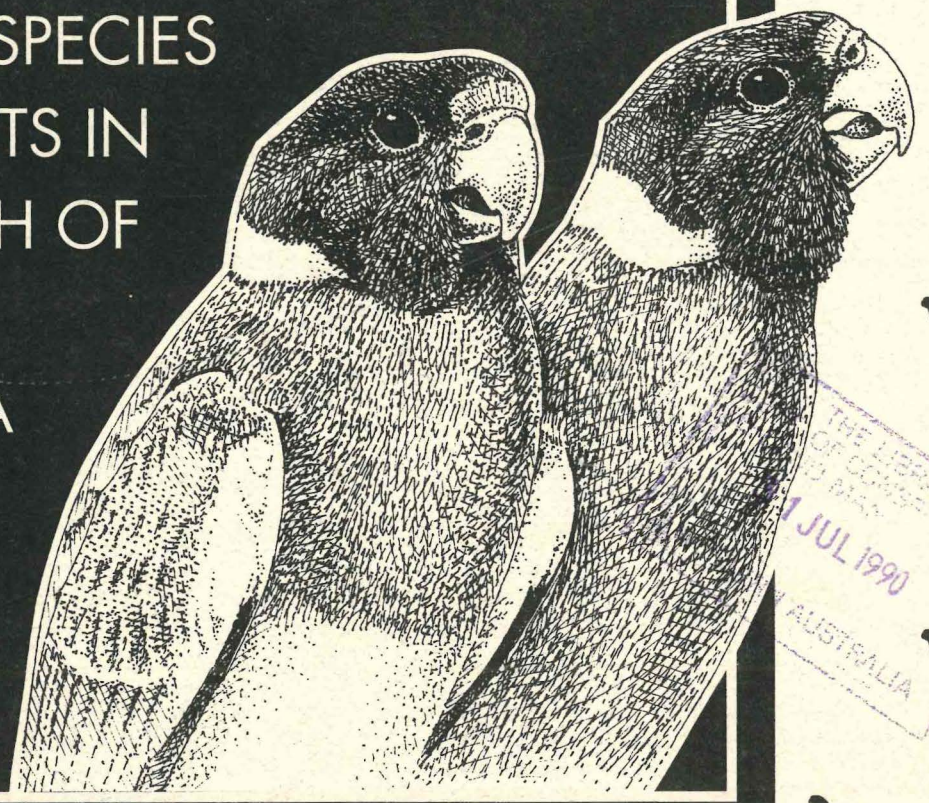
THE BREEDING BIOLOGY OF FOUR SPECIES OF PARROTS IN THE SOUTH OF WESTERN AUSTRALIA



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ABSTRACT

The breeding biology of four small parrot species was examined at different sites in the south of Western Australia. Dimensions of the nest hollows selected by the various species overlapped considerably indicating a potential for interspecific competition for nest sites. However, this appeared to be offset by the use of only a small proportion of the potential nesting sites available in an area.

The most successful breeding species was the Port Lincoln parrot with an overall breeding success (years combined) of 75 percent. Corresponding figures for the other parrots were western rosella 72 percent, regent parrot 63.5 percent and red-capped parrot 27.1 percent. The parrots laid from one to seven eggs. The mean clutch size for western rosellas was 6.3 ± 0.3 (mean ± standard error), red-capped parrots 5.3 ± 0.3, regent parrots 5.1 ± 0.2 and Port Lincoln parrots 4.9 ± 0.2 eggs.

The mean daily weight growth for nestlings was regent parrot 4.7 g, Port Lincoln parrot and red-capped parrot 4.1 g, and western rosella 2.3 g. The comparative development of the body characteristics of the nestling parrots is described and a growth curve for the wing lengths of the four species is shown.

INTRODUCTION

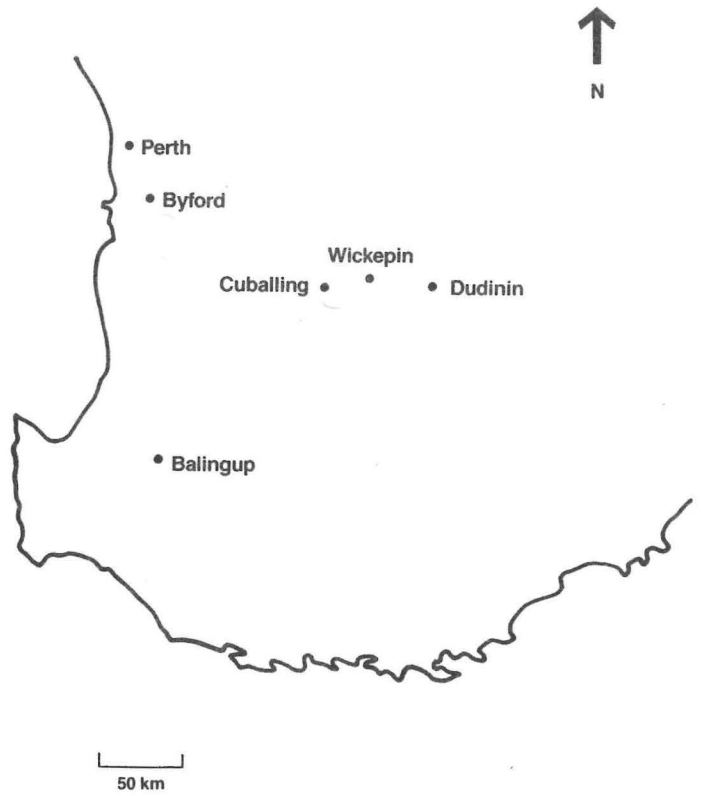
Between 1970 and 1975 the Agriculture Protection Board undertook investigations into the ecology and agricultural impact of the regent parrot (*Polytelis anthopeplus*), western rosella (*Platycercus icterotis*), red-capped parrot *(Purpureicephalus spurius*) and Port Lincoln parrot (*Barnardius zonarius*). All four species inhabit areas of agricultural land surrounded or interspersed with areas of uncleared country. All use the pastures and weeds and occasionally the cultivated crops growing on agricultural lands as a food source, and all nest in hollows in trees.

The western rosella and red-capped parrot are endemic to the south-west of Western Australia. The regent parrot and Port Lincoln parrot have wider distributions and occur in other parts of Australia.

This technical bulletin presents the results of a study of their breeding biology at four localities in Western Australia. Study of the Port Lincoln parrot and the regent parrot was carried out for four years (1971-74), the red-capped parrot for three years (1972-74), and that on the western rosella for two years (1973-74).

Western rosellas, red-capped parrots and Port Lincoln parrots are resident close to the breeding sites throughout the year, either roosting and foraging in the same or adjacent areas. Regent parrots leave the nest area following fledging of the young (November-December). They are rarely observed in it until the following late March-early April. Regent parrots are also rarely observed to feed in the nest area or in adjacent areas and also rarely roost there.

Figure 1. LOCATION OF STUDY AREAS IN SOUTH-WESTERN WESTERN AUSTRALIA



STUDY AREAS

Because of the number of species to be investigated at the same time, small areas which contained only a few pairs of the particular species were selected for study (see map Fig. 1). Port Lincoln parrots (*B.z. zonarius*) were studied on a farming property 11 km W. of Dudinin (270 km S.E. of Perth), regent parrots 30 km N.E. of Wickepin (232 km S.E. of Perth), and red-capped parrots 7 km S.W. of Byford (22 km S.E. of Perth). Isolated nests of western rosellas at Wickepin-Cuballing were studied as no specific area for them was located.

At Dudinin the area of 1.05 ha consisted of a stand of wandoo (*Eucalyptus wandoo*) and some morrell (*E. longicornis*) with sparse undergrowth of *Acacia* sp. and *Leptospermum* sp. The ground cover consisted of various herbs and grasses which were fairly regularly grazed by sheep. Apart from an adjacent stand of similar size and composition which lacked suitable hollows for breeding, the area was isolated from other islands of native vegetation by about 1 km or more. The area supported between six and nine (see Table 7, page 15 for number of nests each year) breeding pairs of Port Lincoln parrots.

The regent parrot breeding area of about 5 ha at Wickepin consisted mainly of salmon gum (*E. salmonophloia*) with some wandoo and morrell. The area had little undergrowth but a ground cover of grasses, rushes and herbs. It also included trees growing along a roadside and supported between four and eight breeding pairs of regent parrots. The area appeared to be grazed irregularly by sheep.

Red-capped parrots were studied in a 4 ha area consisting largely of flooded gums (*E. rudis*) with a few marri (*E. calophylla*) on the higher parts. It was bisected by a rail line. The area was partly waterlogged in winter and had some small *Casuarina* sp. thickets adjoining. The pasture ground cover was regularly grazed by dairy cattle. The area supported six to seven pairs of red-capped parrots which attempted to breed.

The breeding areas at Wickepin and Dudinin were typical of the islands of vegetation frequently left on wheat and sheep farming properties. That at Byford was typical of the remaining island stands of timber on the coastal plain just south of Perth. Dudinin occurs in an area where both subspecies of Port Lincoln parrots (*zonarius* and *semitorquatus*) and their hybrids are found.

Rosellas were found breeding in hollows in wandoo either along roadsides or within isolated stands of timber on farming properties. Breeding hollows at Wickepin were in similar country to that used by regent parrots and those in adjoining Cuballing were in isolated wandoo growing mainly in or near *Casuarina* sp. thickets.

METHODS

Just prior to and during the breeding period visits were made to examine nesting hollows at intervals of six or seven days.

On each visit to the nesting hollow the number of eggs and young were recorded. Nestlings were weighed and measured (bill width, bill length, folded wing and tail) and the stage of development of feathers noted up until they had fledged. For Port Lincoln and regent parrots these measurements were recorded only in the first two years of the study.

During the period of the study observational work on parrot behaviour was carried out on specially selected nests.

Checking a western rosella nest near Wickepin

RESULTS

NEST PREPARATION

Port Lincoln parrots were first seen entering nesting hollows in June. Observations (on unmarked birds) indicated that those entering the hollows at this time were females. Males did not appear to enter the hollow until after the first eggs had been laid. In June other pairs were chased away from the nest tree and females began spending between one and 26 minutes at a time inside the hollow. Time spent in the hollow by the female then gradually increased until shortly before egg laying. By August a large part of the day was spent in the hollow. Males were observed feeding females (courtship feeding) at the same time as the first eggs appeared. Copulation was observed only once between a pair, of which the female had already laid a single egg.

Port Lincoln parrots showed interest in nesting hollows as early as February. They continued to show interest in nesting hollows until June when agonistic encounters increased and birds began to enter the hollows. Table 1 (next page) shows the increase in agonistic encounters and hollow inspections, and the time at which both males and females began to enter the nesting hollows. Fig. 2 (next page) shows the amount of time spent by all the parrot species in the hollows during the observation periods.

Regent parrots began to appear somewhat regularly in the nest area in late March. They showed some interest in the hollows immediately, but regular inspection was not a feature of their activities until May. At this time agonistic encounters between parrots increased substantially. Females began entering hollows and spending periods of between half and 11 minutes inside the hollow in May. This pattern continued through June and July although the parrots were often absent from the area, particularly in June. These absences sometimes lasted for several days. In August both male and female regent parrots were observed entering the nesting hollows, males for short periods (one to nine minutes) and females for generally longer periods of from one to 120 minutes. Time spent by the female in the hollow then gradually increased until egg laying commenced in late August or early September. Males were observed feeding females a few days before the first eggs were found in the area.

Rosellas (probably females) were first seen to enter hollows in July. One week before eggs were laid they were spending a considerable portion of the day in the nesting hollow. Males were first observed to enter hollows in mid-August for brief periods of from one to 15 minutes. Males were observed feeding females at the time the first eggs appeared in the area.

Red-capped parrots showed some interest in trees containing hollows in March. At this time noisy agonistic encounters between small groups of four to eight parrots were noted occasionally in or around known nest trees. This type of encounter was not then seen until July when it began to be observed more frequently. Red-capped parrot pairs were observed looking into and biting at the entrances of hollows in early August. Concurrently females were observed entering the hollows for up to 15 minutes.

Table 1. PARROT ACTIVITY IN RELATION TO THE HOLLOW

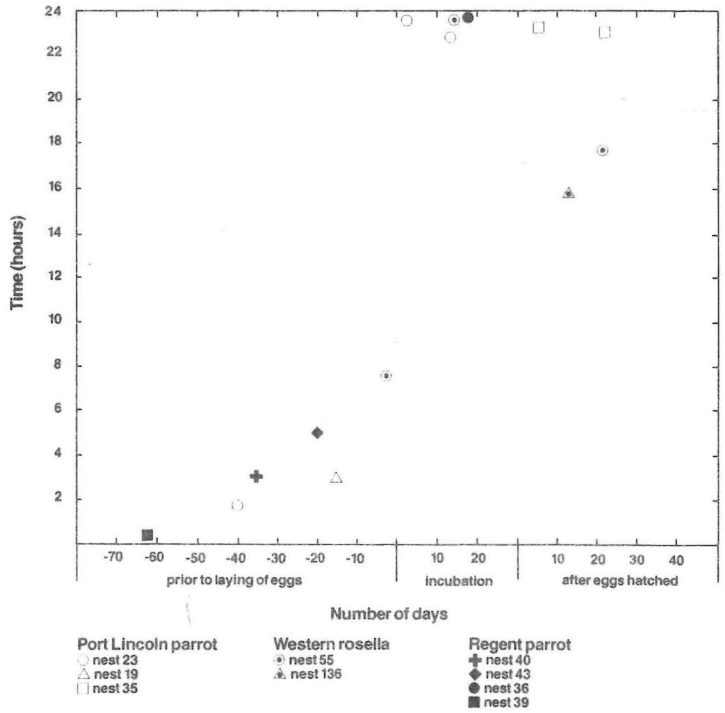
Species	Activity	MONTH J	F	M	A	M	J	J	A	S	O	N	D
Port Lincoln parrot	Agonistic encounters per hour of observation	0	0.22	0.5	0.2	0.15	1.87	2.26	1.74	0.16	0.93	0	0
	Hollow inspections and entrance biting per hour of observation	0	0.06	0.28	0.45	0.73	0.56	0.92	1.09	0.13	0.15	0	0
	Females observed entering hollows	0	0	0	0	0	*	*	*	*	*	*	0
	Males observed entering hollows	0	0	0	0	0	0	0	*	*	*	0	0
	Total hours of observation	15	33	21.5	22	20.5	26.5	18.5	21	14.5	17	18	10
Regent parrot	Agonistic encounters per hour of observation	-	-	0.07	0	0.70	0.27	0.33	1.01		0.04	0	0
	Hollow inspections and entrance biting per hour of observation	-	-	0	0.12	0.97	0.20	0.46	0.84		0	0	0
	Females observed entering hollows	-	-	0	0	*	*	*	*		*	*	*
	Males observed entering hollows	-	-	0	0	0	0	0	*	-	*	*	0
	Total hours of observation	10	15	17	25	21.5	19.5	28.5	26	0	13	10	10

- = No birds present in area 0 = No activity observed Blank space = No observations * = Birds entering hollows

ATTACHMENT TO THE NEST SITES

The attachment of individual parrots to a particular nest site is not known. However Port Lincoln parrots tended to use many of the same nests each year. This attachment was less marked in regent parrots and appeared to be rare amongst western rosellas and red-capped parrots. Of 11 Port Lincoln parrot nests in which eggs were laid during the four years, four were used every year, three were used three times, two were used twice and two were used only once. Of 14 regent parrot nests only one was used four times, two were used three times, two were used twice and nine were used only once in the period of four years. In the two years seven western rosella nests were used once and only one twice. The 12 red-capped parrot nests were used only once each during the three years of the study.

Figure 2. TIME SPENT IN NESTING HOLLOWS BY FEMALE PARROTS



SPACING OF NEST HOLLOWS

Although Port Lincoln parrots tended to select hollows which were confined to a central location in the patch of bush, suitable hollows were well distributed throughout the area. The distance between adjacent nests varied from 17 to 52 metres. Adjacent nests were always in the nearest trees with suitable hollows. Clumping of nests as on this site was not observed in other breeding areas in the district.

Although a similar clumping of nests was apparent for the regent parrot at Wickepin in 1971, in the following years they were more widespread. Nesting hollows of red-capped parrots were well dispersed throughout the area. Two of the western rosella nests were about 100 metres apart but the remainder were considerably further (some kilometres) from one another.

Two pairs of Port Lincoln parrots raised and fledged young from hollows in the same tree, the entrances of which were about two metres apart. Eggs were laid in the second hollow while the first contained nestlings. Only when the two males returned to the nest at

the same time was there much aggressiveness and fighting between the two. A similar occurrence took place between a pair of red-capped parrots and a pair of Port Lincoln parrots. The entrances to these hollows were some six metres apart and on opposite sides of the tree. Again the nests were at different stages, the Port Lincoln parrot laying eggs about 14 days before the red-capped parrot. Both successfully fledged young.

DIMENSIONS OF SUCCESSFUL NEST HOLLOWS

The height of nest hollow entrances above ground, the measurements of hollow entrances (horizontal and vertical), depth of hollows, and the diameter of the hollow at the level of the nesting chamber are given for the four parrot species in Table 2.

The regent parrot tended to utilize nesting hollows which generally had greater depth and a larger nesting chamber than those used by the Port Lincoln parrot. It was not unusual for well developed nestling Port Lincoln parrots of a large clutch (e.g. seven) to be literally sitting on top of one another. Port Lincoln parrots can use hollows with smaller entrance dimensions than the regent parrot and barely manage to fit through some of them.

Differences in hollow depth between nests in *E. wandoo* used by western rosellas and Port Lincoln parrots were not significant ($P = 0.128$).

There were no significant differences ($P = 0.674$) between the western rosella and the Port Lincoln parrot with regard to the diameter of the nest chamber. The remaining parrot species were using different eucalypt species, e.g. regent parrots in *E. salmonophloia* and red-capped parrots in *E. rudis*, hence no comparisons were valid.

Measurements of hollow depth and hollow diameter were subjected to analysis of variance followed by Scheffes procedure of homongeneous subsets (subsets of groups whose highest and lowest means do not differ by more than the shortest significant range for a subset of that size). There were no significant differences between these measurements (hollow depth and hollow diameter) for western rosellas, red-capped parrots and Port Lincoln parrots, but there were between them and those for the regent parrots. Analysis of nest entrance dimensions were also examined in the same manner and showed no significant differences between the four parrot species.

COMPETITION FOR NEST HOLLOWS

No competition was observed between Port Lincoln parrots and western rosellas nor between western rosellas and red-capped parrots for nesting hollows. Few were found in the same areas during this study, but nest measurements suggest that competition would occur in areas used by both species.

During the four years study at Wickepin a trio of galahs (*Cacatua roseicapilla*) excluded a pair of Port Lincoln parrots from nesting in one hollow. Galahs also prevented another pair from using a hollow by dropping bunches of leaves down into the nesting chamber.

During the preparatory period before egg laying frequent fighting was observed between regent and Port Lincoln parrots, but this appeared to wane once the Port Lincolns had laid.

TABLE 2. MEAN HEIGHT AND DIMENSIONS OF NEST HOLLOWS OF PARROTS

Parrot species	Regent parrot	Regent parrot	Port Lincoln parrot	Western rosella	Red-capped parrot
Area	Wickepin	Coomallo Creek	Dudinin	Wickepin-Cuballing	Byford
Tree species	Salmon gum *(Eucalyptus salmonophloia)*	Wandoo *(E. wandoo)*	Wandoo	Wandoo	Flooded gum *(E. rudis)*
Number of nests	19	17	20	6	16
Height of nest entrance above ground (m)	7.80±1.60 (4.70 - 10.45)	5.56±1.75*** (2.74 - 7.90)	6.32±1.32 (3.19 - 8.51)	8.53±2.00 (6.22 - 11.03)	9.60±3.41 (4.75 - 16.40)
Hollow depth (mm)	2760.10±1665.28 (395 - 6058)	1721.76±1304.03 (610 - 5791)	1271.70±843.79 (362 - 4005)	702.16±435.31 (356 - 1510)	607.18±222.92 (190 - 976)
Hollow entrance horizontal measure (mm)	125.89±63.09 (55 - 306)	222.00±83.46 (127 - 432)	97.25±37.24 (46 - 192)	61.67±21.44 (48 - 105)	84.13±24.13 (54 - 157)
Hollow entrance vertical measure (mm)	174.63±69.73 (70 - 398)	254.12±85.37 (127 - 432)	111.10±45.72 (52 - 215)	74.67±19.19 (57 - 105)	109.13±32.98 (70 - 170)
Hollow diameter at nest chamber (mm)	378.52±131.38 (135 - 612)	not recorded	172.64±56.58* (95 - 320)	184.33±60.90 (105 - 275)	129.35±18.87** (103 - 168)

* n = 17 ** n = 14 *** n = 16

THE DISTRIBUTION AND USE OF NESTING HOLLOWS AT DUDININ

At Dundinin there were 35 trees with 52 hollows of suitable size (50 x 50 x >360 mm) available to the Port Lincoln parrots. Only 11 (31.4 percent) of these were used during the study, eight in 1971, eight in 1972, six in 1973 and nine in 1974.

CHANGES IN HOLLOW DEPTH COMPARED WITH NEST USE AT WICKEPIN AND DUDININ

Dimensions of the nesting hollows changed from year to year particularly in regard to the depth of the floor of the chamber from the hollow entrance. These changes were caused by a number of factors including fungus and insect damage to the tree, exfoliation of the heartwood due to wind action and aging of the tree, splitting of the trunks at lower levels allowing material to escape (wind and ageing) and water seeping through entrance holes and down through the hollow centres of trees.

The internal changes to hollows at Wickepin for the regent parrot and at Dudinin for the Port Lincoln parrot were measured following each breeding season during the study. There appeared to be little relationship between the rises and falls in nest chamber levels and nest use in either area. The changes in hollow depth are shown in Table 3.

It was noted, however, that in cases where a large number of coarse pieces of heartwood had exfoliated and fallen into the nest chamber, such nests were not used in subsequent years.

LAYING, HATCHING AND FLEDGING PERIODS

The laying, hatching and fledging periods for the four parrot species for each year are shown in Table 4 (next page). The earliest and latest dates of laying for regent parrots (years combined) were August 21 to October 14, eggs were hatching from September 13 to November 6, and the young were fledging from October 30 to December 12. The corresponding figures for the other parrots were: Port Lincoln parrots August 8 to October 6, August 29 to October 27 and October 4 to December 5; western rosellas August 23 to September 26, September 26 to October 21 and October 30 to November 20; red-capped parrots, September 2 to October 26, October 1 to November 16 and November 6 to December 24 (see Fig. 3, page 12, for laying dates and nest success).

The range in total number of days of nest occupancy during the breeding season from the first laying of eggs to the last young fledged was:

regent parrots	85-108 days
Port Lincoln parrots	88-105 days
western rosellas	76-88 days
red-capped parrots	76-88 days.

At Cuballing in 1974 a second clutch of eggs appeared in a nesting hollow used by western rosellas about a week after the fledging of chicks from the clutch laid earlier in the season. The second clutch fledged in the second week of January 1975. Both nesting pairs were unmarked and it is not known whether this was multiple use of a hollow or a second nesting of the same pair.

Table 3. CHANGES IN HOLLOW DEPTH AND NEST USE AT WICKEPIN AND DUDININ

1. PORT LINCOLN PARROT AT DUDININ

Nest Number	Changes in hollow depth in mm				Nest use in each year			
	1972	1973	1974	1971-74	1971	1972	1973	1974
14A	+630	-56	-444	+130	Yes	Yes	Vacant	Yes
16C	-	-	+182	+182	Yes	Yes	Yes	Yes
19B	-	-61	-909	-970	Yes	Yes	Yes	Yes
21A	-40	-3	-217	-260	Vacant	Yes	Yes	Yes
21C	-	-	-520	-520	Yes	Vacant	Vacant	Yes
21D	-	-	-130	-130	Vacant	Vacant	Vacant	Yes
23B	-70	-34	-1	-105	Yes	Yes	Yes	Yes
31A	+80	+86	-51	+115	Yes	No	Vacant	Vacant
34A	-550	0	-30	-570	Vacant	Vacant	Vacant	Yes
30A	-800	-177	+657	-320	Vacant	Yes	Yes	Yes
35A	-	-	-580	-580	Yes	Yes	Yes	Yes

2. REGENT PARROT AT WICKEPIN

36	-	-21	+33	+12	Yes	Yes	Yes	Yes
37	-	+13	-13	0	Yes	Vacant	Vacant	Vacant
38	-	+23	+25	+48	Yes	No	Vacant	Vacant
39	-	-6	+16	+10	Vacant	Yes	Yes	Vacant
40	-	-168	-2	-170	Vacant	Yes	Vacant	Vacant
42	-	-	-1340	-1340	Yes	Vacant	Vacant	Vacant
43	-	+360	Fallen	+360	Vacant	Yes	Vacant	Fallen
44	-	-56	0	-56	Yes	Yes	Vacant	No
48	-	+63	-65	-2	Vacant	Yes	Vacant	Vacant
50	-	+29	+38	+67	Vacant	Yes	Yes	Yes
51	-	-	-10	-10	Vacant	Vacant	Yes	Vacant

Yes = successful nest (clutch fledged) No = clutch commenced then abandonded Vacant = no attempt to use (no eggs laid) Fallen = tree fell to ground

Figure 3. LAYING DATES AND SUCCESS OF PARROTS

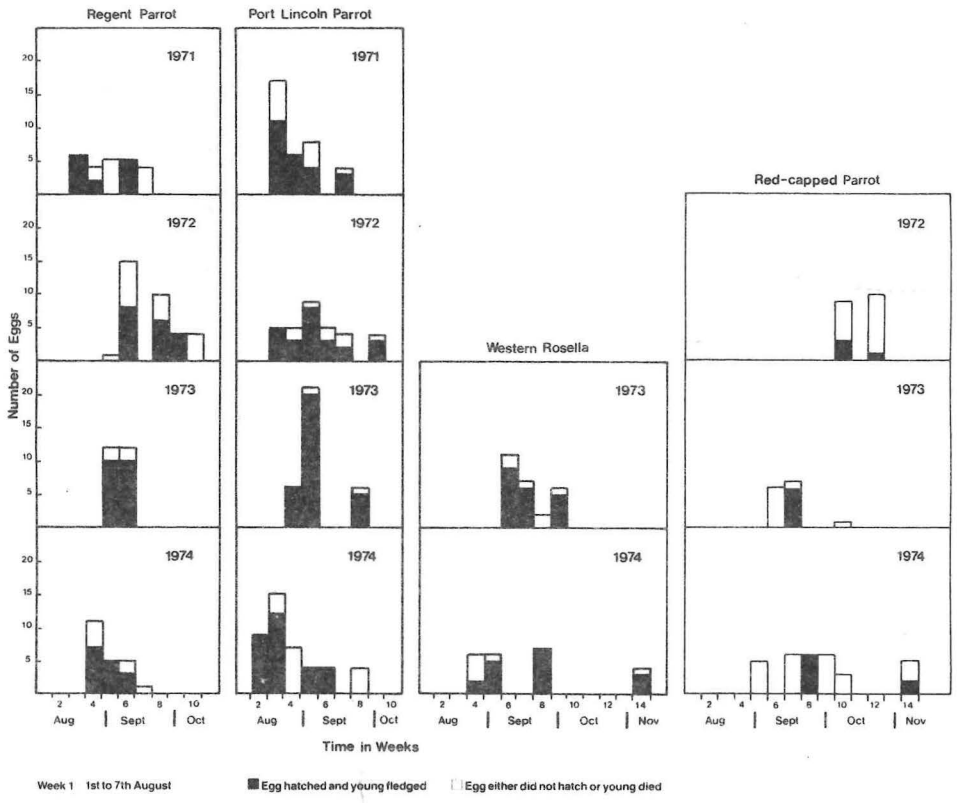


Table 4. LAYING, HATCHING AND FLEDGING TIMES

YEAR	SPECIES	LAYING	HATCHING	FLEDGING
1971	*P. anthopeplus*	Aug 21-Sep 15	Sep 13-Oct 8	Nov 1-Nov 21
	B. zonarius	Aug 19-Sep 20	Sep 9-Oct 11	Oct 17-Nov 18
1972	*P. anthopeplus*	Sep 61-Oct 14	Sep 29-Nov 6	Nov 2-Dec 12
	B. zonarius	Aug 21-Oct 6	Sep 11-Oct 27	Oct 12-Dec 5
	P. spurius	Oct 1-Oct 26	Oct 25-Nov 16	Dec 1-Dec 24
1973	*P. anthopeplus*	Sep 2-Sep 16	Sep 25-Oct 9	Nov 4-Nov 25
	B. zonarius	Aug 27-Sep 25	Sep 17-Oct 16	Oct 22-Nov 24
	P. icterotis	Sep 1-Sep 26	Sep 26-Oct 21	Oct 31-Nov 13
	P. spurius	Sep 10-Oct 5	Oct 1-Oct 30	Nov 6-Dec 6
1974	*P. anthopeplus*	Aug 23-Sep 16	Sep 18-Oct 7	Oct 30-Nov 20
	B. zonarius	Aug 8-Sep 23	Aug 29-Oct 12	Oct 4-Nov 20
	P. icterotis	Aug 23-Sep 25	Sep 26-Oct 18	Oct 30-Nov 20
	P. spurius	Sep 2-Sep 11	Oct 1-Oct 9	Nov 7-Nov 16

INCUBATION, CLUTCH SIZE AND CLUTCH FREQUENCY

The eggs in a limited number of nests were marked and examined every second day to check the incubation periods usually ascribed to these species. For Port Lincoln parrots (number of nests in sample = 3) the incubation period was 20-22 days, regent parrots (n = 3) 21 to 23 days and red-capped parrots (n = 1) 23 days. For western rosellas (n = 2) clutches laid in the same nest in the same year were used. In the first clutch the eggs hatched in 23 days and the other in 25 days. Data from other nests which were less accurately known helped to confirm these periods.

The four parrot species laid from one to seven eggs per clutch. The smallest incubated clutch was four eggs for regent parrots, western rosellas and Port Lincoln parrots, and three eggs for red-capped parrots.

The frequency with which the different clutch sizes occurred is shown in Table 5.

The mean clutch size (for incubated clutches) for regent parrots was 5.1 ± 0.2 (mean ± standard error), Port Lincoln parrots 4.9 ± 0.2, western rosellas 6.3 ± 0.3 and red-capped parrots 5.3 ± 0.3.

EGG SIZE

The mean dimensions of the eggs laid by the four parrot species is shown in Table 6.

Table 5. FREQUENCY OF DIFFERENT CLUTCH SIZES

SPECIES	YEARS	NO. OF CLUTCHES	CLUTCH SIZE 1	2	3	4	5	6	7
Port Lincoln (*B.z.z*)	1971-74	30	1	0	1	12	7	6	3
Regent parrot	1971-74	22	2	0	0	5	9	5	1
Red-capped parrot	1972-74	12	1	0	1	2	2	5	1
Western rosella	1973-74	9	0	1	0	1	1	3	3

Table 6. EGG SIZE IN FOUR SPECIES OF PARROT

SPECIES	AREA	n	$\bar{x}$ L x B	SD L x B	RANGE L x B
Port Lincoln (*B.z.z*)	Dudinin	47	30.46 x 24.3	1.76 x 1.81	24.0 - 32.2 x 18.2 - 26.0
Regent parrot	Wickepin	47	31.1 x 24.7	1.74 x 0.88	29.0 - 36.6 x 22.8 - 27.4
Red-capped parrot	Byford	26	27.5 x 23.2	0.99 x 0.67	25.1 - 28.4 x 21.8 - 24.5
Western rosella	Wickepin-Cuballing	14	24.2 x 20.0	0.96 x 0.52	22.7 - 25.5 x 19.5 - 21.2

LAYING

The laying dates for the first eggs from each hollow are shown in Figure 3 (page 12) for each of the areas and for each of the years. The dates have been grouped into weeks, week 1 being the 1st to the 7th of August. Whether the eggs hatched and the young fledged is also shown. The laying dates did not appear to affect the success of the clutch for any of the parrots. However, the data on regent parrots, Port Lincoln parrots and western rosellas does suggest that success may be correlated with a later and shorter laying period.

As an indication of the breeding season in these and other localities the gonads of male parrots from samples collected at Balingup and Wickepin between June 1970 and October 1972 were weighed and measured. The mean monthly weights of the left testes are shown in Figure 4 for the four parrot species.

REPRODUCTIVE SUCCESS AND NEST MORTALITY

The hatching success (percentage of eggs hatched), nestling success (percentage of nestlings that fledged) and breeding success (percentage of eggs which yielded fledglings) for the four parrot species are shown in Table 7.

Port Lincoln parrots at Wickepin were the most successful of the four species with an overall breeding success (years combined) of 75 percent. Western rosellas were almost as successful with 72 percent and regent parrots slightly less with 63.5 percent success. Although the latter species had a better hatching success (88.5 percent) than either Port Lincoln parrots or western rosellas (81.2 and 84 percent),

Figure 4. MEAN MONTHLY WEIGHTS OF LEFT TESTES

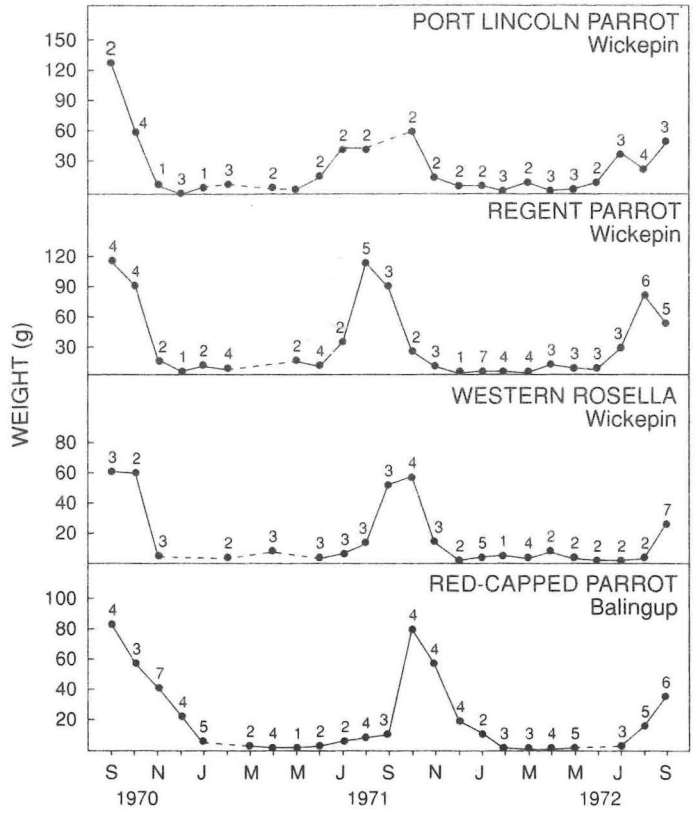


TABLE 7. REPRODUCTIVE SUCCESS OF THE FOUR SPECIES OF PARROTS

SPECIES	YEARS	NO. OF NESTS	NO. OF EGGS AND YOUNG LAID	HATCHED	FLEDGED	% SUCCESS HATCHING	NESTLING	BREEDING
Regent parrot	1971	5	24	22	13	91.7	59.1	54.2
	1972	8	34	27	18	79.4	66.7	52.9
	1973	4	24	22	20	91.7	90.9	83.3
	1974	5	22	21	15	95.4	71.4	68.2
		22	104	92	66	88.5	71.7	63.5
Port Lincoln (*B.z.z*)	1971	7	35	27	23	77.1	85.2	65.7
(Wickepin)	1972	8	32	27	24	84.4	88.9	75.0
	1973	6	34	32	32	94.1	100.0	94.1
	1974	9	43	31	29	72.1	93.5	67.4
		30	144	117	108	81.2	92.3	75.0
Western rosella	1973	5	26	22	20	84.6	90.9	76.9
	1974	4	24	20	16	83.3	80.0	66.7
		9	50	42	36	84.0	85.7	72.0
Red-capped parrot	1972	4	19	7	4	36.8	57.1	21.0
	1973	3	14	11	6	78.6	54.5	42.8
	1974	5	26	14	6	53.8	42.8	23.1
		12	59	32	16	54.2	50.0	27.1

nestling success was considerably lower (71.7 percent as against 92.3 and 85.7 percent).

Red-capped parrots had a poorer hatching and nestling success and consequently a much reduced overall breeding success (27.1 percent). All four parrot species had better than average breeding success in 1973.

GROWTH AND DEVELOPMENT OF THE YOUNG

The development of selected body characteristics with weight and age is shown in Figure 5. Logistic growth curves were fitted for the data on wing length (folded wing) measurements for each of the parrot species (see Figure 6). These were calculated using the methods as outlined by Ricklefs (1967 and 1968), i.e.:

$$\text{wing length} = \frac{a}{1 + be^{-kt}}$$

where a = asymptote, t = time post hatching in days, and b and k are constants. A regression was fitted using various values of around the known asymptote to select the line of best fit (maximum r^2). This method was equivalent to Ricklef's "refining the asymptote". The asymptote, free-flying wing length and value for k for each parrot species are shown in Table 8 (page 18). There was insufficient data to fit curves for each year therefore the data was pooled.

At hatching the nestlings of the four parrot species weighed:- regent parrots 5-7g, Port Lincoln parrots 5-7 g, red-capped parrots 4-6 g, and western rosellas 4-5 g. They then gained weight rapidly, the

Figure 6. LOGISTIC GROWTH CURVE FOR PARROT WING LENGTH MEASUREMENTS

(a) Red-capped parrot (n=18 nestlings)
(b) Western rosella (n=24)
(c) Regent parrot (n=44)
(d) Port Lincoln parrot (n=37)

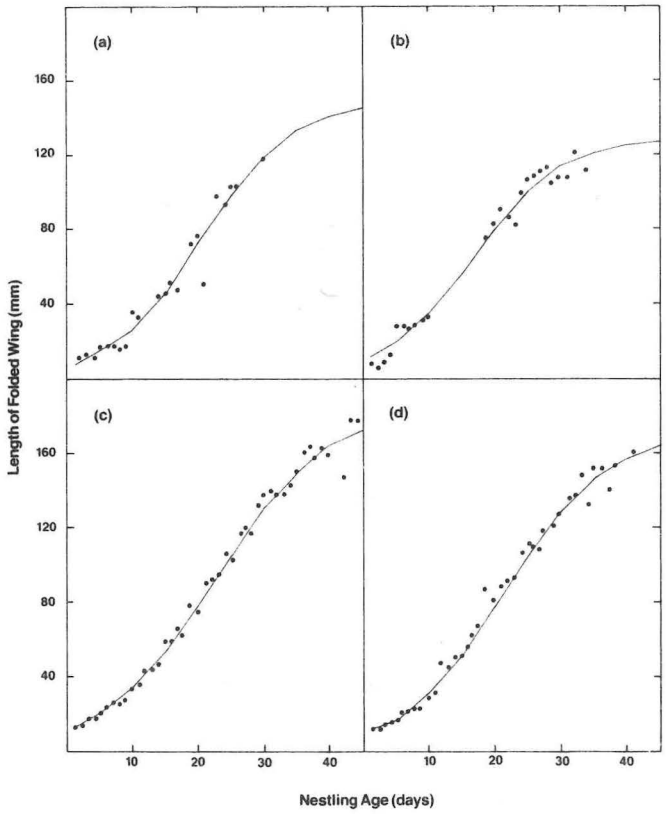


Figure 5. COMPARATIVE DEVELOPMENT OF BODY CHARACTERISTICS DURING NEST LIFE

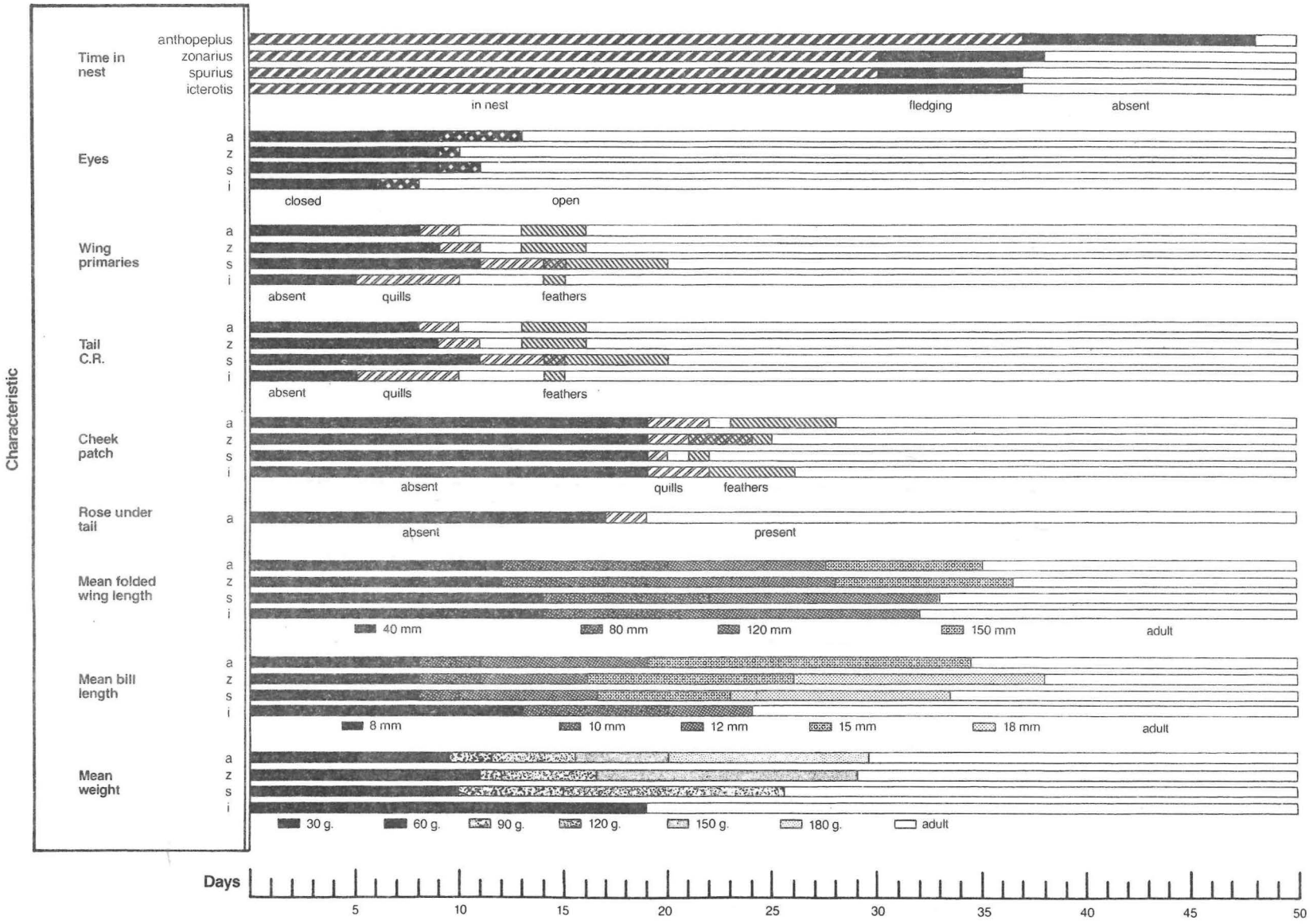


Table 8. WING LENGTH AND GROWTH RATE OF PARROTS

SPECIES	NUMBER OF NESTS	NUMBER OF NESTLINGS	ASYMPTOTE	WING LENGTHS (mm) MALES	WING LENGTHS (mm) FEMALES	GROWTH RATE (K)
Regent parrot	10	44	184	192.02	192.88	0.120
Port Lincoln parrot	9	37	172	182.14	172.39	0.129
Red-capped parrot	4	18	148.5	155.72	148.84	0.145
Western rosella	4	24	130	135.30	130.01	0.147

average daily growth rate (freshly hatched to fledging) for regent parrots was 4.7 g, Port Lincoln parrots 4.1 g, red-capped parrots 4.1 g and western rosellas 2.3 g. Both western rosellas and red-capped parrots reached mean adult weight 7-14 days before fledging. Regent parrot nestlings fledged at approximately the mean weight for adult males and slightly below that of the mean weight for adult females. The young of Port Lincoln parrots fledged before they reached the mean weight for adults.

Because of the wide variation in weights of the nestling parrots, particularly in the weeks prior to fledging, growth curves were not fitted.

DISCUSSION

Why some hollows were used regularly each year by the parrots and others irregularly is not obvious. Port Lincoln parrots used only 31.4 percent of the available suitable hollows. This percentage is probably representative for the other species investigated. The clumping together of hollows used by Port Lincoln parrots at Dudinin was probably related to the direction of human activity on the property. It was not a feature of adjacent breeding areas. No clumping of nesting hollows was noted at Coomallo Creek for either Port Lincoln parrots (Saunders *et al.* 1982) or regent parrots (Saunders pers. comm.). However, regent parrot nests at Wickepin were clumped in the same general area and this tendency has also been noted in South Australia (Burbidge 1985).

White-tailed Black Cockatoos (*Calyptorhynchus baudinii*) used only 45 and 41 percent of available hollows of suitable size at Coomallo Creek and Manmanning, W.A. (Saunders 1979). Saunders concluded that the availability of hollows did not appear to be a limiting factor on the size of the white-tailed black cockatoo population. This also appears true for the parrots investigated in this study.

Although there was little difference between the hollows selected by the four parrot species the sample size for each species was small. Whether regent parrots naturally chose the larger hollows at Wickepin or were forced to accept these by the more aggressive Port Lincoln parrots is not known. In those instances observed, where both species were engaged in preparing the same hollow, Port Lincoln parrots laid eggs in the nest. Agonistic interactions among the four species of parrots suggest that they defend at least a part of the tree in which the nesting hollow is situated.

Hollow selection by these parrots occurs over a lengthy period. Although there were variations between pairs, the range of times before egg laying was 10-11 weeks for regent parrots and 8-10 weeks for Port Lincoln parrots. Less substantiated times of 7-8 weeks for western rosellas, and about 10 weeks for red-capped parrots are also suggested. Coupled with incubation periods and time spent in the nest by the young, interest in the hollow extends for nearly half of the year. Other behavioural observations, particularly that of the interest in the hollows by Port Lincolns and red-capped parrots in February and March, suggests that at least these two species may maintain interest over an even longer timespan than that indicated. Selection of hollows to fledging of the young in white-tailed black cockatoos is about four and a half months (Saunders 1981) and galahs (*Cacatua roseicapilla*) have been reported to maintain interest in the hollow throughout the year (Rowley in Saunders 1981).

There was no loss of hollows in the breeding areas at Dudinin and Cuballing during the study period. Loss due to winds blowing over suitable nest trees or breaking off boughs was 1-2 per year at Wickepin and Byford. However, most of the districts in which the work was carried out suffered losses due to wind, bulldozing and fire in areas adjacent to the breeding sites.

Breeding success was highest in 1973 for all the species of parrots studied. The better breeding success in this year is possibly due to above average rainfall in June and July in all the breeding areas. These rains were responsible for a greater growth of plants during this breeding season. From the laying dates (see Figure 3, page 12) it is indicated that a later laying date and a shorter laying period, which was evident in 1973 for all the parrots, resulted in better breeding success.

DISCUSSION

Overall breeding success (years combined) of 75.0 percent for Port Lincoln parrots, 72.0 percent for western rosellas and 63.5 percent for regent parrots are comparable with that of white-tailed black cockatoos (65 percent) at Coomallo Creek (Saunders 1979). Hatching and fledging success of these parrots was better than that found for budgerygahs (*Melopsittacus undulatus*) (nest success 63 percent, fledging success 40 percent) at Trielmon and Mokely Creek, New South Wales (Wyndham 1981).

The mortality of 73 percent for nestling red-capped parrots at Byford warrants further explanation. It was the product of both a poor hatching success and poor nestling success as compared to the other parrots studied. Red-capped parrots are wary nesters and tolerate less interference at the nest hollow than do the other parrots studied. Flooded gums in which the species nested at Byford may not be optimum nest trees as the species is reported (Forshaw 1969) to nest mainly in marri. Food resources did not appear to be limited although no measurements were taken. A high mortality in most years and perhaps a low mortality in others could explain why the species is occasionally (as in 1983-84) found in such large numbers.

Few reasons were established for the nest mortality amongst the parrots studied. No predation on nests was observed. A severe local hailstorm at Wickepin destroyed a clutch of nestling elegant parrots (*Neophema elegans*) by freezing them in a nest hollow which opened vertically. A clutch of nestling red-capped parrots at Byford drowned when the nest chamber filled with water following a heavy downpour.

Clutches of Port Lincoln parrots in areas adjacent to the breeding area at Dudinin were noted to suffer from a complaint which appeared to affect their ability (head-bobbing) to feed from the parent birds. These nestlings had either blackish or blackish and yellow bills instead of the normal pinkish colour and were usually much lighter in weight than the study nestlings. In these and other areas Port Lincoln parrot nestlings are known to fledge sometimes without tail feathers and with reduced primary wing feather growth.

This study and earlier work on the foods of these parrots (Long 1984) suggests that they have initially benefited by the changes in land use brought about by human interference with the environment. Within the present system of islands of uncleared country and cultivation in wheatbelt areas of Western Australia there appear to be no reasons why their numbers cannot be maintained. It is obvious that in some of the forest areas of the south-west part of the state they could adapt to further changes. However, in the agricultural areas the question of how much more clearing these parrots can stand is not so easily answered. The balance maintained by the present land use may be precarious indeed. The rise and decline in numbers of regent parrots in W.A. may be indicative of the rapidity with which these changes can occur.

Saunders *et al.* (1982) have outlined the demise of the surviving salmon gum woodland in the agricultural areas and its use by a number of nesting cockatoos and the Port Lincoln parrot. The loss of natural woodland also poses serious problems for the small parrot species investigated in this study.

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