprotected
Australian Brush Turkey	fodder oats, lucerne, garden areas	Protected
Spiny-cheeked Honeyeater		Protected
Red Wattlebird		Protected
Blue-faced Honeyeater		Protected
Yellow faced Honeyeater		Protected
White-plumed Honeyeater		Protected
Yellow-throated Miner		Protected
Noisy Miner		Protected
Noisy Friarbird		Protected
New Holland Honeyeater		Protected
Common Blackbird		Unprotected
Song Thrush		Unprotected
Yellow Oriole		Protected
Olive-backed Oriole		Protected
Figbird		Protected
Black-faced cuckoo-shrike		Protected
House Sparrow	competition with native species, fouls public places	Unprotected
Australian King Parrot		Protected
Australian Ring-neck	Forestry plantations (esp blue gum), native vegetation, Xanthorrhoea, garden plants.	Protected
Musk Lorikeet	field crops	Protected
Pale-headed Rosella		Protected
Green Rosella		Protected
Adelaide Rosella		Protected
Crimson Rosella		Protected
Yellow Rosella		Protected
Eastern Rosella		Protected
Western Rosella		Protected
Regent Parrot		Protected
Red-capped Parrot		Protected
Scaly-breasted Lorikeet		Protected
Rainbow Lorikeet	corn, sorghum	Protected
Satin Bowerbird		Protected
Great Bowerbird		Protected
Common Myna	competition with native species, fouls public places	Unprotected
Common Starling	competition with native species, fouls public places	Unprotected
Silvereye		Protected

APPENDIX 5. Common Myna (*Acridotheres tristis*) as a Key Threatening Process

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The following information was provided in response to a request from the NSW Scientific Committee to provide advice on the listing of the common myna (*Acridotheres tristis*) as a key threatening process.

We believe the common myna fulfils the criteria for a key threatening process, as it is likely to adversely affect threatened species and is also likely to lead other bird species that are not threatened to become threatened. Although there is a lack of scientific evidence for the threatened species identified in Australia, studies that have been conducted, including overseas studies, suggests common mynas aggressively exclude native birds from nest hollows, prey upon eggs of native birds (including seabirds) and carry parasites and diseases. The following information is provided to assist the NSW Scientific Committee in evaluating the impact of common mynas.

Competition for nesting sites

Most of Australia's native parrots use hollows in old and dead eucalypt trees for nesting. The supply of such hollows to threatened species has decreased substantially since European settlement due to a range of land management practices including clearing, intensive logging, burning and grazing (Garnett and Crowley 2000). The introduction of the common myna has placed further demands on the supply of this resource.

Anecdotal evidence suggests that in eastern Australia common mynas usurp hollows suitable for use by native parrots, threatening their breeding success (Wright and Wright 1991; Lindenmayer 1993; Peters and Peters 1993).

Common mynas have been shown to be the dominant user of available nest resources in sites in Canberra and were successful in most aggressive encounters with starlings and native parrots during a period of nest-site selection and occupancy (Pell and Tidemann 1997). In this study crimson rosellas (*Platycerus elegans*) and eastern rosellas (*Platycerus eximius*) were mostly affected, but also to a lesser extent red-rumped parrots (*Psephotus haematonotus*) as these smaller species were able to make greater use of cavities with smaller entrances (Pell and Tidemann 1997).

Entrance diameters of less than 45mm exclude common mynas and crimson rosellas but allow entry to species like red-rumped parrots, eastern rosellas and starlings (*Sturnus vulgaris*) (Moeed and Dawson, 1979). This is important to note as smaller threatened, hole nesting species like Coxen's double-eyed fig parrots (*Cyclopsitta diophthalma coxeni*) and turquoise parrots (*Neophema pulchella*) are able to utilise cavities with smaller entrances for which common mynas are unable to compete. Despite this, the presence of common mynas will still reduce the number of holes available to these smaller species that may otherwise use

larger holes (e.g eastern bluebirds and starlings see Pinkowski 1976). This has greater importance for turquoise parrots as loss of nesting sites is outlined as a significant threat to their survival (Garnett and Crowley 2000).

There is also potential for increased competition with the regent parrot (*Polytelis anthopeplus*). Although currently common mynas are not yet established in the south-western corner of New South Wales, where regent parrots occur, they have been sighted in this area and according to a Bioclim model have the potential to expand into this area (Martin 1992). Common mynas are likely to demonstrate dominance and out-compete regent parrots from nesting sites as they have similar nesting requirements to eastern rosellas.

Common mynas have also been implicated in competing with bird species overseas. On Mauritius, common mynas compete for nest holes with the critically endangered echo parakeet (*Psittacula eques*) (Jones 1996). There is also a recorded instance where a common myna attacked a half-grown young echo parakeet which subsequently died (Jones, cited in Feare and Craig 1999). It also is known to displace Mauritius kestrels (*Falco punctatus*) from nest sites (Jones, cited in Feare and Craig 1999).

Predation on native species

Common mynas eat the eggs of seabirds and are known to take eggs of terns (*Sterna*) and noddies (*Anous*) in Fiji and the Seychelles Islands and of gulls (*Larus*) in New Zealand (Feare and Craig 1999). They also eat the eggs and young of other birds (Lever 1987; McCulloch 1991; Watson *et al.* 1992), including the endangered Seychelles magpie robin (*Copsychus sechellnrum*) (Watson *et al.* 1992). The presence of mynas close to magpie robins' nests has also been shown to disrupt egg incubation (Komdeur 1996).

They are also known to attack adult black noddies (*Anous tenuirostris*) and white terns (*Gygis alba*) on Midway Atoll (Grant 1982). A study in Hawaii found in one area that 23% of Wedge-tailed Shearwater (*Puffinus pacificus*) eggs were taken by common mynas, which had entered their burrows (Byrd 1979).

Although there is a lack of evidence in Australia, these overseas studies and recordings may have relevance for a number of native Australian coastal birds, such as the Little Tern (*Sterna albifrons*), Hooded Plover (*Thinornis rubricollis*), Fleshy-footed Shearwater (*Puffinus carneipes*), White Tern (*Gygis alba*) and the Sooty Tern (*Sterna fuscata*). All of these species are threatened species that overlap the distribution of common mynas along the east coast of Australia.

Disease and Parasite hosts

Common mynas may have contributed to declines and extinctions of endemic birds in Polynesia (Holyoak and Thibault 1984) and Hawaii (Warner 1968), where the introduction of exotic parasites like the bird mite (*Ornithonyssus bursa*) and diseases like avian malaria (*Plasmodium cir-cumflexum*) (see Gojrati, 1971) are considered to have been among the processes involved.

Table 1: Threatened Species that may be adversely affected by Common mynas (*Acridotheres tristis*)

Regent Parrot ^{1#}	<i>Polytelis anthopeplus</i>
Coxens Double-eyed Fig parrot ^{1*}	<i>Cyclopsitta diophthalma coxeni</i>
Turquoise parrot ^{1*}	<i>Neophema pulchella</i>
Glossy Black Cockatoo ^{1*}	<i>Calyptorhynchus lathami</i>
Little Tern ^{2*}	<i>Sterna albifrons</i>
Hooded Plover ^{2*}	<i>Thinornis rubricollis</i>
Fleshy-footed Shearwater ^{2*}	<i>Puffinus carneipes</i>
White Tern ^{2*}	<i>Gygis alba</i>
Sooty Tern ^{2*}	<i>Sterna fuscata</i>

¹Competition for nest hollows

²Potential predation of eggs or direct attacks

*Occurs within the current distribution of the common myna

Occurs within the potential distribution (Martin 1992) of the common myna

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APPENDIX 6: Publications, reports and presentations arising from the BRS (NHT)-funded bird project 1999-2003

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