Parrot Damage in Apple Orchards in South-Western Australia – A Review

by S.A. Halse

Technical Report No 8

April 1986

Department of Conservation and Land Management W.A.

ERRATA

PARROT DAMAGE IN APPLE ORCHARDS IN SOUTH-WESTERN AUSTRALIA - A REVIEW. TECHNICAL REPORT NO. 8

Three species of white or yellow-tailed black cockatoo are mentioned in the review. The species referred to as the White-tailed Black-Cockatoo (*Calyptorhynchus baudinii*) is the long-billed species of white-tailed black cockatoo and is better called Baudin's Cockatoo (*C. baudinii*). The species referred to in text as the Yellow-tailed Black-Cockatoo (*C. funereus latirostris*) in fact has a white tail; it is the short-billed species of while-tailed black cockatoo and should be called Carnaby's Cockatoo (*C. latirostris*). The Yellow-tailed Black-Cockatoo (*C. funereus*) listed in Table 6 is restricted to the Eastern States.

The Port Lincoln Ringneck is sometimes erroneously referred to as the Port Lincoln Ringneck Parrot. The species consists of two subspecies: the Port Lincoln (*Barnardius zonarius zonarius*) and the Twenty-eight (*B. z. semitorquatus*).

Page 4, 1st paragraph, line 13 - $400 000 should read $500 000.

Page 9, Table 4 - the second column under Total seed weight should be headed with (gDW) instead of (gFW).

Page 21, 1st paragraph, line 11 - 1984 should read 1985.

Page 25, 1st paragraph, line 20 - Fergusoninidae should read ?Fergusoninidae.

Page 32, 2nd paragraph, line 11 - this year should read 1985.

Page 28, replace 2nd paragraph, line 6 with - However, my own observations suggest it is often not acquired until at least 18 months. As mentioned above, it is possible....

Page 45, replace 2nd paragraph, line 3 with - particularly in the case of the nominate subspecies *zonarius*. Twenty-eights (*semitorquatus*) are confined to the extreme south-west of the state....

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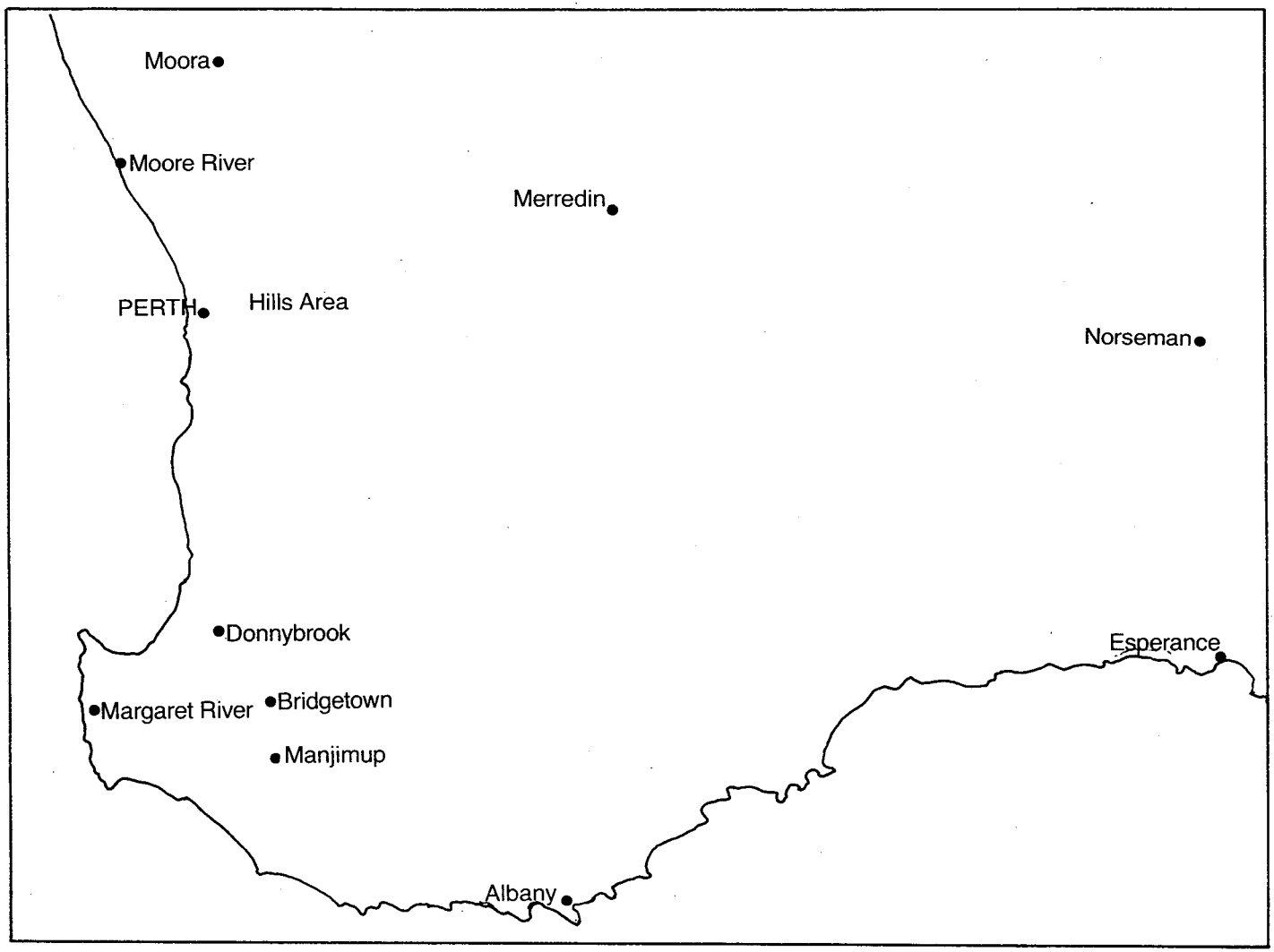

Figure 1. Localities in south-west Western Australia

SUMMARY

In 1984 parrots and cockatoos caused an estimated loss in excess of $1 000 000 by damaging fruit in south-western Australia. Historical records suggest severe damage occurs at intervals of about 10 years, and damage in 1985 was negligible. Most damage occurs to apples, with some varieties being far more susceptible than others, although the reasons for this are not known.

Four species (Port Lincoln Ringneck, Red-capped Parrot, Western Rosella and White-tailed Black-Cockatoo) cause damage. The most important pest species are the Red-capped Parrot in years of severe damage, and the White-tailed Black-Cockatoo in years of light damage.

Marri provides nectar, immature seed capsules and seed for parrots and cockatoos to feed upon. Birds usually move out of orchards when marri flowers (which is also when mature seed capsules dehisce) and levels of damage decline. It is often claimed that severe damage in orchards is the result of poor marri flowering , but the evidence supporting this is weak.

Shooting is the most effective method of controlling the number of birds in orchards, mostly by scaring birds out of orchards, however, rather than reducing populating sizes. With the possible exception of the White-tailed Black-Cockatoo, there is no danger of shooting causing species to become extinct.

Parrot and cockatoo damage in orchards is not a problem confined to Western Australia. There is a problem of similar magnitude in most States, with 20 psittacine species currently causing damage to fruit, nuts and grapes.

It is essential to have more information about the biology of the pest species before satisfactory control measures can be devised. A research programme into the biology of the Red-capped Parrot is proposed.

1 INTRODUCTION

The fruit growing industry in south-western Australia is worth about $30 000 000 annually, of which apples account for 57%, stonefruit 18%, citrus 15%, pears 10% and nuts <1% (personal communication*). Orchards occupy 6 274 ha in three principal areas: Donnybrook, Manjimup and the hills area east of Perth (Fig. 1).

The main arthropod pests in orchards are the Mediterranean fruit fly *(Ceratitis capitata)*, mites (Acarina), lightbrown apple moth *(Epiphyas postvittana)*, San José scale *(Comstockaspis perniciosus)* and apple weevil *(Otiorhynchus cribricollis)*. The only important vertebrate pests are parrots and cockatoos, which cause extensive damage some years. They did so in 1984, which many fruit growers considered the worst year of bird damage on record. The Western Australian Fruit Grower's Association reacted by requesting government agencies to examine ways of controlling parrots and cockatoos; subsequently the Agriculture Protection Board began assessing the efficacy of various bird scaring devices.

The Department of Conservation and Land Management appointed me to review the history of bird damage in orchards, assess its importance, and suggest types of research that might lead to a

* K. Whitely, Department of Agriculture.

reduction in damage levels. Apples are commercially the most important fruit and are also most affected by birds, therefore my work has mostly dealt with damage to apples.

Four psittacine species damage apples in the south-west - the Port Lincoln Ringneck *(Barnardius zonarius)*, Red-capped Parrot *(Purpureicephalus spurius)*, Western Rosella *(Platycercus icterotis)* and White-tailed Black- Cockatoo *(Calyptorhynchus baudinii)*. Honeyeaters and the Silvereye *(Zosterops lateralis)* feed on fruit that is already damaged, but do not initiate damage.

Different varieties of apple ripen at different times, giving an extended picking season that lasts from March until the end of June. Apples become edible for birds some months before they ripen, so that damage can begin occurring as early as December and continue until the end of June. Most apple varieties have been picked by early May.

II DAMAGE IN 1984

From 1982-84 parrots and cockatoos constituted the most important pests in orchards in south-western Australia (personal communication*). As well as apples, which parrots regularly eat, stonefruit and pears suffered damage, which is unusual. In 1984 some citrus fruit were damaged and losses in vineyards were extensive.

Quantitative data on damage levels are available only for 1984, the year of most severe damage. The Manjimup branch of the Western Australian Fruit Grower's Association conducted a survey amongst its apple growers at the end of April. They were asked to estimate losses in their orchards by comparing the quantity of apples actually picked with the production of marketable apples that they would have expected in the absence of bird damage. This circumvented the problem of non-marketable apples (e.g. sunburnt ones) being included in damage estimates. The amount of damage was estimated for varieties that had not been picked at the time of the survey. Some estimates were made by officers of the Department of Agriculture, others were verified by these officers. When J. Long (Agriculture Protection Board) estimated levels of damage on 11 orchards at Manjimup and Donnybrook his estimates were similar overall to those of the orchardists (same in six cases, lower in three and higher in two). Therefore, it seems likely that the data in the survey are soundly based.

* K. Whitely, Department of Agriculture

The survey showed that parrots and cockatoos reduced overall apple production in the Manjimup district by 11.4%, with the mean level of damage in individual orchards being even higher (16.9%, Table 1) because of a tendency for orchards with high total production to suffer less damage. Using 1983 prices to work out the cost of damage (prices were actually higher in 1984 because of a shortage of apples), the mean loss per hectare orchard was $810 (Table 1). This means the average grower in an average-sized orchard lost about $9 000, although the mean loss per orchard was slightly less ($8 000). Cost of control of birds was $76 106. The total cost of parrot and cockatoo damage in the Manjimup district (in terms of reduced production and time or money spent controlling birds) was over $400 000 (Table 2).

Bird damage occurred throughout the apple growing area of south-western Australia in 1984, but was most severe from Donnybrook to Manjimup. It is difficult to extrapolate the Manjimup figures to cover the entire south-west but, on the basis that Manjimup produces only one-quarter to one-third of the State's apples (personal communication*), a $500 000 loss in Manjimup probably means that state-wide psittacine damage cost about $1 000 000. The cost of damage to all fruits would have been higher because stonefruit and pears also suffered significant economic damage in all districts (personal communication**). Around

* K. Whitely, Department of Agriculture.

** J.L. Long, Parrot Research Working Group; K. Whitely, Department of Agriculture.

Margaret River, Port Lincoln Ringnecks caused significant damage to grapes in small vineyards with absentee owners (personal communication*).

Bird damage to citrus fruit is rare, but in 1984 parrots attacked oranges in a few orchards, removing pieces of skin and making the fruit unmarketable (personal communication**; see Robinson, 1960; Sedgwick, 1961). However, this was not economically significant.

* B. Quinlivan, Department of Agriculture.

** C. Scott, Orchardist

TABLE 1

Apple production and losses due to parrots and cockatoos in Manjimup orchards in 1984 (Manjimup Fruit Grower's Association survey)

	Bushels produced ha^{-1}	Bushels lost ha^{-1}	% damage in orchard	$ lost ha^{-1}	Orchard area (ha)
Mean	1434	163	16.9	810	11.6
SE	182	29	3.4	134	2.9
Range	67-4522	0-733	0-100	0-3283	0.4-90
N	33	34	46	34	34

TABLE 2

Financial cost of parrot and cockatoo damage in Manjimup orchards in 1984 (Manjimup Fruit Grower's Association survey)

Variety of Apple	Estimated Loss
Jonathons	$38 580
Red Delicious	$132 402
Golden Delicious	$28 596
Lady Williams	$6 867
Granny Smiths and Cleopatras	$135 754
Yates	$70 468
Others	$15 760
Total Loss	$428 427

III SUSCEPTIBILITY OF DIFFERENT APPLE VARIETIES

The level of bird damage varies amongst cultivars. Red-skinned apples are considered more susceptible to attack than green-skinned ones (Long, 1985). This belief is supported by the 1984 data on damage levels (Table 3). The low figure for Lady Williams apples is a result of the survey being conducted in April before much damage had occurred to this late-ripening variety. Orchardists only estimated damage that had already occurred and did not attempt to predict future damage. Lady Williams suffered severe damage in May and June, when they were the only unpicked apples (personal communication*)

The sugar and acid contents of the flesh of apples of different varieties are variable (Table 3) and damage levels do not appear to be related to either of these parameters in a simple way. Granny Smiths have a low sugar content and suffer little damage, but sugar content seems unlikely to be the complete explanation for this low palatibility because Lady Williams, which have a similar sugar content, sustain severe damage.

Red-capped Parrots and White-tailed Black-Cockatoos eat mostly apple seeds rather than apple flesh (see Section X). Therefore, it seemed likely that damage levels would be better correlated with nutritional value of the seeds than with characteristics of the flesh.

* J. Dell, Western Australian Museum; G. Rowan-Robinson, Orchardist

TABLE 3

Dates of picking of different varieties of apple and their susceptibility to psittacine damage

Variety	Date of picking	Colour	% sugar[1]	Acid content[1] (ml 0.1N NaOH)	1973-75[2]	% damage 1984[3]	1984[4]
Jonathans	early March	red	14.9	12.0	1.3	10-15, 70-80	24 ± 6
Red Delicious	March	red	14.7	11.1	1.4	10-15	24 ± 5
Golden Delicious	March	yellow	15.4	7.0	3.0	10-15	20 ± 5
Lady Williams	early June	red	13.5	11.8	-	-	9 ± 4
Granny Smiths	early March-mid May	green	12.4-13.5	9.3-12.0	0.1	1-2)))	11 ± 3
Cleopatras	early March	green	-	-	0.2	80)	
Yates	late April-early May	red	-	-	1.6	100,100,50,50	43 ± 7
Doughertys	April	red	-	-	3.4	-	-

[1] values at time of harvest for fruit grown at Stoneville Research Station near Perth (G. Ward, personal communication)

[2] mean results from six orchards (Long, 1985)

[3] results from individual orchards (J. Long, unpublished data)

[4] mean results (± SE) from 55 orchards (Manjimup Fruit Grower's Association survey)

TABLE 4

Weight, number, protein and phosphorus content of seeds of different apple varieties

Variety	N	Apple weight (gFW)	Total seed weight (gFW)	Total protein content (gDW)[1]	Total phosphorus content (gDW)[2]	No. of seeds	Weight per seed (gDW)	Protein content per seed (%DW)	Phosphorus content per seed (%DW)
Jonathans (small)	2	104	0.34						
(large)	1[3]	148	0.45	0.26	0.084	0.0016	5, 6, 7	0.038	32	0.62
Red Delicious	2	187	0.46	0.29	0.095	0.0016	9,10	0.030	33	0.56
Golden Delicious										
(small)	2	110	0.31						
(large)	2	200	0.46	0.25	0.087	0.0015	5, 6 7, 8	0.038	35	0.61
Lady Williams	4	157	0.56	0.33	-	-	4-8	0.058	-	-
Granny Smiths	2	204	0.51	0.31	0.134	0.0019	6, 7	0.048	43	0.62
Yates	3	125	0.66	0.42	0.154	0.0027	8-10	0.047	37	0.66
Doughertys	2	130	0.84	0.52	0.181	0.0025	12,15	0.039	35	0.48

[1] micro-Kjeldahl analysis using duplicate samples assuming protein content (gDW) = 6.25 x nitrogen content

[2] spectrophotometric analysis with molybdate-metavanadate using duplicate samples

[3] values from a large Jonathan with only 3 seeds were discarded because it was considered atypical

Weight, protein content and phosphorus content of the seeds were measured for different apple varieties (Table 4).

Yates and Doughertys, the varieties that suffer most damage (Table 4; personal communication*) did have the greatest total weight of seeds and, therefore, the greatest protein and phosphorus content. However, the low damage suffered by Granny Smiths is impossible to reconcile with the supposition that the nutritional value of seeds is the primary factor influencing choice of apples by parrots and cockatoos.

Date of ripening (hence time of picking) does not appear to have any more effect on damage levels than intrinsic properties of the apples, such as rate at which the seeds mature, colour or other factors. Further research is required to explain feeding preferences amongst the different cultivars.

* J.L. Long, Parrot Research Working Group

IV DAMAGE IN 1985

The level of damage in apple orchards in 1985 was much lower than in 1984 and was similar to that recorded in the mid-1970s (Long, 1985). Some apples were damaged in January and the first half of February, then parrot numbers and damage levels dropped sharply as marri *(Eucalpytus calophylla)* began flowering. Around Bridgetown marri flowers heavily until mid-March, with a small amount of blossom remaining until the end of March. Many of the same trees flowered heavily again in May.

The number of parrots in orchards increased again towards the end of March after the first flowering period of marri, but they never became as numerous as in January and the amount of damage remained low. Parrots were almost completely absent from some Manjimup orchards the whole season; damage levels at Manjimup, Donnybrook and in the hills area near Perth were low. There was even less damage to pears and stonefruit than to apples. Grapes were not much affected by Port Lincoln Ringnecks. In economic terms damage by parrots and cockatoos was negligible (cf. Long, 1985).

V BACKYARD FRUIT TREES

Although damage by parrots was negligible in commercial orchards in 1985, it remained severe for people growing a few fruit trees in their backyard both around Perth and in country areas. Apple, pear, stonefruit and almond trees were all affected. Many people lost their entire crop to parrots. At City Beach in Perth, Port Lincoln Ringnecks even nipped almost all the flowers off rose bushes in some private gardens.

Damage will probably always be severe in situations where only a few fruit trees are grown and parrots are present. The simplest solution to the problem is to use netting to protect trees. This is rarely economic in commercial orchards, but financial considerations are often less important for backyard fruit growers. Furthermore, the difference between prices paid to orchardists and retail prices for fruit means that people growing fruit for their own use can afford to spend more on bird control per tree than commercial orchardists.

VI HISTORY AND FREQUENCY OF DAMAGE

History

Examination of *The Journal of Agriculture of Western Australia, The Emu, The Western Australian Naturalist* and *The Warren-Blackwood Times* shows parrots have been recorded eating cultivated fruit in orchards in the south-west since before the turn of the century (Anon, 1897). This led to Port Lincoln Ringnecks and Western Rosellas being declared vermin in 1921 and Red-capped Parrots being declared in 1943. Orchardists lobbied to have bonuses paid for the destruction of Port Lincoln Ringneck and Red-capped Parrots in the early 1930s (Anon, 1933) but this was not possible until Red-capped Parrots were formally declared vermin, after which bonuses were paid for some years (Warham, 1957).

White-tailed Black-Cockatoos were first declared vermin in the Shire of Albany in 1926, but were not declared in the major fruit growing areas until 1942. They were causing damage to apples in Bridgetown by the mid-1930s (Anon, 1936) but were not mentioned as being a pest in orchards there by Whittell (1933), suggesting that they caused little damage prior to the mid-1930s. Bonuses were paid for their destruction from 1952 (Anon, 1952) until 1968.

At present all four species are declared Category A7 animals under the Agriculture and Related Resources Protection Act, which means that the landholders or their approved agents may destroy them on

properties where fruit is grown. Prior to 1984 it was necessary for orchardists to obtain a damage permit from the local Wildlife Officer before shooting birds.

Frequency of Damage

Scanning *The Warren-Blackwood Times* (formerly *The Manjimup-Warren Times)* over the last 50 years leads to the conclusion that although there has been a recognized and continuing problem with birds throughout this period, it has rarely been acute. There was severe bird damage from 1982-84 and in 1969 (personal communication*). If it is assumed that a series of articles about parrots or cockatoos in *The Warren-Blackwood Times*, declaration of species as vermin, or initiation of bonus payments indicates periods of comparatively severe damage, then damage by birds was bad in the early 1950s, early to mid-1940s, early to mid-1930s and early 1920s. Thus it appears there is a period of heavy damage by birds about once every 10 years.

Judging from the temporal spread of articles in *The Warren-Blackwood Times*, and other events, periods of bird damage usually last several years. The 1982-84 patterns, with two years of above-normal damage leading to a very bad year, may be typical.

*J.L. Long, Parrot Research Working Group

Although no data are available, the opinion of older fruitgrowers in the Manjimup and Bridgetown areas is that levels of damage in the 1940s were similar to those experienced in 1984, with damage being less in the outbreaks of the 1950s and late 1960s. Thus there is no indication that the level of damage is increasing with time.

VII FACTORS AFFECTING DAMAGE LEVELS

There are two likely explanations for the level of bird damage being so high in 1984 (or any other year of intense damage). One is that a shortage of natural food forced a greater proportion of the psittacine population than usual out of forest areas into orchards, the other is that the number of parrots and cockatoos had increased because of favourable breeding conditions in the previous seasons and, therefore, when the usual proportion moved into orchards there were more birds. These two explanations are not mutually exclusive, severe damage by birds may be the result of a food shortage occurring when the psittacine population is larger than usual. The number of parrots and cockatoos in forest areas is discussed later (see Section X). The effect of natural food supplies on levels of damage is discussed below as well as the possible influence of a variety of management practices in forests and orchards.

Natural Food Supplies

Marri is the principal natural food source for parrots and cockatoos (see Sections IX and X). When marri flowers heavily the number of parrots in orchards and the amount of damage drops dramatically (personal communication*; personal observation). In addition, marri seed capsules dehisce about the time the trees flower. The relative importance of seeds and nectar in attracting birds out of orchards

* J.L. Long, Parrot Research Working Group

is not clear, but observations by myself and J. Long suggest both are preferred to apples.

Many orchardists attach considerable importance to the flowering of marri in determining whether damage levels will be high in orchards. This is an oversimplification. While marri flowering results in a temporary drop in damage in normal years, damage began in December in the 1983-84 apple season, and by January was already severe. The poor flowering of marri in 1984 exacerbated the situation but did not cause it. Presumably parrots moved into orchards in large numbers in December because of a shortage of natural food. This may have been the result of most native plants flowering and setting seed poorly (Long, 1984, p. 367), or it may have been the consequence of the parrot and cockatoo populations being unusually large and, therefore, exhausting normal levels of food supplies.

The exact importance of marri flowering and seed production in terms of parrot and cockatoo damage can only be determined by detailed investigation over a number of years. Drawing conclusions from historical analysis is fraught with difficulty. For example, the amount of marri honey produced in particular areas has been used previously as an indicator of marri nectar production (Rooke, 1983); in fact it is probably the only available indicator. Yet 1985 was one of the worst honey producing years in the last decade in spite of the fact that marri flowered extensively. The nectar

produced was too dilute for bees to work easily, hence honey production was low (personal communication*), but parrots around Bridgetown fed on it extensively (see Section X).

One interesting anomaly to emerge in 1984, which further emphasizes that marri flowering is not the key to bird damage, is that while Port Lincoln Ringnecks moved into vineyards as well as orchards the traditional vineyard pests, Silvereyes, never appeared in appreciable numbers (personal communication**).

Rooke (1983, 1984a) stressed the importance of marri flowering in preventing damage to grapes, but experience in 1984 suggests that other factors are probably also important.

Meteorological Factors

Meteorological data from Manjimup and Perth between 1961-84 suggest that there is no unique combination of factors giving rise to severe psittacine damage (Figs 2, 3). At Manjimup the 1984 apple season consisted of a warm January preceded by a warm, dry October. Overall, 1983 had slightly below average rainfall. The 1969 season, in contrast, consisted of a cool January preceded by a cool October with close to average rainfall. Rainfall was just below average in 1968.

* J. Spurge, beekeeper

** B. Quinlivan, Department of Agriculture

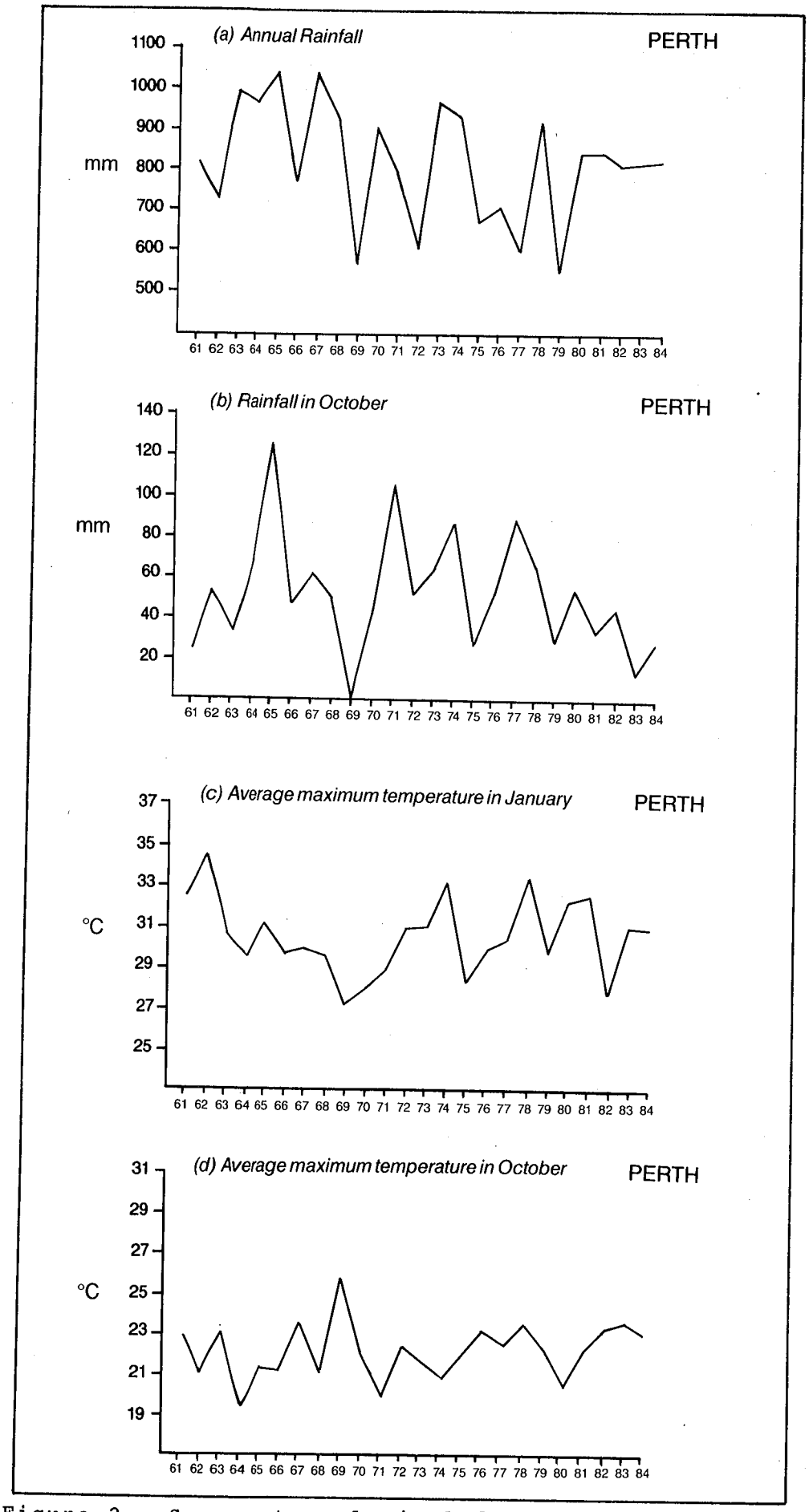

Figure 2. Some meteorological data for Perth, 1961 - '84.

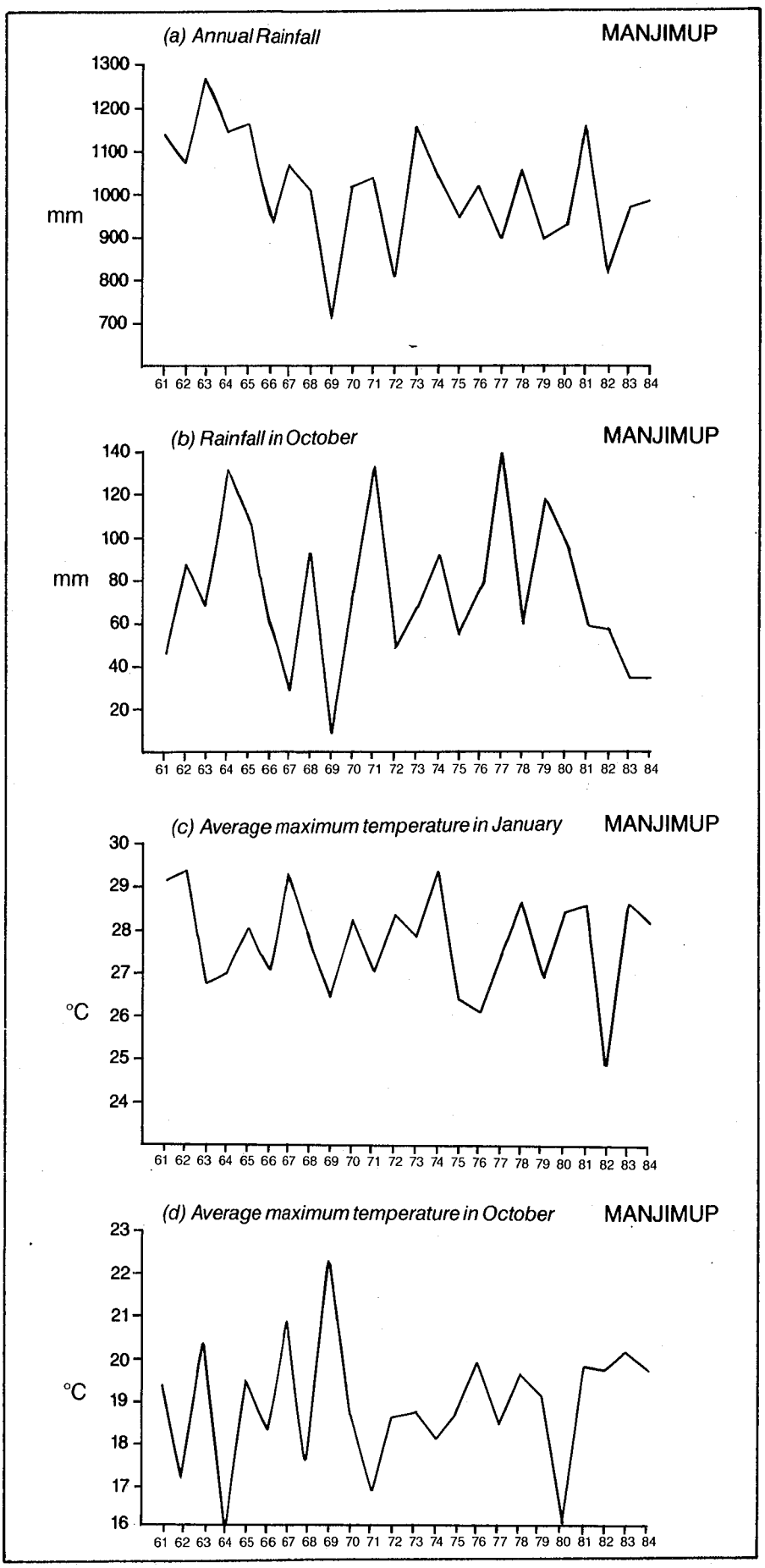

Figure 3. Some meteorological data for Manjimup, 1961 - '84.

Tree Pulling Schemes

There have been two 'tree pulling' schemes for apple trees in recent times, one ending in the late 1970s and a much more significant one between 1981-84. As a result of the second scheme 135 000 apple trees (mostly Granny Smiths) were removed, reducing the number of producing trees by 16% (personal communication*). The purpose of the schemes was to reduce chronic over-production of apples. The second scheme coincided with increasing bird damage from 1982-84, which led to the claim by some orchardists that reduced acreage of orchard had resulted in the birds concentrating their activities on a smaller area, causing more intensive damage. The low level of damage in 1984, however, counters this assertion. Most of the trees removed were Granny Smiths, which never supported many birds. The acreage of susceptible varieties changed little as a result of the schemes.

Leaving Apples on Trees

It has been argued that the practice of leaving unpicked apples on trees, rather than destroying them, has encouraged parrots and cockatoos to utilize orchards by providing a food source for longer than necessary. It is possible that this could lead to a behavioural change whereby the birds would prefer feeding in orchards to feeding in natural areas. This has happened with many species of

* K. Whitely, Department of Agriculture

waterfowl (Bossenmaier & Marshall, 1958; Thomas, 1981; Halse, 1984a). Parrots probably underwent some kind of behavioural change to make extensive use of orchards and farmland, but there is no evidence of additional change towards increasing use of orchards. Regular shooting in orchards probably has an important role in preventing further change.

Cultivation in Orchards

Prior to 1965 fruit growers regularly cultivated their orchards with a rotary hoe or similar implement to prevent weeds growing. Since then it has become more popular to let weeds grow, although most orchards around Donnybrook are still cultivated (personal communication*). Some growers mow the weeds regularly, others do not and the weeds set seed. Since parrots eat many of these seeds, it has been suggested that unmown weeds attract parrots into orchards. However, data collected in an orchard containing unmown weeds suggest that while these may attract Western Rosellas and, to a lesser extent, Port Lincoln Ringnecks, they have little effect on Red-capped Parrots, which were recorded eating almost no weed seeds (see Section X).

Grain Growing

There has been a steady increase in the amount of grain grown just east of Manjimup and Bridgetown over the past decade (personal communication**). It has been suggested by some orchardists that

* K. Whitely, Department of Agriculture

** N. Halse, Department of Agriculture

this has caused an increase in size of the parrot population in fruit growing areas, but a mechanism by which this could have occurred is difficult to find. Although grain comprises an energy-rich food source (Halse, 1984b), it becomes available only after young parrots have fledged, and so is unlikely to affect breeding success. In fact, because it is abundant during the early part of the apple season, grain is more likely to attract parrots out of orchards, and reduce damage, than to increase it. Grain is not available in large quantities in winter and, therefore, would not increase survival rates at this time of year.

Woodchipping

Because of the importance of marri as a food source for parrots and cockatoos, it is possible that in the long-term woodchipping and other forestry practices that reduce the amount of marri will result in increased bird damage in orchards and vineyards. Whether this is likely to occur depends on:

1) to what extent present levels of nectar and seed production oversupply the various vertebrate and invertebrate consumers.
2) to what extent a shortage of marri would actually reduce the size of populations of various parrot and cockatoo species rather than just forcing them to feed on cultivated fruit.
3) to what extent the nest sites destroyed by felling marri trees are replaceable.

Woodchipping is restricted to karri *(Eucalyptus diversicolor)* forests, which represent only about 10% of the forest area in the south-west. Marri mostly occurs at low densities in these forests,

of which about 2 000 ha are clear-felled annually. Large karri trees provide millable timber, small karri and marri trees are turned into woodchips. Intensive research is required to elucidate what effect, if any, this has on parrot and cockatoo populations and damage levels in orchards. Clear-felling in karri forests is more likely, however, to affect White-tailed Black-Cockatoos than the parrots (see Section IX).

Forest Management Practices

Low-intensity fuel reduction fires do not seem to have any widespread effect on levels of bird damage. They do not affect flowering of trees or the amount of seed set, although they do have a temporary effect on herbs and some shrubs (personal communication*). The extensive bird damage in 1984 certainly cannot be related to any change in the forest burning programme.

The possibility that the proportion of commercially unimportant marri may be reduced in jarrah forests by poisoning or some other means is cause for concern, however. As with woodchipping, the effect of this management practice can only be predicted through intensive research.

* I. Abbott, Department of Conservation and Land Management

VIII PHENOLOGY OF MARRI

Marri occurs throughout the main forest areas of the south-west. It only comprises about 5% of the trees (DOB > 10 cm) in jarrah *(Eucalyptus marginata)* forests around Perth, the rest being jarrah, but the proportion of marri increases with latitude; in some areas around Manjimup 80-90% of 'jarrah forest' trees are marri (personal communication*). Marri also occurs in karri forests. Because until recently they have had no commercial value, marri have hardly been studied and not much is known about their phenology. Schuster (unpublished report**) suggested that the species has a three-year floral cycle with seed capsules maturing 11-12 months after flowering, which usually occurs in February and March. Flowering usually lasts four to six weeks. Trees around Perth begin flowering about two weeks earlier than those at Manjimup. There can be two periods of flowering on the same tree in one year, such as occurred in 1985 when marri flowered from mid-February until the end of March and then again in May. Developing seeds are discernible when seed capsules are cut open one month after flowering. There are usually four or five seeds in healthy seed capsules. However, a high proportion of the capsules examined contained larvae and pupae (Diptera: Cyclorrhapha: Fergusoninidae) which destroyed some of the seeds.

* I. Abbott, Department of Conservation and Land Management

** Department of Conservation and Land Management

The flowering buds (or pin buds) of marri develop during the spring prior to flowering.

Although Schuster believed heavy crops occurred only every three years, his data indicated that trees could flower one year after they had previously flowered heavily and most trees flowered two years later. Beekeepers believe the fundamental flowering cycle of marri is a two-year one (personal communication*) but they stress that the cycles of individual trees are not always in synchrony so that it is possible to have reasonable flowering (and seed-set) in the same area in consecutive years.

Unfavourable weather may result in light flowering with low honey production for several years. High-intensity fires interrupt the floral cycle for three to five years, according to Schuster (personal communication**), but low-intensity fires have no effect.

* B. Burking, Department of Agriculture

** C. Schuster, Department of Conservation and Land Management

IX GENERAL BIOLOGY OF THE PEST SPECIES

Port Lincoln Ringneck Parrot

There are two subspecies of this parrot: *B. z. zonarius*, which has a yellow belly and *B. z. semitorquatus*, which has a green belly and a red spot above the beak. The *semitorquatus* subspecies is restricted to the extreme south-west of Western Australia south of a line drawn from Perth to just west of Albany (Forshaw, 1969). Thus almost all Port Lincoln Ringneck Parrots found in fruit growing areas are *semitorquatus*. Plumage is similar in adults of both sexes and juveniles.

Port Lincoln Ringneck Parrots are abundant in the south-west (Forshaw, 1969), occupying both forest and farmland. They breed in hollows in dead or live trees, between August and February. If conditions are favourable they may lay two clutches. Four to seven eggs are laid, the average being five. Incubation lasts about three weeks, the young fledge about five weeks later. According to Forshaw (1969) the species is sedentary.

Port Lincoln Ringneck Parrots feed both on the ground and in trees or shrubs (Forshaw, 1969). The most important native food items in the diet are marri seed capsules and nectar. The main introduced food eaten is apples. A range of insects is taken [Appendix I(a)].

Red-capped Parrot

This species is confined to the south-west, occurring in forest or parkland-cleared farmland south of a line extending from Moore River to Esperance and is common within this restricted range (Forshaw, 1969). Although some authors have stated males and females are differently coloured (Serventy, 1938: Harwood, 1955; Forshaw, 1969), in fact they are similar (Webster, 1948; Warham, 1957; Forshaw, 1964a); perhaps females take longer to reach full colour. Juvenile birds have a much duller plumage than adults.

Nesting begins in August and continues until early December. The species nests in hollows in trees, often marri trees. Four to seven, usually five, eggs are laid. Incubation lasts about three weeks, fledging occurs about five weeks later. Forshaw (1969) states that adult plumage is acquired about 14 months after hatching. However, my own observations suggest it is possible that females do not attain complete adult plumage in the first adult moult. The species is mostly sedentary, although there is some local movement (Forshaw, 1969).

Red-capped Parrots feed both on the ground and in trees (McGilp, 1931; Robinson, 1960; Forshaw, 1964a), although more time is spent in trees. The main native food items are marri seed and nectar, jarrah seed and nectar and *Banksia grandis* seed and nectar. The most important introduced food item is apples. A small number of insects is taken as well [Appendix I(b)].

Western Rosella

This species is confined to the south-west, occurring in forest, farmland, grassland and belts of trees south of a line connecting Moora, Merredin and Norseman. It is relatively common (Forshaw, 1969). Adult males and females have differently coloured plumage; juvenile birds have duller plumage than adults with no difference between sexes.

The breeding season lasts from August until December; the species nests in hollows in gum trees. Three to seven, usually five, eggs are laid. Incubation lasts about 25 days; the young fledge about 30 days after hatching. Forshaw (1969) states that adult plumage is acquired 14 months after hatching: my own observations suggest it is often not acquired until at least 18 months. The species is mostly sedentary (Forshaw, 1969).

Western Rosellas feed both on the ground and in trees or shrubs. Their main native foods are seeds of various shrubs and trees. The main introduced food items are seeds of various grasses and herbaceous plants. A fairly wide range of insects is eaten [Appendix I(c)].

White-tailed Black-Cockatoo

This species is confined to the extreme south-west, more or less south of a line between Perth and Albany (Saunders, 1979a). It is restricted to jarrah and karri forests although birds move into

orchards from forest (Davies, 1966; Saunders, 1979a). There are probably fewer than 20 000 White-tailed Black- Cockatoos (personal communication*) and, although they are common throughout their restricted range, the species may be endangered because they are regularly shot by orchardists. Males and females have similar plumage, the main differences between them are the size of the cheek patch and colour of the mandible. Juvenile birds generally resemble females (*Reader's Digest*, 1976).

White-tailed Black-Cockatoos probably have a similar breeding season to other parrots in the south-west (i.e. spring) but there is little information available.

They nest in tree hollows, mostly in karri according to Saunders (1974a), and observations suggest they are restricted to karri forest during the breeding season (Saunders, 1979a). By extrapolation of data on Yellow-tailed Black- Cockatoos *Calyptorhynchus funereus latirostris* (*Reader's Digest*, 1976; Saunders, 1982), they probably usually lay two eggs but rarely rear more than one young. Incubation probably lasts about four weeks, with the young fledging 10-11 weeks later. Breeding success is probably quite low; only 65% of Yellow-tailed Black-Cockatoo nests produce a fledged bird and survival in the first year is about 15% (Saunders, 1982). Female Yellow-tailed Black- Cockatoos breed at four or five years of age. White-tailed

* D. Saunders, Parrot Research Working Group

Black-Cockatoos range widely in forest areas during the non-breeding season (Saunders, 1979a).

White-tailed Black-Cockatoos feed both on the ground and in trees (Saunders, 1974a, 1979a) although they spend more time in trees. Their most important native food is marri seed, and the main introduced food item is apples. Some insect larvae are also eaten [Appendix I(d)].

X STATUS OF THE SPECIES AS PESTS

The two most important pest species are the Red-capped Parrot and White-tailed Black-Cockatoo (Long, 1985). In 1984 the Manjimup Fruit Grower's Association surveyed 44 orchards to find the relative importance of parrots and cockatoos in terms of apple damage. The White-tailed Black-Cockatoo was a pest in 37 orchards; the Port Lincoln Ringneck Parrot a pest in 28; and the Red-capped Parrot a pest in 42: Western Rosellas were not included in the survey.

In years of heavy bird damage, like 1984, Red-capped Parrots cause more damage than White-tailed Black-Cockatoos but the reverse applies in normal years (Long, 1985). From comparing accounts of damage in 1984 with the situation in 1985, it appears that changes in activity of Red-capped Parrots in orchards largely determine the severity of damage. Port Lincoln Ringnecks seem to have a more constant level of activity between years; furthermore, according to most orchardists, individual Port Lincoln Ringneck Parrots are less destructive than Red-capped Parrots. In 1984 Red-capped Parrots were by far the most common parrot in orchards whereas this year, and probably in most normal years, there are almost as many Port Lincoln Ringneck Parrots. Western Rosellas are not a serious problem and occur in orchards in lower numbers than the other two parrot species, except perhaps late in the apple season when their numbers increase. It is doubtful whether they eat apples unless they have already been

opened up by another bird (personal communication*). Although they certainly do feed on already damaged apples, a considerable amount of their feeding time in orchards is spent eating weed seeds (personal observation).

The amount of damage caused by White-tailed Black-Cockatoos varies between years. Futhermore, within a district in any one year the damage has a very uneven and unpredictable distribution.

Cockatoos tend to move through areas in flocks comprised of family groups rather than spending long periods in the vicinity of a particular orchard, which is probably the case with parrots. They can cause extensive damage in a very short period, breaking many small branches as well as eating apples. This can affect apple production the following year. However, cockatoos are noisy, highly visible birds that are easily frightened away, so orchardists quickly become aware of their presence and can chase them from an orchard. Parrots are less noticeable and more difficult to drive out of an orchard, but take much longer to cause appreciable damage.

Of the two species, only White-tailed Black-Cockatoos cause damage in orchards; the similar-looking Yellow-tailed Black-Cockatoos do not feed there (Saunders, 1974a).

* J.L. Long, Parrot Research Working Group

Diets around orchards

I shot a number of parrots in the vicinity of two orchards between February and May, 1985, and examined the contents of their crops. Observations were also made of birds feeding in orchards.

Red-capped Parrots fed mostly on apple seeds [Appendix II(a)] although they chewed pieces of apple (presumably to extract the juice) (Long, 1985; personal observation), which they then discarded. Pieces of dried apple flesh on the ground under a tree indicated that damage had been caused by Red-capped rather than Port Lincoln Ringneck Parrots. Red-capped Parrots were also observed eating plums. Robinson (1960) stated they eat apples, pears, stonefruit and almonds. Outside the orchards, Red-capped Parrots fed extensively on marri nectar while it was available and, to a lesser extent, on immature seed capsules of marri that were infested with cyclorrhaphid larvae and pupae [Appendices II(b) and II(c)]. There were no marri trees with mature seed capsules in the areas I worked, but at Donnybrook, where mature capsules were dehiscing, Red-capped Parrots fed extensively on marri seed (personal communication*).

Port Lincoln Ringneck Parrots had a more varied diet in the orchards, feeding on both apple seeds and apple and pear flesh, although more flesh was eaten than seeds [Appendix II(a)]. Seeds of *Chenopodium album* were also eaten. Because they ate the flesh of the apple only pieces of skin were found under trees where Port

* J.L. Long, Parrot Research Working Group

Lincoln Ringneck Parrots had been feeding. According to Robinson (1960), they eat pears, stonefruit, almonds and pie-melons as well as apples. Outside the orchards, Port Lincoln Ringneck Parrots fed on grain, marri nectar and extensively on immature, cyclorrhaphid-infested seed capsules of marri [Appendices II(a) and II(b)]. In vineyards they usually ate several whole grapes from a bunch but occasionally bit through the peduncle of a bunch, dropping it to the ground. They began eating the grapes only after their sugar content reached about 15% (grapes are picked with a sugar content of 21-23%) (personal communication*). Silvereyes cause more damage in vineyards than Port Lincoln Ringneck parrots because they eat small quantities of many grapes, which then ferment or become infected with fungus and cannot be used for wine.

Western Rosellas fed mostly on seeds of *C. album, Rumex* sp. and other weeds in the orchards rather than on fruit, although small quantities of apple flesh were eaten [Appendix II(a)]. Outside the orchards, the diet of Western Rosellas probably comprised mostly seeds picked up from the ground.

No White-tailed Black-Cockactoos were collected, but they feed on the seeds of apples and pears in orchards (Robinson, 1960); they do not often eat the flesh. Because cockatoos remove larger chunks of flesh than parrots the damage they cause is distinctive (Long, 1985).

* B. Quinlivan, Department of Agriculture

Diets in forest areas

A number of parrots were shot in areas of forest far removed from orchards, and their crop contents were examined. Two Red-capped Parrots, which had been collected in jarrah forest, had been feeding on marri seeds and immature, cyclorrhaphid-infested seed capsules [Appendix II(c)]. Three of the Port Lincoln Ringneck Parrots collected in jarrah forest had been feeding on immature, cyclorrhaphid-infested marri seed capsules, the fourth had been feeding on seeds and the large developing fruits of a monocot [Appendix II(c)]. Most of the Western Rosellas were collected in karri forest, where psyllid bugs and the sugary tests they produce were the major food item. *Bossiaea laidlawiana* and *Trymalium spathulatum* seeds were also important.

With the notable exceptions of psyllids and the cyclorrhaphids in immature seed capsules of marri, insects were not an important component of the diets of the parrot species around orchards or in forest.

Birds in orchards

Long (1985) found there was usually no relationship between numbers of parrots observed in an orchard and the amount of damage done. However, there is little doubt that the very high damage levels in 1984 were due to larger numbers of parrots than usual frequenting orchards. Only when a narrow range of damage levels is being examined will there be no relationship between

parrot numbers and damage because of variations in feeding behaviour of the parrots. The subject is currently being further investigated by J. Long.

Almost all the parrots I shot or observed around orchards were juvenile birds. This is in agreement with Warham's (1957) and Long's (1985) observations. It is sometimes stated by orchardists that the proportion of adult birds increases during the apple season, but I believe this is the result of second-year birds acquiring adult plumage. I found no evidence that paired adult birds move into orchards in years of light damage although J. Dell (personal communication*) reports that adults sometimes bring juvenile birds into orchards in December.

White-tailed Black-Cockatoos used orchards very little in 1985, in contrast to 1984. This species moves about in family groups so adults and juveniles occur together in orchards at all times (personal communication**). Some idea of the variation in numbers of cockatoos in orchards between years is given by the bounty payment figures for the Bridgetown district from 1960-65. It seems reasonable to believe that all birds were shot in or very close to orchards. Sixty-seven were shot in 1960, 166 in 1961, 365 in 1962, 140 in 1963, 447 in 1964 and 449 in 1965. According to the Manjimup Fruit Grower's Association survey, 828 White-tailed Black-Cockatoos were shot in 1984.

* J. Dell, Western Australian Museum

** D. Saunders, Parrot Research Working Group

Numbers in forest areas

Table 5 presents data on the densities of parrots in forest areas at Serpentine, Collie and Manjimup. Densities are higher around Manjimup than farther north, and are higher in karri than jarrah forest. Red-capped Parrots show less fluctuation in density over their range than the other two species, varying from 0.18-0.41 bird ha^{-1} (Table 5).

Jarrah forest occupies approximately 1 500 000 ha in the south-west; karri forest occupies a little over 150 000 (personal communication*). Assuming Red-capped Parrots are restricted to those forests and occur at a density of 0.2 birds ha^{-1} (a conservative value, Table 5), then there are 330 000 of them in the south-west jarrah and karri forests. In fact, Red-capped Parrots also occur in farmland and some other habitats (Warham, 1957) but the population estimate is too imprecise to justify making allowances for these birds.

A similar calculation (using the same density value, Table 5) gives an estimated population of 330 000 Port Lincoln Ringneck Parrots. This species occurs outside forest areas to a greater extent than Red-capped Parrots, but again the population estimate is too imprecise to justify trying to include non-forest birds.

Although it is not known what distance juvenile birds will move to gain access to orchards, it is informative to calculate the kinds of numbers that would be found there in normal years if all juvenile Red-capped and Port Lincoln Ringneck Parrots moved into orchards. This can only be done if the proportion of juveniles in the

* P. Collins, Department of Conservation and Land Management

population is known. This can be calculated from birth and death rates. Because no data are available I have assumed that in any year 75% of adults that are capable of breeding do so, producing four fledglings per nest. The mortality rate for post-fledging birds was assumed to be 55% in the first year and 20% per annum subsequently. I assumed birds were incapable of breeding until their fourth year and stopped breeding at 10 years of age. A population with these parameters is stable and has about 50% juvenile birds.

On the basis of the calculations above, 165 000 juvenile Red-capped and 165 000 juvenile Port Lincoln Ringneck Parrots would be found in orchards if they all moved there. Since the area of apple orchards is about 4 000 ha, this represents a density of 41 Red-capped Parrots ha^{-1} orchard, or 480 birds in an average-sized orchard of 11.6 ha (Table 1). Damage to fruit is more severe in the southern fruit growing areas than around Perth, presumably indicating parrot density is higher there. Nevertheless, even assuming Red-capped Parrots only occurred at a density of 41 birds ha^{-1} the 56 Manjimup orchards surveyed in 1984 would have contained 27 000 Red-capped Parrots. They would also have contained the same number of Port Lincoln Ringneck Parrots if all birds of this species moved into orchards. However, observations made in 1984 suggested a smaller proportion of the Port Lincoln Ringnecks than the Red-capped Parrot population moved in (personal communication*). Nevertheless, because only 10 860 parrots, including Port Lincoln Ringneck Parrots and Western Rosellas, were shot in orchards (Manjimup Fruit Grower's

* J.L. Long, Parrot Research Working Group; G. Rowan-Robinson, orchardist

Association survey) the figures demonstrate that the observed levels of damage in 1984 could have resulted from a large proportion of the normal parrot population in forests moving into orchards; it is not essential to invoke a population increase to explain damage levels.

There is no quantitative information on the number of White-tailed Black-Cockatoos although, as stated previously, D. Saunders has estimated there are no more than 20 000 birds.

TABLE 5

Numbers of parrots per hectare in forest

	Port Lincoln Ringneck Parrot	Red-capped Parrot	Western Rosella
Serpentine jarrah[1]	0.12	0.18	0.03
Collie[2]	-	0.22	-
Manjimup jarrah[3]	0.55	0.33	0.66
Manjimup karri[4]	0.74	0.41	2.33

[1] 10 counts, spring 1980 to winter 1982 using Emlen's (1971) strip-transect method (Wykes, 1985)

[2] summer, autumn, winter, spring counts at five sites of known area (J. Dell, personal communication)

[3] autumn, spring counts 1984 using Emlen's (1971) method (P. Christensen, personal communication)

[4] two spring, two summer counts 1982-84 using Emlen's (1971) method (P. Christensen, personal communication).

XI METHODS OF CONTROL

The traditional method of controlling parrots and cockatoos in Western Australian orchards is shooting. The number of birds shot each year varies according to the severity of damage to fruit, but in 1984 10 860 parrots and 828 cockatoos were shot in the Manjimup district alone (Manjimup Fruit Grower's Association survey). Far fewer birds were shot in 1985 because damage levels were low and little effort was expended controlling parrots. However, similar numbers certainly could have been shot, as indicated by the fact J. Long* shot 303 parrots in a small orchard at Donnybrook between March and May. The average number of parrots shot on Manjimup orchards between December or January and the end of April 1984 (time of the survey) was 194.

The value of shooting lies mostly in its scaring effect. Orchardists comment that it does not appreciably reduce the number of parrots using an orchard but it reduces considerably the amount of time they spend feeding there. J. Long noticed the same phenomenon in the Donnybrook orchards where he was shooting. The tendency for the number of parrots to remain constant suggests that some kind of self-regulation of parrot density is occurring (cf. Brereton, 1971).

* Parrot Research Working Group

Almost all the parrots shot in orchards are juvenile birds. Besides having little immediate effect on the number of parrots utilising orchards, shooting is unlikely to have any long-term effect on population sizes because juvenile parrots certainly have high natural mortality (see Saunders, 1982; Buckland *et* al., 1983) and, therefore, shooting is probably compensated for by a reduction in natural mortality. This occurs in waterfowl (Burnham & Anderson, 1984; Hill, 1984) and probably most other exploited bird populations. There are numerous studies that demonstrate the difficulty (assuming it is desirable) of reducing populations of pest species by killing (e.g. Murton, 1967; Wright, 1968) because of compensatory reduction in natural mortality, increased breeding success at reduced population densities (see Caughley, 1977 pp. 172-177), and the increasing effort required to kill pests as their numbers decline. The situation for cockatoos is different and will be discussed in Section XII.

In spite of functioning mostly to scare birds out of orchards rather than reduce their numbers, shooting remains the most efficient method of bird control. Other scaring methods include various kinds of gas cannons and machines producing loud high-frequency noise. None of these methods has yet proved successful against parrots, but they are being further investigated by J. Long. An alternative method of preventing damage to fruit is covering trees with netting (see Section V). At present this is not ecnomic, but

the cost would be justified for high-yielding orchards if there were a series of years with severe bird damage. The type of grid system on which trees have been planted and tree size have a considerable effect on the cost of covering trees with netting; it is cheapest when trees are grown on trellises.

XII CONSERVATION STATUS OF THE PEST SPECIES

Red-capped Parrots and White-tailed Black-Cockatoos are confined to the extreme south-west of Western Australia, the area where fruit is grown commercially. Both occur naturally in forest habitats but Red-capped Parrots nowadays make extensive use of parkland-cleared farmland for breeding as well as feeding. Many authors have commented on the important role of marri in the diet of Red-capped Parrots (e.g. Robinson, 1960), and Webster (1948) suggested that reduction in the amount of marri available might result in fewer birds of this species. However, Robinson (1960) believed there had been no decline in number as a result of clearing farmland in the Coolup district and the rough estimate of 330 000 birds in south-west forests (see Section X) suggests that Red-capped Parrots are in no danger of extinction.

Unlike the situation with parrots, shooting may have a deleterious effect on the smaller population of White-tailed Black-Cockatoos. They move into orchards in family groups although these often amalgamate to form larger flocks. This means that adult birds as well as juveniles are shot in orchards. Extrapolation of data from Yellow-tailed Black-Cockatoos suggests that White-tailed Black-Cockatoos probably rely on a high adult survival rate for persistence of the species (see Saunders, 1982). Even if shooting mortality is compensated for by a reduction in natural mortality it is

possible that shooting could increase the overall rate of mortality beyond the natural mortality rate to the point where the reduced number of adults could not produce enough young to replace dying birds. This would cause White-tailed Black-Cockatoos to become extinct. Whether this is, in fact, likely to occur can only be determined by more detailed study.

Port Lincoln Ringneck Parrots have a widespread distribution and have probably become more abundant as a result of agriculture, particularly in the case of the nominate subspecies *B. zonarius; B. semitorquatus* are confined to the extreme south-west of the state but are common throughout this range, with an estimated 330 000 birds in jarrah and karri forests. They also occur in other natural habitats and farmland in the south-west and so are in no danger of extinction.

Western Rosellas are restricted to the south-western part of the state but have a wider distribution than Red-capped Parrots and White-tailed Black-Cockatoos. I have not attempted to estimate their abundance; observations suggest their numbers vary considerably between different areas and habitats. Very little is known about Western Rosellas so it is difficult to comment on their conservation status other than to say reasonably large numbers occur in some forest areas; they have persisted in agricultural areas that have been extensively cleared, like Wickepin (Long, 1984); and they are probably not shot as much as Red-capped or Port Lincoln Ringneck Parrots. Forshaw (1969) claimed clearing forest for farming caused the number of Western Rosellas to increase.

XIII PARROT AND COCKATOO DAMAGE IN AUSTRALIA

Parrots and cockatoos have been recorded eating fruit for as long in the rest of the continent as in Western Australia (e.g. French, 1905; North, 1912 p. 443). Recent accounts of damage to fruit are rather sparse, however (McColl, 1957; Boehm, 1959; Green, 1983; Brown, 1984). To discover the extent of present-day depredations in orchards I wrote to Departments of Agriculture in all states, and to some wildlife authorities, requesting information about species causing damage and crops that they eat. Table 6 summarizes the information I received (Queensland and the Northern Territory did not provide information). Twenty parrot and cockatoo species damage fruit crops in Australia, with apples, pears, stonefruit, bananas, grapes, cherries, raspberries, blackcurrants, almonds, walnuts, chestnuts and pecan nuts being eaten. Other species of birds also cause damage to some of these crops (e.g. Paton & Reid, 1983; Rooke, 1983) but were not included in the survey.

In South Australia parrots and cockatoos cause extensive damage on many properties in the hills around Adelaide in some years, but levels of damage are highly variable (personal communication*). The situation is analogous to that in Western Australia except that bad years probably occur more frequently in S.A.. In northern New South Wales a variety of crops is affected by psittacine species. Levels of damage are generally below 10% but much higher levels have been recorded for apples and grapes (personal communication**). Orchardists in Tasmania claim that damage by

* R. Sinclair, Vertebrate Pest Control Authority, South Australia

** D. Robinson, Department of Agriculture, New South Wales

several species of bird, including parrots, cost them an average of about $1 000 per orchard in 1980 (Bates, unpublished report) although parrots do not seem to be as important a pest in Tasmania as in some mainland States.

TABLE 6

Species of Psittacidae known to damage fruit and nuts in Australia

Species	State	Crop
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*	SA, Tas, NSW	apples, cherries, almonds
*White-tailed Black-Cockatoo *Calyptorhynchus baudinii*	WA	apples, pears
Gang-gang Cockatoo *Callocephalon fimbriatum*	Vic, NSW	apples, stonefruit, walnuts, chestnuts, almonds
*Galah *Cacatua roseicapilla*	SA, Vic, NSW	apples, stonefruit, walnuts, chestnuts, almonds
*Long-billed Corella *Cacatua tenuirostris*	Vic	apples, grapes[1], almonds
*Little Corella *Cacatua sanguinea*	SA	almonds
Pink Cockatoo *Cacatua leadbeateri*	Vic	apples, stonefruit, walnuts, chestnuts, almonds
*Sulphur-crested Cockatoo *Cacatua galerita*	SA, Tas, Vic, NSW	apples, pears, stonefruit, grapes, cherries, walnuts, chestnuts, almonds, pecan nuts
*Rainbow Lorikeet *Trichoglossus haematodus*	SA, Vic, NSW	apples, stonefruit, cherries
Musk Lorikeet *Glossopsitta concinna*	SA, Tas, Vic, NSW	apples, pears, stonefruit

Table 6 (cont.)

Species	State	Crop
*Australian King Parrot *Alisterus scapularis*	Vic, NSW	apples, cherries, bananas
Regent Parrot *Polytelis anthopeplus*	SA, Vic	stonefruit, almonds
*Red-capped Parrot *Purpureicephalus spurius*	WA	apples, pears, stonefruit, almonds
Green Rosella *Platycercus caledonicus*	Tas	apples, cherries, raspberries
*Crimson Rosella) *Adelaide Rosella) *Platycercus elegans* Yellow Rosella)	SA, Vic. NSW	apples, stonefruit, pears, cherries[2], almonds[2], grapes
*Eastern Rosella *Platycercus eximius*	Tas, Vic, NSW	apples, stonefruit, pears, cherries, blackcurrants
Western Rosella *Platycercus icterotis*	WA	apples, stonefruit
*Port Lincoln Parrot *Barnardius zonarius*	WA	apples, stonefruit, pears, grapes, almonds

* more important pest species

[1] eat shoots on grapevines

[2] eat buds and flowers as well as fruit

XIV GENERAL DISCUSSION AND SUGGESTED RESEARCH

Parrots and cockatoos have the potential to be the most serious pests of Western Australian orchards - this was the case between 1982-84. The information in Table 6 suggests the situation is similar in South Australia and New South Wales, and that parrots and cockatoos can cause substantial financial losses. Nevertheless, until now years of severe damage in Western Australia have been infrequent and there is no indication that the pattern is changing. Predicting future patterns of damage is hampered by a lack of understanding of the factors causing high levels of damage. Indeed, it is still not known whether high levels of damage occur only after there has been a series of favourable breeding seasons to increase population.

The information available suggests marri is the most important natural food of the pest species; it is commonly asserted that damage levels are low when marri flowers well. In this respect the situation in Western Australia appears analogous to that in England, where Bullfinches (*Pyrrhula pyrrhula*) damage fruit buds, especially on pear trees, when ash (*Fraximus excelsior*) fails to set much seed (Newton, 1968). However, we should examine the relative importance of marri nectar (as opposed to the quantity of marri seed set the previous year and being released about the time of flowering) in providing a more desirable food source than cultivated fruits. Marri seed may be very important, which could explain why

years of heavy damage to grapes by Silvereyes do not coincide with bad psittacine years, although Rooke (1983) claimed Silvereye damage was inversely related to marri nectar production. There are certainly more factors involved in heavy parrot and cockatoo damage than just poor nectar production by marri: size of the parrot and cockatoo populations, and seed production by marri are both promising avenues for further investigation.

No biological solution to the problem of parrot and cockatoo damage is possible without further research into their basic biology. Flegg (1980) pointed out in some detail the necessity for research in solving bird problems, and there are numerous examples of its benefits in dealing with avian and other vertebrate pests. Study of the biology of possums in New South Wales enabled researchers to show early fears that possums would be a major pest in pine plantations were unfounded (Barnett *et al.*, 1977). Once the migration patterns of Queleas (*Quelea quelea*), the most important bird pest in Africa, were understood it was found that damage to rice crops could sometimes be avoided by manipulating planting times so crops ripened and were harvested when Queleas were absent (Elliot, 1979). When it was understood why Skylarks (*Alauda arvensis*) grazed medic pastures in Iraq, it was possible to suggest ways of overcoming the problem (Halse & Trevenen, 1985). Research has also led to the development of non-biological control methods to deal with birds (e.g. Wright, 1961; Besser, 1973; Feare, 1974; Green, 1980; Benjamini, 1981; Rooke, 1984b).

A research program into parrot and cockatoo damage in Western Australian orchards would have Australia-wide value, as well as being of direct economic benefit to Western Australian fruit growers. Parrots and cockatoos are major pests in many grain crops as well as in orchards. There are at least two other reasons why a program should be initiated.

1. Parrots are a colourful, noisy and characteristic part of the Australian avifauna, about which surprisingly little is known. Because they occupy a prominent position in the Australian heritage and many people would like to know more about them, government authorities have a duty to foster or conduct research into their biology. As with all research, there is the possibility that information gathered will be of applied benefit in totally unexpected ways. The present study illustrates this point. I found that there is an extremely high level of infestation by cyclorrhaphid larvae in marri seed capsules, which results in substantially reduced seed production. This could have important implications for marri silviculture.

2. Parrots and cockatoos are components of forest, and other, ecosystems in the south-west. Studying them (e.g. their diet) contributes to knowledge of how the components of the ecosystems are integrated, something that must be known for effective land management. They can also serve as indicator

species showing how other animals inhabitating the same ecosystems may react to proposed changes in land management when there is insufficient time or money to study all animals involved. An example of this is that parrots could be used to examine the likely effect of clearfelling in forests on hole-nesting species.

A future research program should focus on Red-capped Parrots because they are the most serious pest in years of heavy bird damage in orchards, and information gained about them can, with certain reservations, be extrapolated to the other two species. Although virtually nothing is known about White-tailed Black-Cockatoos, the closely-related Yellow-tailed Black-Cockatoos have been intensively investigated (Saunders 1974a, b, 1976, 1977, 1979a, b, 1980, 1982). Some monitoring of numbers of White-tailed Black-Cockatoos is desirable, however. The programme on Red-capped Parrots should examine diet, food preferences and nutrition, phenology of native plants, breeding, and population movements and numbers.

Diet

Although a considerable amount of work has already been done on the diet of Red-capped Parrots [Appendix I(b)], there is a need for detailed, quantitative information about their diet in forest areas far removed from agriculture, i.e. their natural diet. The composition and nutritional value of the natural diet could then be compared with that of their diet around orchards, which may

indicate why birds leave forest areas. This study would be similar in its aims and scope to Newton's (1964, 1967) work on Bullfinches in England.

Food preferences and nutrition

The dietary work could be more easily interpreted if food-choice experiments were conducted using captive birds. At the same time nutritional requirements of the parrots could be examined. Food-choice experiments would determine whether the parrots preferred cultivated fruits to some natural foods, or none, and would establish a preference hierarchy amongst alternative crops that could be grown to reduce parrot damage. This sort of work has been done by Sorensen (1983, 1984) and Sinclair & Smith (1984).

Phenology of native plants

A study of the natural diet of Red-capped Parrots needed to be accompanied by knowledge of the availability of food plants. Therefore, the phenology of these plants should be studied, particularly that of marri, which appears to be such an important food source for Red-capped Parrots (Robinson, 1960) and some other species (Rooke, 1983, 1984a).

Breeding

The breeding biology of Red-capped Parrots just south of Perth has been studied by J. Long but warrants further investigation. It is extremely difficult to manage any species without knowledge of birth

rates and some information about mortality rates, particularly in juvenile birds. Preliminary computer modelling has shown that the Red-capped Parrot population is probably very sensitive to changes in juvenile mortality. The proportion of adults that breed, the number of young fledged, and juvenile mortality should be measured, and habitat and nest-site preferences should be studied. There is a considerable body of literature dealing with this type of work (e.g. Gibb, 1950; Snow, 1958; Perrins & Moss, 1975, Saunders, 1982; Newton *et al.*, 1981; Coulson *et al.*, 1982).

Population movements and numbers

In most years only juvenile Red-capped Parrots are found in orchards; presumably adult birds remain in breeding areas all year. Red-capped Parrots may have a social system similar to that proposed for Eastern Rosellas (*Platycercus eximius*) by Brereton (1971), with a "core" and a "subsidiary" population. What proportion of the juvenile population feeds in orchards in normal years and in years of heavy bird damage and the distances juveniles move are important questions, which can only be answered satisfactorily with a banding programme. Patagial tags (Rowley & Saunders, 1980) would be ideal for this kind of study.

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APPENDIX I (a)

Food items eaten by Port Lincoln Ringneck Parrots (subspecies *semitorquatus*) in the south-west of Western Australia

Native plants	Reference[1]
Acacia pulchella seeds	A
Baeckea camphorosmae seeds	A
Banksia grandis nectar, pollen	A, B
Diplopeltis huegelii seeds	B
Eucalyptus calophylla seeds, seed capsules, nectar	A, B, C, D
E. diversicolor nectar	E
E. marginata seeds	A, B
E. rudis seeds	B
Macrozamia sp. seeds	B
Phyllanthus calycinus seeds	B
Xanthorrhoea gracilis seeds	A
Introduced plants	
Arctotheca calendula seeds	B
Avena spp. seeds	B
Briza maxima seeds	B
Bromus spp. seeds	B
Carduus spp. seeds	B
Chenopodium spp. seeds	B
Citrullus lanatus melonsi	E
Datura sp. seeds	B
Erodium botrys seeds	B
Hordeum sp. seeds	B
Malus sylvestris fruit	B, C
Melia azederach seeds	B, E
Polygonum aviculare seeds	B
Prunus spp. fruits	C
Pyrus communis fruits	C
Romulea rosea seeds	B
Rubus fructicosus fruits	B, C
Rumex spp. seeds	B
Sonchus spp. seeds	B

Trifolium subterraneum seeds	B
Insects	
Coleoptera larvae, pupae	B
Diptera larvae, pupae	B
Leopidoptera larvae, pupae	B, F
Psyllidae	B

[1] A = Wykes (1985), B = Long (1984), C = Robinson (1960), D = Sedgwick (1938), E = Forshaw (1964b)

APPENDIX I (b)

Food items eaten by Red-capped Parrots in the south-west of Western Australia

Native plants	Reference[1]
Acacia spp. seeds	A, B
Banksia grandis seeds, nectar	A, C
B. menziesii flowers	C
Casuarina spp. seeds	A, B, D, E
Dryandra sp. flowers	C
Eucalyptus calophylla seeds, flowers	A, B, E, F, G
E. marginata seeds, flowers	A, B, E, H
Grevillea robusta flowers	E
Hakea spp. seeds	B, C, E
Melaleuca sp. flowers	E
Oxalis sp. seeds	B
Xylomelum sp. seeds	E
Introduced Plants	
Arctotheca calendula seeds	B
Avena spp. seeds	B, I
Briza maxima seeds	B
Carduus spp. seeds	B
Erodium botrys seeds	B
Hordeum leporinum seeds	B
Hypochoeris spp. seeds	B
Malus sylvestris fruits	B, C, E
Prunus spp. fruits	E
Pyrus communis fruits	E
Silybum marianum seeds	B
Sonchus oleraceus seeds	B
Rubus fructicosus fruits	B
Rumex sp. seeds	B

Insects	
Coleoptera larvae, pupae	B
Psyllidae	B

[1] A = Wykes (1985), B = Long (1984), C = Warham (1957), D = Alexander (1930), E = Robinson (1960), F = McGilp (1931), G = Webster (1948), H = Sedgwick (1938), I = Forshaw (1964a)

APPENDIX I (c)

Food items eaten by Western Rosellas in the south-west of Western Australia

Native Plants	Reference[1]
Bossiaea linifolia fruits	A
Baeckea camphorosmae seeds	B
Banksia grandis pollen	B
Cyperaceae seeds	C
Eucalyptus calophylla seeds, flowers, leaf petioles	A, B
E. marginata seeds, seed capsules	C
E. rudis seeds	C
Juncaceae seeds	C
Leucopogon revolutus fruits	A
Melaleuca spp. seeds	C
Oxalis corniculata seeds	C
Stypandra sp. seeds	C
Introduced plants	
Arctotheca calendula seeds	C
Avena spp. seeds	C
Brassica tournefortii seeds	C
Briza maxima seeds	C
Bromus sp. seeds	C
Chenopodium spp. seeds	C
Ehrharta sp. seeds	C
Erodium botrys seeds	C
Physalis peruviana fruits	B
Poa annua seeds	C
Romulea rosea seeds	C
Rubus fructicosus fruits	C
Rumex sp. seeds	C
Silybum marianum seeds	C
Sonchus oleraceus seeds	C
Trifolium subterraneum seeds	C

Insects	
Coccidae	C
Coleoptera larvae, pupae	C
Diptera larvae, pupae	C
Hymenoptera larvae, pupae	C
Lepidoptera larvae, pupae	C
Psyllidae	B, C

[1] A = Abbott (1981), B = Wykes (1985), C = Long (1984)

APPENDIX I (d)

Food items eaten by White-tailed Black-Cockatoos

Native plants	Reference[1]
Banksia spp. seeds, flowers	A
Dryandra spp. seeds	A
Eucalyptus calophylla seeds	A, B
Introduced plants	
Erodium sp. seeds	A
Malus sylvestris fruits	C, D
Pyrus communis fruits	C
Insects	
unidentified larvae	A

[1] A = Saunders (1974a, 1979a), B = Carnaby (1948), C = Robinson (1960), D = Davies (1966)

APPENDIX II (a)

Plant food items in diet of the three parrot species collected in or near orchards[1] between February and May 1985 based on frequency of occurrence in crop contents

Food item	Port Lincoln Ringneck Parrot (n=19) %	Red-capped Parrot (n=13) %	Western Rosella (n=4) %
Native plants			
Eucalyptus calophylla immature seed capsules	37	8	-
E. calophylla nectar	16	62	-
Introduced plants			
Avena sp.	5	-	-
Chenopodium album seeds	16	-	75
Poaceae seeds	5	8	-
Malus sylvestris[2] seeds	21	85	-
M. sylvestris flesh	32	-	50
Pyrus communis[3] flesh	10	-	-
Rumex sp. seeds	-	-	75
Unidentified seeds	-	-	75

[1] two orchards - one at Bridgetown growing apples, the other at Manjimup growing apples and pears

[2] apple

[3] pear

APPENDIX II (b)

Insect food items in diet of the three parrot species collected in or near orchards between February and May 1985 based on crop contents. Number of birds feeding on each item is indicated, generally birds ate only one or two insects.

Food item	Port Lincoln Ringneck Parrot (n=19) %	Red-capped Parrot (n=13) %	Western Rosella (n=4) %
Coleoptera	1	1	-
Coleoptera larvae	1	2	-
Collembola	-	-	1
Diptera	1	1	-
Diptera - Cyclorrhapha larvae, pupae	6	2	-
Hemiptera - Psyllidae	2	1	-
Hymenoptera	1	-	-
Lepidoptera larvae	2	-	-
Thysanoptera	-	1	-

APPENDIX II (c)

Food items in diet of the three parrot species collected in forest between February and May 1985 based on crop contents. Number of birds feeding on each item is indicated.

Food item	Port Lincoln Ringneck Parrot (n=4)	Red-capped Parrot (n=2)	Western Rosella (n=10)
Native plants			
Bossiaea laidlawiana seeds	-	-	3
Eucalyptus calophylla seeds	-	2	-
E. calophylla immature seed capsules	3	1	-
Trymalium spathulatum seeds	-	-	6
Unidentified fruits	1	-	-
Unidentified seeds	1	-	4
Insects			
Coleoptera	-	-	1
Diptera	-	-	1
Diptera - Cyclorrhapha larvae, pupae	2	1	2
Hemiptera - Psyllidae	-	1	9
Hymenoptera	-	1	-
Hymenoptera pupae	-	-	1
Lepidoptera larvae	-	1	-

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