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Reproductive biology of the endangered Ouvea Parakeet *Eunymphicus cornutus uvaeensis*

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The reproductive biology of the endangered Ouvea Parakeet *Eunymphicus cornutus uvaeensis*, an endemic subspecies of Ouvea island (Territory of New Caledonia, Southwest Pacific) was studied from June 1994 to February 1996. Breeding was recorded from early August until late January. All nests were sited in cavities of native forest trees, 90% of them in *Syzygium* sp. and *Mimusops* sp. Mean clutch size was 2.9 eggs (range 2–3), and double clutches were recorded. Incubation lasted 21 days and the nestling period averaging 43 days. An average of 1.65 chicks fledged per nest but only 0.75 per breeding pair were still alive 30 days after fledging. The main causes of chick loss were starvation of the third sibling during the first week due to hatching asynchrony, raptor (presumably Brown Goshawk) predation of fledglings and human harvest for the pet trade. Growth curves and multiple regressions of weight, culmen-width and -length, tarsus- and wing-length, showed that wing-length was a good predictor of age, and that there were significant differences between the sexes for weight and culmen-width. The pattern of the breeding season, brood reduction, nest-site characteristics and presumed size of breeding territories suggest that both food and availability of suitable nest-sites may be factors limiting breeding productivity. Proposals for conservation of this endangered bird are presented.

Although parrots are one of the most common and well-known group of birds in captivity, there are few studies on their biology and ecology in the wild. Their high mobility, non-territorial flocking behaviour, typical rainforest habitat and relatively inacccessible nesting cavities make them difficult to catch and study. Knowledge of their reproductive biology is therefore often based on anecdotal evidence. Few parrots have been well-studied in the wild and these include the Puerto-Rican Parrot *Amazona vittata* (Snyder 1977, Wiley 1985, Snyder *et al.* 1987), the Monk Parakeet *Myiopsitta monachus* (Bucher *et al.* 1991, Navarro *et al.* 1992) and the Bahama Parrot *Amazona leucocephala bahamensis* (Gnam & Rockwell 1991) in the neotropics, and several cockatoos (Saunders *et al.* 1982, Rowley 1983, Saunders 1986, Smith & Saunders 1986) in Australia. In the Pacific Islands, only the Kakapo *Strigops habroptilus* has been studied in detail (Powlesland *et al.* 1992), and some data on reproduction are available on Kaka *Nestor meridionalis* (Moorhouse 1991), Red-crowned Parakeet *Cyanoramphus novaezelandiae* (Taylor 1985; Green 1991) and Red Shining Parrot *Prosopeia tabuensis* (Rinke 1989). This is of particular concern as 90 (27%) of the 330 parrot species are threatened with extinction (Rands 1991, IUCN 1996), and most of these lack the basic demographic and biological data necessary to identify threats, monitor populations and review the efficacy of conservation measures taken (Green & Hirons 1991).

The Ouvea Parakeet *Eunymphicus cornutus uvaeensis*, a subspecies endemic to Ouvea Island (20°30′S–166°35′E) in the Loyalty archipelago, is one of the most endangered parrots of the tropical Pacific. Along with the other subspecies, the Horned Parakeet *E. c. cornutus*, which inhabits the New Caledonian main island, the Ouvea Parakeet belongs to an endemic genus related to *Cyanoramphus* and *Prosopeia*. These three genera are usually considered as an island branch of the Australian Platycercine parrots (Berlioz 1945, Smith 1975, Christidis *et al.* 1991, Homberger 1991). The Ouvea Parakeet is restricted to the 132 km² island of Ouvea. It has suffered a marked decrease in

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abundance since European colonization, due to destruction of its habitat and possibly captures for the live bird trade (Robinet *et al.* 1995). The population is now 300–600 individuals with less than 100–120 breeding pairs remaining (Robinet *et al.* 1996). The status of the Ouvea Parakeet was considered critical by the IUCN (Mace & Lande 1991, Lambert *et al.* 1992).

The aim of this study was to obtain basic reproductive data and to elucidate the factors affecting reproductive success in order to assist with recovery of this endangered bird.

STUDY AREA AND METHOD

Ouvea is a raised atoll of limestone, approximately 50 km long by 6–8 km wide with a narrow strip of land in the centre, extended by a rosary of islets that surround a shallow lagoon. Ouvea parakeets are now almost completely restricted to the northern part of the island, where the remaining forest covers less than 2500 ha (for more details see Robinet *et al.* 1995, 1996).

This study covered two breeding seasons between June 1994 and February 1996. Both former and active nests were located in the first season by interviewing local people, inspecting known nests, and by following apparent breeding pairs. All of the nests found in these ways were inspected by climbing and the use of a strong torch and articulated mirror. For each nest, the tree species, its diameter at breast height, the height and mean diameter of the nest entrance and the depth of the nest was estimated or measured to the nearest 5 cm. The nest chamber was carefully inspected for signs of occupation (clean chamber without spider webs, feathers, eggs, young, adults, remains and flies). Once an occupied nest was discovered, it was inspected every six days or less until fledging or nest failure. On each visit, we recorded development of external characters of the nestlings (whitish down, grey down, opening of the eyes, white notch on the nape, appearance of feather quills and opening, wings complete, appearance of the red crown and the crest, darkening of the beak) and mortality.

Five growth parameters were recorded: weight, using a 200-g Pesola spring balance (± 1g); culmen-length, taken from the tip of the upper mandible to the anterior edge of the cere (to the nearest 0.1 mm); culmen-width, the width of upper mandible taken at the anterior edge of the cere (to nearest 0.1 mm); tarsus-length, the distance from the posterior surface of the tibio-tarsal joint to the anterior surface of the articulation with the middle toe (to nearest 0.1 mm); wing-length, the distance from the anterior surface of the ankle (radio-carpal joint) to the tip of longest primary (to the nearest mm). Measurements were made with Vernier callipers.

We fitted growth data to logistic models using the SPSS non-linear regression (a) procedure (SPSS/PC+ version 5.0, 1992). Such models have been successfully used to fit growth data in numerous postnatal development studies including parrots (Ricklefs 1967, 1983, Saunders 1986, Rinke 1989, Beissinger & Waltman 1991, Navarro *et al.* 1992). The logistic equation used in this study was: $f(x) = A/(1 + B \exp^{-Kx})$, in which A is the asymptotic value, $B = (A - f(0))/f(0)$, and K a rate constant whose unit is 1/time. Multiple regressions (SPSS/PC+ version 5.0, 1992) were done between the five growth variables and age (dependent variable) before 45 days old, in order to determine which variable (or combination of variables) is the most accurate predictor of age. Chicks were sexed *a posteriori* using culmen-length and -width, as there is no overlap between adult males and females for the combination of these two variables (O. Robinet pers. obs.).

A hide was built near three nests and observations of parental behaviour (i.e. brood and female feeding, vocalizations) were made. All chicks were individually ringed with metal and plastic leg bands. In addition, 15 prefledglings were radiotagged with a single-stage transmitter (pulse: 18 ms, 40/min; silver-oxide batteries average lifespan 5 months, Sirtrack Ltd), attached on the back with an harness and a weak link (see Karl & Clout 1987 for design of harness). The transmitters plus harness weighed 5 g which represents about 4–5% of body weight of fledglings. The fledglings were then radiotracked twice a week until the transmitter failed or fell off. Three adult parakeets were caught with a mist-net set at the entrance of three nests just before fledging time. They were ringed and radiotagged but the transmitters were destroyed by the parakeets within a few hours.

Demographic parameters were defined as follows. Breeding success: the number of fledglings per eggs laid; hatching success, the proportion of eggs laid which hatched; and fledging success, the proportion of hatchlings which fledged. Reproductive output was defined as the number of live 75-day-old young produced per breeding pair per year. Survival rates were estimated directly. All means are given ± standard error.

RESULTS

Breeding season and nest-sites

From the 16 active nests and 24 clutches followed

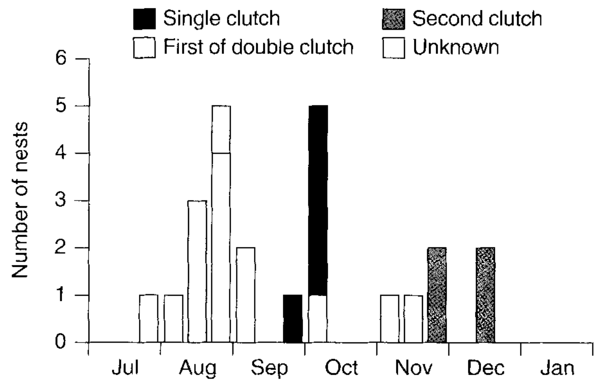


Figure 1. Breeding season of Ouvea Parakeets based on the dates of the first egg laid in each of 24 nests studied (in 10-day intervals).

during the study, the first egg was laid on 30 July and the last known chick fledged on 24 January. A peak of laying was observed in August and early September, followed by a second peak in early October, and some further laying in November and December, including second clutches. No second clutches were recorded for birds which first laid in the second peak (Fig. 1). The four second clutches recorded were produced by two marked pairs (one for two successive years) and an unmarked pair. This later pair had a ringed juvenile fed by the male who, at the same time, was feeding the female brooding the second clutch. Renesting was not related to nest failure, as the four first clutches of these birds were all successful.

Like most parrots, Ouvea parakeets are secondary cavity nesters, using a hollow in the trunk of a live tree. The 71 active or former nests identified during the study were all found in trees of only five species: *Syzygium pseudopinnatum*, *Mimusops elengi*, *Dysoxylum rufescens*, *Intsia bijuga* and *Ficus* sp. The first two species contained more than 90% of the total (see Table 1 for characteristics of nests). Two pairs were found nesting at the same time only 30 m apart without any evidence of agonistic behaviour, which suggests a 'breeding territory' limited to the nest itself. The birds appeared to show a strong fidelity to nesting sites. The three identified pairs (each with one adult ringed) reused the same nest in successive years. Of the three nests not reused, in one case, one of the parents had died; in the two others, the nests were opened and destroyed by islanders to capture the young.

Clutch size and incubation

Of the 24 clutches studied, 22 had three eggs, and two had two eggs (total 70 eggs, mean 2.92 ± 0.06). The laying interval for nests visited at least daily, between the first and second egg was 24 h (± 6 h, n = 14) and 24–72 h (± 6 h, n = 11) between the eggs 2 and 3. The eggs were pure white with an average size of 27.1 mm × 22.5 mm (n = 3). Behavioural observations suggest that females started to incubate after the second egg (n = 4). Length of incubation ranged from 19 to 22 days (mean 21.2 ± 0.3, n = 8). The hatching of the two first chicks occurred at the same interval (± 6 h) as between laying (24 hours, n = 13), whereas the third hatched on average 48 h after the second (range 24–96 h ± 3.2; n = 11). In total, 63 chicks hatched (mean/clutch 2.62 ± 0.14).

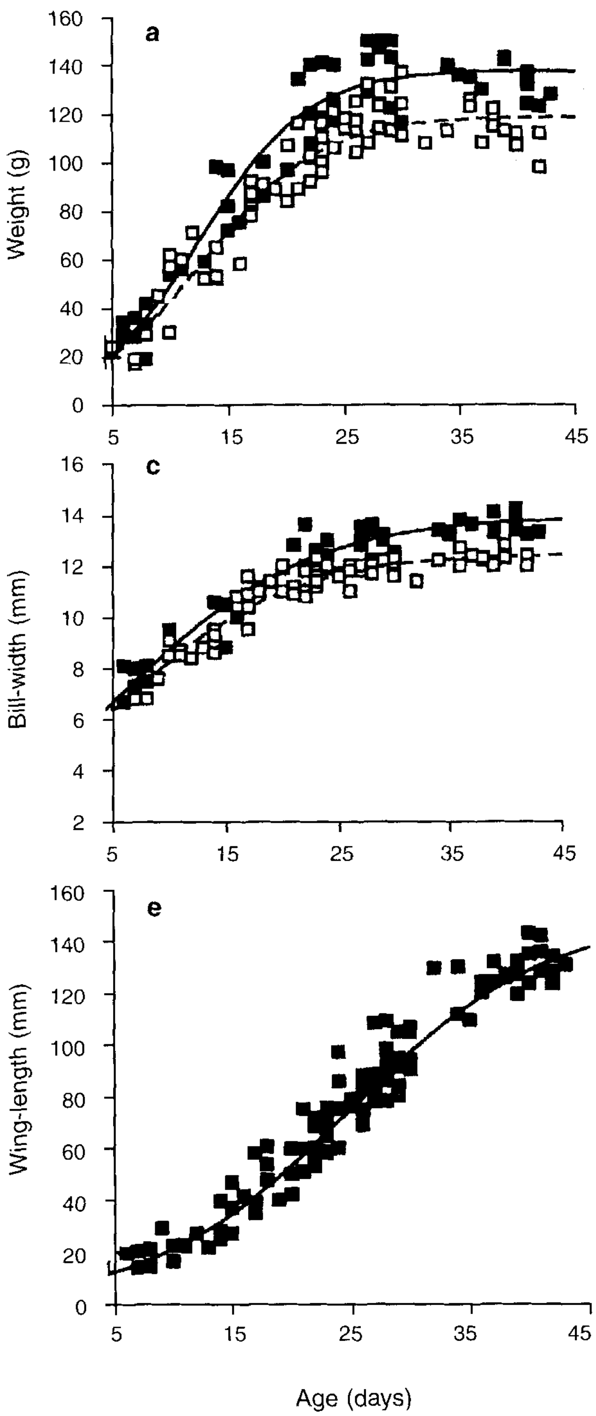
Postnatal development

At hatching, the chick is blind and covered only by thin white down. The eyes start to open at 10 days and are fully open at 14 days (mean 10.1–14.7; n = 7). Meanwhile, the white down is replaced by dense dark-grey down. A white spot appears on the nape which is

Table 1. Characteristics of 71 nest sites recorded for the Ouvea Parakeet.

	Tree species used			
	Syzygium pseudopinnatum	*Mimusops elengii*	*Dysoxylum rufescens*	*Intsia bijuga*
n	37	27	5	1
Proportion (%)	52	38	7	1

	Diameter at breast height (cm)	Average diameter of entrance (cm)	Depth of the nest chamber (cm)	Height above ground of the entrance (cm)
Mean	39.0	11.5	97.8	183
se	1.5	1.4	11.6	21.7



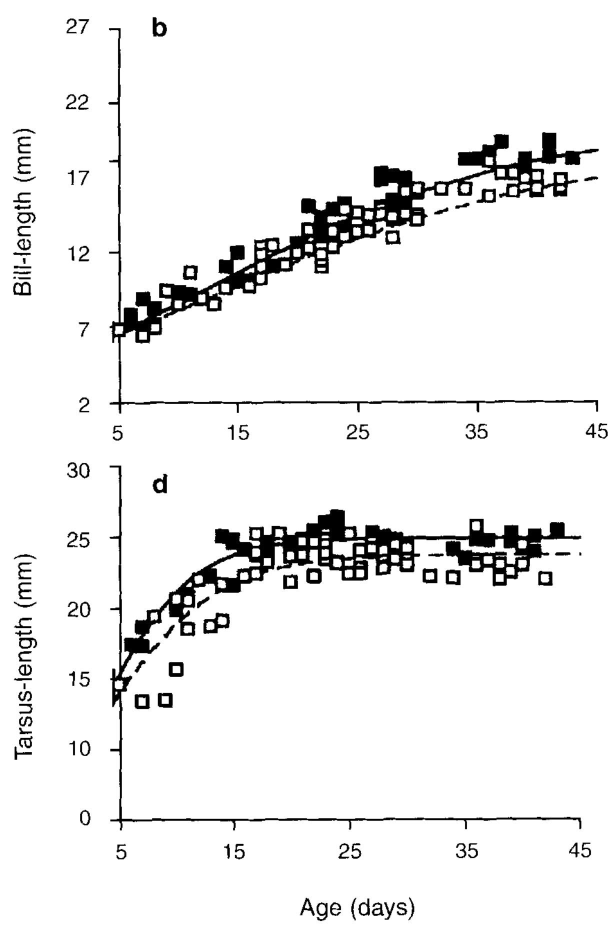


Figure 2. Growth curves of nestling Ouvea Parakeets (from 5 to 45 days) for (a) weight, (b) bill-length, (c) bill-width, (d) tarsus-length and (e) wing-length according to sex. ■–■, Male; □- - -□, female. Sexes are not separated for wing-length.

characteristic of most members of the Platycercinae and persists in the adult (Smith 1975). The beak becomes yellow and the feather quills appear on wings and tails at 13.6 ± 0.6 days (n = 7). The feathers appear on wings and tails at 25.6 days ± 0.6 (n = 8), and are completely formed at 32.4 ± 0.8 days (n = 7). The red on the forehead and the feathers of the crest appear at 36.8 ± 0.5 days (n = 6). The beak progressively turns to a bluish black a few months later. We observed one juvenile with a half-black beak in December (about three months old) and in August (minimum seven months old). The iris, brown in nestlings, turns to orange-red in juveniles and adults. Fledging occurs on average at 43 days after hatching (range 38–48, n = 11).

The logistic model described the growth pattern well ($r^2 > 0.9$). Growth curves showed that tarsus-length reached adult size early in fledgling life, with a significant difference between males and females. Culmen-width and weight similarly reached adult values before fledging, whereas wing- and culmen-length were still increasing at 45 days of age (Fig. 2).

Multiple regressions showed that wing-length was the best factor to predict age. The following prediction equation was obtained: Age = 0.25 (Wing-length) + 5.21 ($P < 0.001$; $r^2 = 0.94$; se = ± 2.52), without any significative improvement by adding other variables.

Parental behaviour

We spent over 92 hours observing three nests from preparation to fledging. Preparation of the nest occurred between two and seven weeks before laying. The nest was cleaned out and a roughly circular 10–15cm depression was excavated and lined with powdered wood, presumably from the walls of the nest chamber. During this time, adults were seen coming in and out of the nest with their faces covered with organic material.

The female incubated alone and stayed at the nest most of the time. She was fed by the male, who called her from the entrance by characteristic soft 'trumpet' calls. The typical feeding pattern was as follows: the female left the nest swiftly and perched on a branch at 10–30 m from the nest, followed by the male who perched alongside. The female presented her head held slightly back, the bill open, and made a loud *clok*. The male then jerked his head back and forth and regurgitated his crop contents. The process lasted 1–23 min (mean 9.2 ± 1.48, $n = 21$) with alternation of feeding and pauses.

The female was fed four times a day on average during incubation and early breeding (range 3–6). Until 15–20 days after hatching, the female alone brooded and fed the chicks. The time spent at the nest decreased from 73% during the first ten days, when the chicks had a thin white down, to 57% from 11 to 20 days when they were protected by a dense grey down. The female was still fed by the male but foraged increasingly by herself during that period. After about 20 days, both male and female fed the nestlings, which called the parents by a rapid succession of trumpet calls. The feeding lasted 1–13 min (mean 5.6 ± 0.76, $n = 23$), and the average interval between feeding was 145 min. The female stayed only 20% of the time in the nest during this period and the absences lasted an average of 70.1 min (Table 2). After fledging, the young were still fed by the male (and possibly the female) for several weeks (up to 80 days in one case) even if there was another clutch.

Breeding success

From the 70 eggs laid, 63 (90%) chicks hatched. Of the 54 hatchlings for which data were available, only 34 reached fledging age, giving a fledging rate of 63%. Nine out of these 34 young were captured by local people, producing a breeding rate of only 46%. The overall breeding success was thus only 42%, although this increases to 57% if human trapping is excluded. Of the 25 fledglings, 15 were equipped with radio-transmitters, four of which were lost, six birds died and five were still alive after 30 days (survival rate 46%, $n = 11$). On average, each pair produced 2.9 eggs per clutch, fledged 1.65 young, from which only 0.75 was still alive 30 days after fledging. This represents a 74% loss of the initial investment (Fig. 3).

Causes of nestling and fledgling mortality

Of the 24 clutches followed in the study, five failed before any fledging, from human disturbance, screw-

Table 2. Female behaviour during different stages of breeding in three nests of Ouvea Parakeet.

	Incubation	0–10 days	11–20 days	21–43 days
Number of observations	6	5	4	4
Total length (min)	1308	1410	1197	1224
Average length of the observations (min)	218	282	299	306
Average time spent out of nest per exit (min)	15	34	44	70
se	3.5	7.4	8.1	17.0
No. of exits observed	9	14	16	15
Time female out of the nest during observations (%)	14	19	43	80
Average time spent in the nest per stay (min)	150	72	49	16
se	20.5	10.8	12.4	4.4
No. of stays observed	9	14	14	14
Time female in the nest during observations (%)	86	81	57	20
Average number of exits per day[a]	4.8	7.4	8.4	9.0

[a]Estimated by the number of exit/stay cycles possible in a 13-h day (5.30–18.30 h).

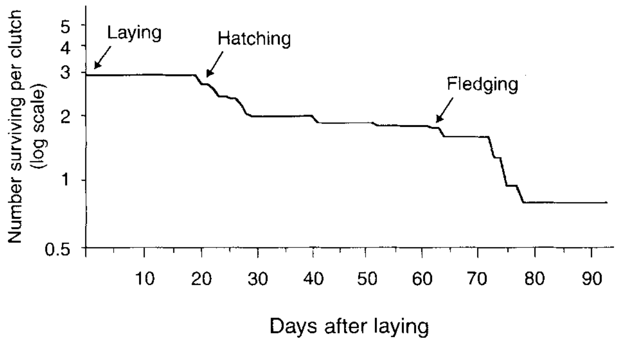


Figure 3. Survival curve during laying, rearing and fledging periods of Ouvea Parakeets, expressed as number of eggs/chicks per active nest.

worm (fly larvae) infestation, or presumed predation by Kiore *Rattus exulans* or feral cat *Felis catus*. The hatching asynchrony observed in Ouvea Parakeets affected nestling survival; survival rates were respectively 67%, 57% and 42% for first, second and third siblings. Six out of seven deaths in broods that partially failed within the first eight days were caused by starvation of the third sibling. After fledging, four out of the six recorded deaths were caused by raptor attack (scattered feathers found on the ground), presumably by the Brown Goshawk *Accipiter fasciatus*. A third major cause of loss was capture by islanders for pets (nine nestlings from four nests), usually during the last ten days before fledging. These results are shown in Table 3.

DISCUSSION

Comparison with other parrots

Breeding season

The Ouvea Parakeet seems to have a longer breeding season than the Horned Parakeet, which is known to breed from October to January (pers. obs., Hannecart & Létocart 1983, Forshaw & Cooper 1989). For the Red-crowned Parakeet, which ranges from subantarctic Auckland Islands north to New Caledonia, October to December is the main time for egg-laying (Taylor 1985, Forshaw & Cooper 1989). In contrast, the Red Shining Parrot which lives in the tropical Fiji and Tonga breeds earlier (May–October) during the dry and cool season, presumably because heavy rains and cyclones of the hot season have deadly effects on nestlings (Rinke 1989). The intermediate breeding pattern of the Ouvea Parakeet which starts during the cool months but ends in January in the hot and humid season suggests that food availability is high enough to allow the breeding period (7 months) to be extended from the 'core' season (October–January) shared with the Horned Parakeeet and *Cyanoramphus* subspecies. This extension of the breeding season has occurred towards the cool and dry months because breeding is probably more limited in the hot but humid months. An important implication of the extended breeding season is the possibility of double clutches, which are unusual in closely related parrots (Taylor 1985, Rinke 1988, Forshaw & Cooper 1989), and reportedly

Table 3. Causes of nest failure in 24 nests of Ouvea Parakeet.

	Number of clutches	Number of chicks (eggs)	Time of failure (days)	Cause of failure
Total laying failure	1	(3)	L + 10	Human disturbance
Partial hatching failure	4	(4)	L + 21	Non fertile egg
Total brood failure	1	3	H +2	Nest abandonment
	1	2	H + 6	Fly larvae infestation
	1	3	H + 7	Predation (kiore or cat)
	1	3	H + 20	Nest abandonment
Partial brood failure	6	7	H + 1–8	Starvation
	4	9	H + 25–35	Human captures
	1	1	H + 31	Fly larvae infestation
	1	1	H +42	Entanglement in *Ficus* roots
Juvenile mortality	1	1	F + 2	Unknown
	2	4	F + 10–12	Predation (goshawk)
	1	1	F + 15	Unknown

L, Laying; H, hatching; F, fledging.

infrequent in birds over 100 g (Perrins & Birkhead 1983).

Nest-site selectivity

Ouvea Parakeets use a narrow range of nest-sites: hollows in essentially *Syzygium* and *Mimusops* trees. This nesting behaviour contrasts greatly with the Horned Parakeet which breed in holes in banks and steep slopes in the New Caledonian Mountains (pers. obs., Hannecart & Létocart 1983, Forshaw & Cooper 1989).

These differences are not related to the availability of nest-sites because hollow trees occur in the Horned Parakeet habitat and are used by the sympatric Red-crowned Parakeet. On the other hand, Ouvea is a raised atoll with a profusion of terrestrial cavities that could have been used for nesting. This change in the choice of breeding site is the opposite to the Bahama Parrot, an island-specialized subspecies of the Cuban Parrot, which breeds in limestone cavities beneath the ground (Gnam 1991). The selection of mature trees for nesting by the Ouvea Parakeet, on an island where most of the native forest has been cleared and replaced with a patchwork of coconut plantations and traditional fields (Robinet *et al.* 1995), combined with a strong nest fidelity and apparent small home range, is likely to lead to nest-site limitation.

Nest-site limitation has been described in many parrot species, as they are secondary-cavity nesters unable to dig into wood to excavate nests. Well known examples are the Puerto Rican Parrot (Snyder, 1977, Wiley, 1985), Macaws *Ara* sp. (Munn 1992), Green-rumped Parrotlet *Forpus passerinus* (Beissinger & Waltman 1991) and also Cockatoos (Saunders *et al.* 1982).

Clutch-size and hatching asynchrony

The clutch size of the Ouvea Parakeet is similar that of the Horned Parakeet in captivity, and the New Caledonian Red-crowned Parakeet subspecies *C. n. saisseti* (2–4 eggs) (Hannecart & Létocart 1983, Taylor 1985, Forshaw & Cooper 1989). The larger clutches laid by the Red-crowned Parakeet in New Zealand (Table 4) can be related to latitude – birds in temperate regions tending to lay bigger clutches than tropical birds of the same body size (Lack 1968). The same pattern is observed in the genus *Platycercus* in Australia, with a clutch size smaller on average for the tropical species (2–5 eggs) than for the temperate one (3–9) (Forshaw & Cooper 1989).

The hatching asynchrony and brood reduction observed in Ouvea Parakeet may be explained by Stinson's insurance hypothesis (Stinson 1979), the later-laid eggs being insurance against failure of earlier-laid eggs or chicks. Hatching asynchrony might also be explained by the limited-breeding opportunities hypothesis, since most parrots are cavity-nesting birds that do not defend territories and when nest-sites are limited the female may defend the cavity by initiating incubation before the last egg is laid (Beissinger & Waltman 1991).

Breeding success

The Ouvea Parakeet has a high hatching success (90%) compared with other parrots (Table 4). Moreover, this high hatching-rate, and to a lesser degree fledging-success, is also related to a very low predation rate in the nest. Both Ship Rats *Rattus rattus* and Norway Rats *R. norvegicus* are absent from Ouvea (Robinet & Salas 1996) and Kiore, the only rat present, may have been responsible for the only case of nest predation. These

Table 4. Comparison of breeding parameters between Ouvea Parakeet and other psittacids.

	Ouvea Parakeet[1]	New Zealand Red-crowned Parakeet[2,3]	Red Shining Parrot[4]	North Island Kaka[5]	Western Australia Black Cockatoos[6,7]	Cuban parrots[8]	Monk Parakeet[9]	Green-rumped Parrotlet[10]
Body weight (g)[11]	130	80	250	450	660	270	135	25
Clutch size	2.9 (2–4)	6.9 (2–10)	2.2 (2–3)	3.7 (1–5)	1.4 (1–2)	3.1 (2–6)	6.0 (1–11)	7 (5–10)
Hatching success (%)	90	86	81	56	70 (50–82)	46	59 (48–66)	81
Fledging success (%)	63	34	83	34	53 (43–72)	67	47 (8–63)	82
Breeding success (%)	57	29	66	19	40	31	28 (4–42)	67
Successful attempts (%)	81	70	84	40	50 (35–66)	66	45	66
Juveniles fledged per breeding pair	1.6	2.0	1.1	0.7	1 (0.3–2)	1.6	1.5 (0.5–2.3)	4.7 (1–8)
Incubation period (days)	21 (19–23)	(19–22)	24	(24–26)	(28–30)	(26–28)	24	20 (18–22)
Nestling period (days)	44 (37–48)	(35–42)	(45–55)	70	(77–84)	(56–60)	35	31 (28–35)

Results are means with range in parentheses. [1]This study, [2]Taylor (1986), [3]Green 1991, [4]Rinke (1989), [5]Moorhouse (1991), [6]Smiths & Saunders (1986), [7]Saunders & Ingram (1987), [8]Gnam (1991), [9]Navarro *et al.* (1992), [10]Beissinger & Waltman (1991), [11]Forshaw & Cooper (1989).

unusual features have considerable implications for long-term conservation as they help to counterbalance the loss of prefledglings harvested by islanders. The high mortality during the few weeks after fledging due to predation by raptors is similar to that observed for juvenile Puerto Rican Parrots (Lindsey *et al.* 1994) and confirms that the most vulnerable part of the life-cycle of an endangered species is often the survival of juveniles from fledging to successful breeding (Perrins 1991).

Reproductive strategy and implications for conservation

This study describes the overall reproductive success and fundamental features of the reproductive biology of the Ouvea Parakeet, including a high breeding success, an extended breeding season and the occurrence of second clutches.

As observed in other island parrots (Rinke 1989, Gnam 1991), the clutch size of Ouvea Parakeets is not affected by insularity. On the other hand, second clutches, as a consequence of the extended breeding season, may be possible partly because there are fewer competitors for food or nest hollows in Ouvea, as a result of insularity. These features, and foraging observations (Robinet *et al.* unpubl. data), suggest that although food availability may determine the survival of the third chick, it is less important than post-fledging predation in limiting the productivity of this taxon.

The degree to which nest-site limitation is a threat to the conservation of the Ouvea Parakeet is unknown, but a shortage of hollows is strongly suggested by this study and confirmed by other data (Robinet *et al.* unpubl. data). It is thus important that further reductions in native forest vegetation is prevented and that larger *Syzygium* and *Mimusops* trees are especially protected.

We have established that the main causes of loss include the death of the youngest chicks by starvation, the removal of prefledglings by people and predation after fledging. The absence of introduced Ship and Norway Rats appears fundamental in keeping predation rates low at nests.

The ageing of chicks in the nest using both wing-length and external characters, and of sexing nestlings from 30 days old by a combination of culmen-length and -width, allows comparison of weight gain between chicks of different nests as a measure of food availability, thus habitat quality. This method has been used by Saunders (1986) with Carnaby's Cockatoo *Calyptorhynchus funereus latirostris* for assessing viability of populations in a given area, and could also be used for the Ouvea Parakeet.

To ensure ongoing protection for the endangered Ouvea Parakeet, three actions are needed. First a public awareness campaign in Ouvea to stop the capture and trade of young parakeets, secondly an effective and permanent protection against the introduction of European rats and finally ongoing protection for remaining forest, especially larger *Mimusops* and *Syzygium* trees.

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APPENDIX

Values and significance in logistic equations obtained for the different growth parameters of Ouvea Parakeet.

Parameter	Sex	r^2	A	B	K
Weight	Male	0.92	137.9 (3.04)*	16.33 (4.44)	0.22 (0.02)
	Female	0.92	118.9 (2.48)*	13.16 (3.02)	0.20 (0.02)
Culmen-length	Male	0.94	20.3 (0.85)	3.07 (0.28)	0.08 (0.01)
	Female	0.93	18.8 (0.79)	2.70 (0.19)	0.07 (0.01)
Culmen-width	Male	0.93	13.9 (0.23)*	1.97 (0.21)	0.12 (0.01)
	Female	0.93	12.4 (0.15)*	1.87 (0.17)	0.13 (0.01)
Wing-length	Male	0.96	144.6 (5.93)	18.66 (3.49)	0.13 (0.01)
	Female	0.96	154.3 (8.13)	22.19 (3.67)	0.12 (0.01)
	Male + Female	0.95	150.1 (5.14)	20.15 (2.66)	0.12 (0.01)
Tarsus-length	Male	0.83	24.9 (0.18)*	2.18 (0.62)	0.25 (0.04)
	Female	0.75	23.7 (0.28)*	1.91 (0.42)	0.20 (0.03)

$f(x) = A/(1 + B \exp^{-Kx})$, where A = the asymptotic value, $B = (A - f(0))/f(0)$ and K = a rate constant.
*Significant difference between sexes ($P < 0.01$); asymptotic standard error is given in parentheses.