

## Growth and fledging of kakapo

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**Abstract** The kakapo (*Strigops habroptilus*) is a critically endangered, flightless parrot endemic to New Zealand. In 2002, 24 chicks were raised on Codfish Island (Whenua Hou) to increase the total population by 37% to 86 individuals. Data on hatching and fledging of kakapo chicks allowed comparisons to be made between males and females, and between broods of one and two chicks, in hatching weight, growth, weight at fledging, and age of fledging. There was no significant difference in hatching weight between sexes or brood sizes but males were significantly heavier at 60 days old and at fledging. Chicks from broods of one grew more slowly and fledged earlier at lighter weights than chicks from broods of two. Early fledging of solitary chicks might be in response to a lack of mental and physical stimulation.

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## INTRODUCTION

The kakapo (*Strigops habroptilus*) is a large, flightless, nocturnal parrot, endemic to New Zealand. It is one of the world's most critically endangered species (Hilton-Taylor, 2000) with total population (in 2005) of only 86, all of which are on three islands off the coast of New Zealand's South Island and Stewart Island. The entire population is intensively managed, with all birds carrying transmitters and most being frequently located, weighed and provided with supplementary food.

Kakapo breed once every three - five years, apparently in response to a rich food source, such as the mast seeding of rimu (*Dacrydium cupressinum*) trees (Butler 1989; Low 1994). Kakapo are lek breeders and incubation and raising of the altricial young is undertaken entirely by the female (Powlesland *et al.* 2006). Because of infrequent breeding and a small population size only eight kakapo fledged in the wild between 1981 and 2000, and there has been little chance to study the behaviour of young kakapo. However, in 2002, 24 chicks were raised on Codfish Island (Whenua Hou) thereby increasing the total population by 37%. Four chicks were partially or completely hand-raised, but 20 were raised in the wild by 14 female kakapo. Of these, seven females raised one chick and seven raised two. This presented the opportunity to study weight gain, growth and age of fledging in kakapo chicks, and to assess differences between sexes and brood sizes.

## MATERIALS AND METHODS

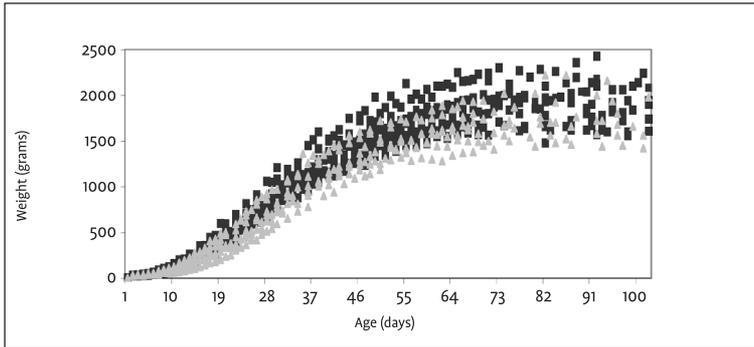
The study was conducted from April to June 2002 on Codfish Island (Whenua Hou), a 1396 ha island located 3 km off Stewart Island, (167° 38' E, 46° 46' S). The island vegetation comprised a shrubland dominated by manuka (*Leptospermum scoparium*), rata (*Metrosideros umbellata*) and inaka (*Dracophyllum longifolium*) on high flat areas, tall forest dominated by rimu, miro (*Podocarpus ferrugineus*), kamahi (*Weinmannia racemosa*), rata over most of the island, and coastal shrubland dominated by hebe (*Hebe elliptica*) and tree daisies (*Olearia* spp.).

All kakapo carried back-pack radio-transmitters (20-35 g.) and the chicks had theirs fitted when approximately 70 days old. Once hatched, chicks were initially weighed daily, with the frequency of weighing decreasing with increasing age. Chicks were placed in cotton bags and weighed to the nearest gram on spring or electronic scales. Chicks were weighed during the night while they were in the nest, but during the day once they had fledged.

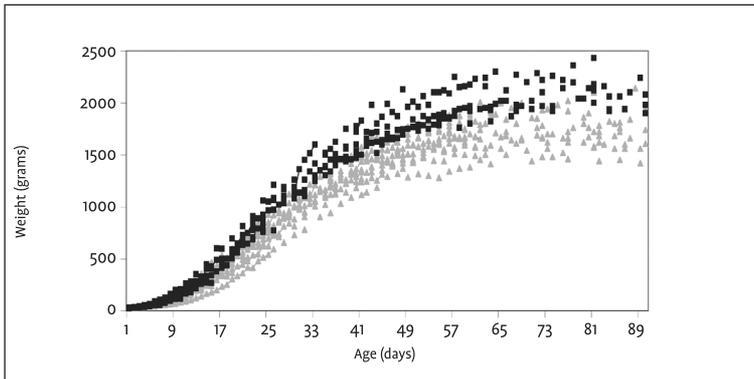
After the transmitter was fitted, every chick and its mother was located four to five times a week from 24/04/02 to 04/06/02 and 19/06/02 to 23/06/02, by which time all chicks had fledged. Fledging was defined as the age at which the chick left the nest and did not return. Radio signals were detected with a radio receiver and a hand held three-element Yagi antenna. Each chick was located twice a week at night (between one hour after sunset and one hour before sunrise) to determine if the chicks were leaving the nest and how far they moved. The other two to three locations were taken during the day (between one hour after sunrise and one hour prior to sunset) to determine if the

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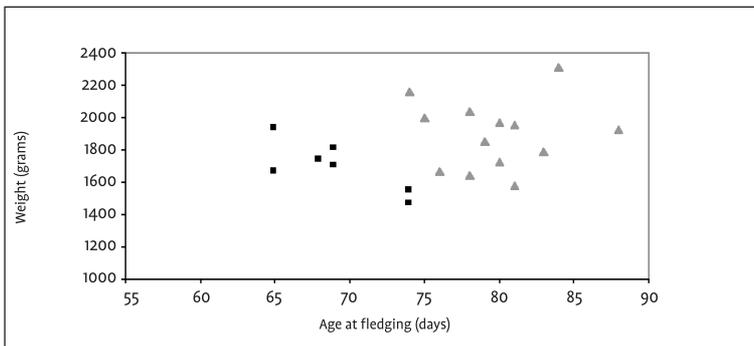
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► **Figure 1** Weights of wild-reared kakapo chicks on Codfish Island, 2002, to 100 days old. Chicks from broods of one ( $\blacktriangle$ ) and chicks from broods of two ( $\blacksquare$ ).



► **Figure 2** Weights of the wild-reared kakapo chicks on Codfish Island, 2002, to 100 days old. Female chicks ( $\blacktriangle$ ) and male chicks ( $\blacksquare$ ).



► **Figure 3** Fledging weights of wild-reared chickson Codfish Island, 2002. Chicks from broods of one ( $\blacktriangle$ ) and chicks from broods of two ( $\blacksquare$ ).

chick and mother had returned to the nest to roost. Two chicks fledged during a two week sampling break in June 2002. The fledging age of these two chicks was taken as the age when sampling resumed.

To determine if there were differences in weights between the sexes and between brood sizes, the weights of chicks at hatching, 60 days and fledging were compared using analysis of variance. Fisher's exact test was used to determine any association between whether mothers or chicks first left the nest and brood size. All analyses were performed using the computer program "R" (Ihaka & Gentleman 1996). Means are presented with standard deviations.

## RESULTS

### Chick weight and growth

Average weight at hatching was  $28.89 \text{ g} \pm \text{sd } 4.08$  (range 22.4 - 38 g). There was no statistically significant difference in weight at hatching between sexes ( $F = 1.95$ ,  $df = 1,18$ ,  $P = 0.178$ ) or between brood sizes ( $F = 3.42$ ,  $df = 1,18$ ,  $P = 0.081$ ). (Figs. 1, 2).

At 60 days old, there was a statistically significant difference in the weights of chicks from one and two-brood nests ( $F = 8.89$ ,  $df = 1,18$ ,  $P = 0.008$ ), with chicks from broods of two being, on average, 161 g heavier than chicks of the same sex from broods of one. There was also a significant difference between sexes ( $F = 32.53$ ,

$df = 1,18$ ,  $P = 0.000$ ), with males being heavier than females ( $\text{♂} \text{♂} 1920 \text{ g} \pm 134$ , range 1785 - 2110 g;  $\text{♀} \text{♀} 1610 \text{ g} \pm 144$ , range 1441 - 1850g).

The average weight at fledging was  $1813 \pm 213 \text{ g}$  (range 1470 - 2310 g). Chicks fledged from broods of two ( $1891 \text{ g} \pm 213$ , range 1575 - 2310) were significantly heavier than those from broods of one ( $1695 \text{ g} \pm 155$ , range 1470 - 1935) ( $F = 13.08$ ,  $df = 1,18$ ,  $P = 0.002$ ) (Fig. 3.), and males ( $1984 \text{ g} \pm 190$ , range 1700 - 2310) were significantly heavier than females ( $1715 \text{ g} \pm 156$ , range 1470 - 1999) at fledging ( $F = 24.15$ ,  $df = 1,18$ ,  $P = 0.000$ ).

### Fledging

The ages at fledging varied from 65 to 88 days, with an average of  $76.1 \pm 6.3$  days. Males fledged 3.5 days before females from broods of the same size but this difference was not significant ( $F = 2.86$ ,  $df = 1,18$ ,  $P = 0.074$ ). Chicks from broods of two fledged 5.5 days later than chicks from broods of one, a statistically significant difference ( $F = 2.864$ ,  $df = 1,18$ ,  $P = 0.010$ ).

Chicks from most broods of two roosted away from the nest after their mothers had started roosting away, whereas chicks from all broods of one, roosted away from their nests before or at the same time as their mothers. This difference was statistically significant (Fishers exact test  $P = 0.011$ ).

### DISCUSSION

Male and female chicks from broods of both one and two were similar weights at hatching, but by 60 days old, males were heavier than females, and chicks from broods of two were heavier than chicks from broods of one. Males and females fledged at about the same age, but chicks from broods of two fledged later and at heavier weights than those from broods of one.

The heavier weights of males at fledging reflects adult characteristics of males being 30 - 40% heavier than females (Elliott *et al.* 2001; Eason *et al.* 2006).

Many studies have found that the age of fledging increases with brood size (e.g., Martins 1997; Michaud & Leonard 2000) and this is generally attributed to chicks from small broods getting more food and suffering less sibling rivalry than chicks from large broods. The reverse was the case for kakapo. A possible explanation for the slower growth of solitary kakapo chicks is heat loss. Solitary chicks might use more energy thermo-regulating than chicks with a sibling to snuggle up to, or their mothers might have to spend more time brooding them and thus less time seeking food for them.

That young which grow faster, fledge at a younger age compared to other, slower growing individuals has been shown in many studies (e.g., oystercatcher (*Haematopus ostralegus*) Kersten & Brenninkmeijer 1995; rhinoceros auklets (*Cerorhinca monocerata*) Harfenist 1995;

Montagu's harrier (*Circus pygargus*) Amar *et al.* 2000). In contrast, fast growing kakapo chicks from broods of two fledged later than slower growing chicks from broods of one. This is of particular interest, since, in many species, fledging weights affect subsequent survival (Perrins & McCleery 2001; Green & Cockburn 2001; Michaud & Leonard 2000). There have been too few recorded breeding events of kakapo for this phenomenon to be investigated.

Early fledging of solitary chicks may be due to the need for mental and physical stimulation. Kakapo, like most parrots, are intelligent and inquisitive (Low 1994; Climo & Ballance 1997). Early accounts of kakapo behaviour compared them to dogs (Buller 1873; Hutton & Drummond 1904) and early European settlers to New Zealand claimed that, as pets, they were more fun than a dog, cat or monkey, being both playful and inquisitive (Butler 1989). Young kakapo are social and playful when given the opportunity (MF pers. obs.). Social play may be important for learning and developing basic physical skills. Kakapo chicks with siblings receive plenty of mental and physical stimulation in the nest, whereas solitary chicks are likely to receive more mental and physical stimulation if they follow their mothers and leave the nest.

Maternal or parental aggression is one mechanism that may influence timing of fledging, due to the different costs and benefits to nestlings and parents (Ydenberg *et al.* 1995; Harfenist 1995; Trivers 1974). We have no evidence of this in kakapo, either from video tapes of monitored nests or from numerous sightings of chicks and mothers together at night. Whilst aggression did not appear to initiate fledging, in broods of two chicks it appeared that the mother may initiate fledging in another manner; most mothers of two-chick broods commenced roosting away from their nests before the chicks did so whereas, in single chick broods, the mother was never the first to roost away. This suggests that fledging is often initiated by the mother in two-chick broods, but not in nests with a single chick.

Critical fledging thresholds have been described for several bird species where, if the threshold of the parameter in question is not reached, fledging will not be successful. Nilsson & Svensson (1993) found that fledging in marsh tits (*Parus palustris*) and pied flycatchers (*Ficedula hypoleuca*) relied on young reaching a critical threshold size, while other studies have found fledging occurs **once young have obtained a critical wing loading** or a period in feather growth that allows for flight (Martins 1997; Michaud & Leonard 2000). It is possible that, in kakapo, fledging is enabled by the attainment of a critical minimum weight, size or condition. Once this threshold is reached and when food is abundant, as it was during this study, chicks from single broods fledged immediately due to their need for mental and physical stimulation. Two-chick broods, although exceeding the minimum fledging threshold, fledged later (possibly stimulated by the departure of their mother) as siblings provide mental and physical stimulation.

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